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PHASE I REMEDIAL INVESTIGATION
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CONNECTICUT

SECTIONS 1.0 THROUGH 8.0

Prepared For:

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
LESTER, PENNSYLVANIA

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Appendix D: Applicable, Relevant and Appropriate Requirements (ARARs)
Appendix E: Human Health Risk Assessment Data
Appendix F: Ecological Risk Assessment Data

GLOSSARY

ARARs	Applicable or Relevant and Appropriate Requirements
CBU	Construction Battalion Unit
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CTDEP	Connecticut Department of Environmental Protection
DDTR	DDT and residues
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
EIC	Engineer in Charge
EM	Electromagnetic
ESQD	Explosive Safety Quantity Distance
GC	Gas Chromatograph
gpd/ft^2	Gallons per day per square foot
gpm	Gallons per minute
GPR	Ground Penetrating Radar
IAS	Initial Assessment Study
IDL	Instrument Detection Limit
IR	Installation Restoration
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
NGVD	National Geodetic Vertical Datum
NACIP	Navy Assessments and Control of Installation Pollutants
NEESA	Naval Energy and Environmental Support Activity
NESO	Navy Environmental Support Office
NTUs	Nephelometric Turbidity Units
OBDA	Over Bank Disposal Area
OBDANE	Over Bank Disposal Area Northeast
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PM10	Concentration of suspended particulate matter in air for a particle size fraction of ten microns or less.
POC	Point of Contact

GLOSSARY (continued)

ppb	parts per billion
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
RQD	Rock Quality Designation
SARA	Superfund Amendment and Reauthorization
SCS	Soil Conservation Service
SVOs	Semi-Volatile Organics
TAL	Target Analyte List
TIC	Tentatively Identified Compounds
TRC	Technical Review Committee
TBC	"To be considered" values
TCLP	Toxicity Characteristic Leachate Procedure
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOAs	Volatile Organic Compounds

PREFACE

This document is the Phase I Remedial Investigation Report for the Naval Submarine Base-New London. It is prepared as part of the United States Navy's Installation Restoration Program. Included in this report are the results of Step I investigations (preliminary assessment/site inspection) at seven sites and Step II investigations (remedial investigations) at four sites. Of the seven Step I sites, it is recommended that four proceed to Step II investigations; supplemental Step I investigations are recommended at the remaining three sites. Supplemental Step II (remedial investigations) are recommended for all four Step II sites. Presented below is a summary of the present status of all eleven sites investigated.

SUMMARY OF SITE INVESTIGATION STATUS

Site Name	Investigation Status		Recommendation
	Step I	Step II	
CBU Drum Storage Area	•		Perform supplemental Step I investigation
Rubble Fill at Bunker A-86	•		Proceed to Step II investigation
Torpedo Shop	•		Proceed to Step II investigation
Goss Cove Landfill	•		Proceed to Step II investigation
OBDANE	•		Perform supplemental Step I investigation
Spent Acid Storage and Disposal Area	•		Proceed to Step II investigation
Former Gasoline Station	•		Remove tank and perform corrective actions, if necessary, in accordance with underground storage tank regulations.
Area A		•	Perform supplemental Step II investigation
OBDA		•	Perform supplemental Step II investigation
DRMO		•	Perform supplemental Step II investigation
Lower Subase		•	Perform supplemental Step II investigation

The first draft of this report was submitted to the technical review committee (TRC) for review in August of 1991. Written comments were received from several TRC members as listed below:

- United States Environmental Protection Agency - November 12, 1991
- Connecticut Department of Environmental Protection - November 25, 1991
- Town of Waterford - October 16, 1991
- National Oceanic and Atmosphere Administration - September 22, 1991
- Mr. Fromer - October 13, 1991
- United States Department of Interior, Fish and Wildlife Service - December 6, 1991

The Navy prepared detailed responses to these comments (March 20, 1992 and March 26, 1992). The USEPA submitted a letter (May 20, 1992) responding to the Navy's response letters. The Navy had a series of discussions with the USEPA to resolve outstanding issues. As a result of these discussions, an agreement was reached on the outstanding issues and documented in writing by the Navy.

This report has been modified to address comments from the TRC, and those USEPA comments requiring revision to the report at this time. Several USEPA comments will be addressed in the Phase II Remedial Investigation report, which will follow the implementation of the recommended additional field investigations.

The following documents pertaining to comments and responses to the draft report are provided in Attachment 1 to this preface.

- List of comments that have been addressed by making revisions to the report
- Navy summary of resolutions reached regarding EPA's additional comments of May 20, 1992
- Navy's response to EPA's comments of November 12, 1991 (March 20, 1992)
- Navy's response to EPA's Risk Assessment comments of November 12, 1991 (March 26, 1992)
- Navy's response to CTDEP's comments of November 25, 1991 (March 26, 1992)
- Navy's response to Town of Waterford comments of October 16, 1991 (March 26, 1992)
- Navy's response to NOAA's comments of September 22, 1991 (March 26, 1992)
- Navy's response to Mr. Fromer's comments of October 13, 1991 (March 26, 1992)

All revisions to the report have been made in bold print, except for revisions to tables or figures.

ATTACHMENT NO. 1

LIST OF COMMENTS THAT HAVE BEEN ADDRESSED BY MAKING REVISIONS TO THE REPORT

LIST OF COMMENTS THAT HAVE BEEN ADDRESSED BY MAKING REVISIONS TO THE REPORT (REFERENCED TO THE NAVY'S RESPONSE TO COMMENTS)

NAVY RESPONSES TO EPA COMMENTS (NOVEMBER 12, 1991) ON DRAFT IR REPORT (AUGUST 1991)	
Page	**Comment Number(s)**
Section 1.0 - Introduction	
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4	6, 7, 8, 9, 10, 11, 12, 13
5	14, 15
Section 2.0 - Site Investigation	
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9	15
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11	23, 25, 26
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29	5, 7, 9, 10

NAVY RESPONSES TO EPA COMMENTS (NOVEMBER 12, 1991) ON DRAFT IR REPORT (AUGUST 1991) (continued)	
Page	**Comment Number(s)**
Section 8.0 - Summary and Conclusions	
34	1, 2, 3
37	17
Varies	All recommendations for no further action will be changed to a recommendation for supplemental Step I investigations.
Section 1.0 - Preliminary Remedial Technologies	
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NAVY RESPONSES TO THE CTDEP's COMMENTS (NOVEMBER 25, 1991) ON DRAFT IR REPORT (AUGUST 1991)	
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1	3, 4
2	5, 6, 7, 8, 10
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General Observations	
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4	2
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NAVY SUMMARY OF RESOLUTIONS REACHED REGARDING EPA'S ADDITIONAL COMMENTS OF MAY 20, 1992

NAVY SUMMARY OF RESOLUTIONS REACHED REGARDING EPA COMMENTS (MAY 20, 1992) ON DRAFT IR REPORT (AUGUST 1991)

Introduction

These responses reflect discussion and agreements regarding resolutions of the comments from a phone conference on June 4, 1992 between USEPA, CTDEP, Navy and Atlantic.

General Observations

1. *As discussed in EPA's November 12, 1991 comment letter on the draft report, EPA cannot concur with the Navy's determination that sufficient data exists to support a "No Further Action" decision at three sites. As discussed on page 30 of the aforementioned correspondence, the fact that analytical results from a particular site did not result in contaminant values that exceeded ARARs or risk-based criteria is not a sufficient means for determining whether the site should undergo further investigation. The CERCLA criteria for determining whether a Remedial Investigation (RI)/Feasibility Study (FS) should be performed on a particular site does not consider ARARs or risk-based values. Generally, the amount of sampling which is performed for a PA/SI (Step I investigation) is only sufficient to determine the presence of contamination, not the nature or extent. Furthermore, all media are not typically sampled in the PA/SI phase. In addition, since there have been documented releases at all three sites, further investigation must be conducted that completely characterizes these areas.*

   The recommendation in the RI report has been changed from "No Further Action", however, a full remedial investigation (Step II investigation) will not be initiated. It was agreed that, in lieu of Step II investigations, a supplemental Step I investigation will be conducted at CBU and OBDANE to determine if Step II investigations are necessary or to support a no further action recommendation. Details of the scope-of-work for the supplemental investigation for these sites will be presented in future work plans that will be submitted for review and approval. Regarding the Former Gasoline Station the underground storage tank will be removed. After the tank is removed, samples will be collected from excavation sidewalls, at a depth just below the tank bottom and at the depth of the ground water table interface. If contamination is detected, corrective actions will be performed in accordance with the underground storage tank regulations. If no contamination is detected, no further actions will be required.

2. *Site-specific background soil data for inorganics must be collected during Phase II activities.*

   It was agreed that background data will be collected. This investigation effort will be fast tracked to expedite completion of the Phase II RI report.

3. *Several responses offered by the Navy indicate only that EPA comments "will be considered in future work plans". Examples of this include sampling for dioxins, suggestions for additional sampling locations, modification of the North Lake overflow plumbing, etc. Such responses are unacceptable and must be resolved prior to initiation of Phase II activities. In addition, as discussed during the March 31, 1992 TRC meeting, EPA has not agreed that the nature and extent of contamination have been adequately determined for those sites which the Navy has moved into the FS phase of the investigation. It is recommended that the Navy refrain from submitting the draft FS report until adequate characterization data is collected.*

The following is a discussion of each of the comments responded to with "will be considered in future work plans", as discussed during our conference call. As you are aware, the EPA and TRC will have an opportunity to comment on the supplemental work plans prior to implementation.

The Navy agrees to perform dioxin testing (Response 1 - Contaminant Fate and Transport section) and to delineate the extent of wetlands (Response 8 - Summary and Conclusions section).

Regarding general comments concerning development of future work plans; ground water samples to be analyzed for metals will be analyzed for both total and dissolved metals; when feasible, well screens will not be placed over different stratigraphic units, and all soil gas hot spots will be evaluated to determine if a monitoring well or soil boring at that location is required.

The work plan for Step II investigations at the Torpedo Shop will include collection of a soil sample or samples with a hand auger in the location of the soil gas hot spot observed at the north leach field. Some of the borings to be proposed for this site will be located in an effort to determine the bedrock contact and will include the collection of bedrock core samples. In addition, any bedrock outcrops in this area will be surveyed. We will also evaluate the use of geophysical methods, however, the signature between the two formations may not be different enough to allow the use of geophysical methods.

The work plan for supplemental Step II investigations at Area A will include collection of samples of water and sediment in areas where ground water seepage into North Lake is evident and will include additional surveying of bedrock overcrops. EPA suggested continuous monitoring at two locations in Area A. The work plan will include some longer term water level monitoring at these locations. As the work plan is developed, we will further discuss the need for continuous monitoring. The Area A Downstream scope of work will include further sediment sampling, however, analysis for all TCL and TAL parameters is not necessary. After we develop a list of parameters, we will further discuss this issue. The ecological survey in this area will include a benthic survey and will most likely include sediment toxicity testing.

Presently, preparation of the FS is on hold pending completion of the RI, including the further definition of the nature and extent of contamination, and other items requested by the EPA.

4. *A baseline quantitative ground water risk assessment must be conducted to adequately evaluate potential risks to human health. Comparison of ground water quality to MCLs is unacceptable.*

   The Navy agrees to perform a baseline quantitative risk assessment regarding ground water ingestion. This will be performed after the supplemental investigations are completed.

5. *As discussed during the February 13, 1992 meeting with EPA, the Navy, and its contractor, the use of surrogate RfDs does not reduce uncertainty and is unacceptable in the baseline risk assessment. More specific comments on outstanding risk assessment issues can be found on proceeding pages.*

   The spreadsheets will be re-calculated. The source of RfDs for the revised spreadsheets will be the values in the IRIS database or the HEAST tables that are current at the time the Phase II RI Report is completed.

Response to "General Comments"

1. ***Page 2, Response 7:*** *The "other Navy analytical data" mentioned was not presented in the draft IR report. In addition, the Navy has not provided EPA with information on the DQO level of these data, the analytical methods used, or the specific locations from which samples were collected.*

   EPA believes that additional sampling of North Lake is warranted due to the fact that the lake appears to be recharged by ground water. This matter should be discussed further. The addition of a sample location near Triton Avenue is not a suitable substitute location for additional sampling at North Lake.

   The "other Navy analytical data" was summarized in Table 1-6. Copies of original laboratory reports are available. The Phase II RI will include information regarding the DQO level of the data and analytical methods used. The locations of samples collected by the Navy within North Lake are unknown.

   The Navy will conduct additional sampling of North Lake as requested. The scope of these additional investigations will be addressed in the supplemental Step II work plans.

2. ***Page 2, Response 10:*** *The tidal cycle investigation discussed on pages 3-42 and 3-48 of the draft IR report is not adequate to interpret and predict the fate and transport of ground water contamination. The IR report does not state whether the investigation was performed*

during spring or neap tides. It is not clear whether additional wells (in addition to those discussed in the report) were monitored to determine a tidal influence.

Although the statement that "the reversal of ground water flow direction at high tide does not extend farther than 300 feet inland from the river" may be correct, the tidal effect at the Goss Cove and the DRMO were not investigated. Furthermore, there are additional impacts or effects of tidal influence other than changes in ground water. For example, tidal induced water levels may complicate hydraulic conductivity test analysis, and the existence of floating product may vary with the rise and fall of the tide.

It was generally agreed, after further explanation, that the work completed was adequate. This section of the report will be revised in the Phase II RI to include water elevation information from tidal charts to show that the survey was performed during normal tides. A graphical presentation of elevation measurements from all the wells surveyed will be provided. Discussion will be provided to explain that the tidal survey conducted at Lower Subase is applicable to the DRMO and Goss Cove sites due to their similar location adjacent to the river, and similar subsurface geology (fill).

We acknowledge that tidal impacts may effect more than just ground water elevations, and will consider these impacts in data evaluation and any future investigations.

Section 1.0 - Introduction

1. *Page 4, Response 11: This information should be included in the draft final IR report.*

   This information is included in the Phase I RI Report.

Section 2.0 - Site Investigation

1. *Page 6, Response 3: EPA has reviewed the February 1992 Geophysical Investigation Report and submitted comments to the Navy via a letter dated April 20, 1992. EPA would appreciate a response to this letter and requests that a follow-up meeting be convened to discuss additional geophysical work that may be warranted based on data gaps identified in the report.*

   A response is presently being prepared by Weston Geophysical and will soon be submitted to the Navy. Shortly thereafter, the response will be finalized and submitted to the EPA for review.

2. *Page 7, Response 6: EPA does not require "vigorous QA/QC" to be applied to screening methodologies, only that QC samples have defined objectives of acceptability. The use of standard acceptance criteria is intended to apply reasonable limits to the subjectivity of the*

analytical system. For example, the accepted degree of precision for soil gas field duplicates need not be as stringent as those applied to laboratory analysis, but there should be a limit to the impression which will be accepted. That limit should be defined.

The Phase I RI Report has been revised to define the precision limit which was qualitative. Results were considered acceptable if, in comparison of duplicate analyses, there was a general match of identified compounds (presence of or absence of the same compound) and if there was no significant difference in concentration, generally around an order of magnitude.

3. ***Page 8, Response 12:*** *The discussion on page 2-13 of the draft report does not indicate the specific selection criteria employed for each sample collected. This discussion is vague and cannot be used to develop an understanding of how a particular sample from a given boring was selected for analysis. Additional information is needed.*

   An explanation and further details of the criteria used to select soil samples will be compiled and provided in the Phase II RI Report.

4. ***Page 8, Response 13:*** *Although EPA is not requesting that the Navy install additional wells to determine the base wide ground water flow directions, a ground water map which encompasses all of the hazardous waste sites is fundamental to the interpretation of contaminant fate and transport and determining background reference sampling locations at the base.*

   A base wide ground water contour map will be prepared utilizing existing ground water monitoring wells installed at NSB-NLON. This will be accomplished by collection of a water depths over a one to two day period. Note, at Goss Cove, Lower Subase, and DRMO, the measurements will be collected during the same general time frame to minimize the effect of tidal fluctuations. For wells that have not been surveyed by Atlantic, existing well elevation information will be used to develop a consistent reference elevation.

5. ***Page 9, Response 15:*** *A bedrock elevation map must be provided in the draft final IR report.*

   Based on subsequent discussions following the phone conference of June 4, 1992, it was agreed that a base wide bedrock elevation map will not be prepared at this time due to the lack of available data. As additional data becomes available regarding bedrock elevation, we will consider preparation of a base wide map.

6. ***Page 10, Response 16:*** *The draft IR report indicates that ground water flow reversals occur as far as 300 feet inland. It is probable, therefore, that "tidal effects" are pronounced several thousand feet inland, significantly more than "200 feet" indicated in the Navy's response. Continuous monitoring water level recorders should be installed to document tidal effects at these sites.*

See response No. 2 regarding the general comments above. The Navy does not propose to install continuous monitoring water level recorders as part of future tidal investigations.

7. ***Page 12, Response 30:*** *EPA requires PRPs to perform data validation of all samples used for risk assessment, regardless if the data were generated using DQO Level II methods. At a minimum, federal facilities are required to submit a representative subset (no less than ten percent) of analytical results to validation in accordance with EPA Region I guidelines. It is recommended that the Navy identify critical data points, i.e., analytical results generated from sample locations where multiple analyses were performed, and submit these data for additional validation in accordance with the November 1, 1988 Region I Laboratory Data Validation Guidelines for Evaluating Organic and Inorganic Analyses. Conclusions regarding the acceptability of these data will then be applied to the remainder of the data.*

   The Navy agrees to perform the additional data validation specified.

Section 3.0 - Characteristics of Study Area

1. ***Page 14, Response 2:*** *A bedrock elevation map for the entire base must be constructed and included in the draft final IR report. Although the collection of additional data is not necessary at this time, the bedrock elevation map must portray the confidence level of each contour through the use of dashes and question marks or other standard symbols.*

   Refer to item No. 5 in the Site Investigation section.

2. ***Page 14, Response 3:*** *The water table and water level elevations should be depicted on cross-sections. Where sufficient data exists, flow sections should be prepared as well. For maps, areas of unsaturated overburden and posted water level elevations should be included.*

   The Navy agrees to include the elevation of ground water on the geologic cross-sections and qualitatively the ground water flow directions (flow direction arrows) on all cross-sections in the Phase II RI Report.

3. ***Page 20, Response 31:*** *The text should be changed that qualifies the useability of the data. A suggested revision to the text is to include a statement indicating that the pump test data are not accurate due to the factors discussed in EPA's November 12, 1991 comment letter.*

   The text in the Phase II RI will include a discussion of the useability of pump test data.

Section 4.0 - Nature and Extent of Contamination

1. ***Page 21, Response 2:*** *The collection of inorganic background samples for soils is an important issue, since without background data, the Navy must consider all inorganics detected as site contaminants. If it can be demonstrated that certain inorganics are naturally occurring (via comparison to site-specific background data), they need not be included in the risk assessment.*

   In addition, the draft IR report contains several references to inorganic levels in soil that are "below background levels". Such statements must not be included in the draft final IR report unless site-specific background data are available.

   Background soil data will be collected. Please refer to item No. 2 in the General Observations section.

2. ***Page 21, Response 3:*** *Comments on the ARARs tables were offered by Robert DiBiccaro of EPA Region I's Office of Regional Counsel at the February 13, 1992 meeting. The Navy is encouraged to contact Mr. DiBiccaro at (617) 565-3449 with any additional questions or concerns in this regard.*

   We have noted Mr. DiBiccaro's comments and will be contacting him regarding additional ARAR questions that have arisen.

3. ***Page 24, Response 14:*** *Table 4-2 needs to be updated as follows:*

   - *Barium has final MCL and MCLG of 2,000 ppb;*
   - *Copper has final MCLG and action level of 1,300 ppb;*
   - *Chloroform has a MCL of 100 ppb (from total trihalomethanes); and*
   - *Endrin has a proposed MCL of 0.2 ppb.*

   In addition, the Navy's response indicates that some of the state's regulations are more stringent than EPA's. The fact is that many states adopt EPA's drinking water regulations. When EPA promulgated new regulations based on new data, most states still use EPA's old regulations. This seems to be the case for the State of Connecticut because all the values mentioned here are EPA's old standards. Therefore, it may be appropriate to cite EPA's standards.

   Our previous response indicated that we will revise our tables to show the newer values. The State of Connecticut has indicated that we should use their existing standards not EPA's new values and note that they may be revised in the future to correspond to EPA's values.

4. ***Page 26, Response 28(a):*** *Response 29 in Section 3.0 does not respond to EPA's query. This sentence should be removed from the draft final IR report until the Navy is able to present conclusive evidence that bedrock ground water does not discharge into North Lake.*

This section of the report has been revised.

5. *Page 27, Response 32: An "approximate delineation of 'hot spots' of soil contamination" is inadequate for determining soil contamination limits at a site. Additional data must be collected from this site to more accurately define the nature and extent of contamination.*

   This data will be collected during supplemental investigations to be performed at this site.

6. *Page 27, Response 34: It was recently brought to my attention by EPA Region I's Office of Environmental Review that the Navy is proposing to dredge 2.7 million cubic yards of sediment on an eight mile stretch of the Thames River in order to provide sufficient channel depth for the SEAWOLF nuclear submarine. The Navy submitted a Draft Environmental Impact Statement (DEIS) in April 1991 which neglected to mention the existence of documented CERCLA hazardous waste sites at upgradient (from the Thames River) locations on the base. Since it has been determined in the draft IR report that additional information on surface water and sediments is needed to fully evaluate potential impacts of the lower subase, Area A wetlands, downstream watercourses, DRMO, and ponds along the Thames River, the Navy may want to consider coordinating its sample collection efforts pursuant to the proposed NEPA activities (see EPA's July 15, 1991 comment letter on the DEIS0 with those underway as part of the ongoing CERCLA/IRP program).*

   To the extent feasible, the Navy will coordinate sample collection efforts between the dredging and IR programs.

Section 5.0 - Contaminant Fate and Transport

1. *Page 29, Response 6: EPA believes that analysis for all chlorinated dioxin/furan compounds should be conducted, at a minimum, at locations where dibenzofurans were detected on the base. In addition, EPA has found through discussions with other Regional Federal Facility offices, that dioxins and furans are also being found at facilities were TCL "identifiers" such as 2,4,5-trichlorophenol, 1,2,4-trichlorobenzene, PCBs, and dibenzofurans, were not detected. This finding is prevalent at areas where petroleum products (containing aromatic organic compounds such as benzene and toluene) have been burned with chlorinated solvents such as PCE and TCE or other chlorine sources.*

   The Navy agrees to test for dioxins during future field investigations at sites where dibenzofurans have been detected. The five sites where dibenzofurans have been detected are Area A Landfill, OBDA, Torpedo Shop, DRMO, and Goss Cove. Based upon the site histories, the only sites where petroleum products and chlorinated solvents may have been burned together are the DRMO and the former garbage incinerator. Incinerator ash from the former garbage incinerator was reportedly disposed in Goss Cove and Area A Landfill.

2. *Page 31, Response 15: Please explain what is meant by "soil background levels". As previously discussed, the Navy has not provided information on background contaminant levels at NSB-NLON. In addition, EPA does not allow use of published values for background levels of inorganics in soils. Site-specific data must be collected to support such a finding. Additional maps and/or text must be provided to support the contention that there is an upgradient source of copper and lead contamination.*

   As stated above, the Navy agrees to determine site-specific soil background levels. The Navy will provide additional text to support the contention that there is an upgradient source of copper and lead in the Phase II RI, if justified. Supplemental Step II investigations will include additional upstream surface water sampling to aid in this determination.

3. *Page 31, Response 17: Refer to comment on preceding page - page 29, response 6.*

   Refer to response to comment on preceding page - page 29, response 6.

Section 8.0 - Summary and Conclusions

1. *Page 34, Response 4: EPA agrees that further discussion on this issue is warranted.*

   The Navy agrees to perform additional investigations at these sites. Please refer to item 1 in the General Observations section.

2. *Page 35, Response 5: EPA agrees that further discussion on this issue is warranted.*

   The Navy agrees to perform additional investigations at these sites. Please refer to item 1 in the General Observations section.

3. *Page 35, Response 7: Refer to comment on preceding page.*

   The Navy agrees to sample for dioxins and furans at sites where dibenzofurans have been detected. Please refer to response 1 in the Contaminant Fate and Transport section.

4. *Page 35, Response 9: Refer to comment on preceding page.*

   Sediment sampling in this location will be included in future work plans and these investigation efforts will be coordinated with those for the dredging project to the extent feasible. Study of the "ball field" underground tanks and possibly any sediment sampling in this location will be done under a separate contract and not included in the IR report. EPA and CTDEP will, however, be kept informed of all Navy activities regarding contaminant investigations associated with management of these underground tanks.

5. *Page 36, Response 10: EPA agrees that further discussion on this issue is warranted.*

The Navy agrees to perform additional investigations at this site. Please refer to response 1 in the General Observations section.

6. *Page 36, Response 14: EPA disagrees. Cross-sections and flow nets are fundamental tools in portraying the extent of contamination, especially in ground water and must be included in the draft final IR report.*

The Navy agrees to qualitatively show ground water flow directions on all cross-sections in the Phase II RI. Please refer to item 2 in the Characterization of Study Area section for further details. In our discussion, we came to a general agreement that the available data would not allow the development of detailed flow nets. However, ground water flow direction would be added to future geologic cross-sections.

7. *Page 37, Response 16: Refer to comment on preceding page - Page 29, Response 6.*

The Navy agrees to sample for dioxins and furans at sites where dibenzofurans have been detected. Please refer to response 1 in the Contaminant Fate and Transport section.

8. *Page 37, Response 18: This response suggests that several data collection efforts will be delayed until the FS stage, including wetlands delineation, further definition of the nature and extent of contamination, and other activities. This strategy is unacceptable. As stated in EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA", a clear objective of the RI is to "determine the nature and extent of contamination". The FS then relies on the RI to determine the waste types, volumes and concentrations. It is recommended that the Navy redirect their efforts to proceed with a Phase II RI, prior to the submittal of the draft FS report, in accordance with the RI/FS guidance.*

The Navy agrees to perform the wetlands delineation as part of the Phase II RI.

Presently, the FS report is on hold pending completion of the RI including the further definition of the nature and extent of contamination, and other items requested by the USEPA.

9. *Page 38, Response 19: Refer to comment on page 5 - page 29, response 6.*

The Navy agrees to sample for dioxins and furans at sites where dibenzofurans have been detected. Please refer to response 1 in the Contaminant Fate and Transport section.

Appendices

1. *Appendix A, Page 39: The depths of the soil gas samples should be provided in the Appendix A tables.*

   The depth of the soil gas samples was three feet at all locations except at the Lower Subase. At the Lower Subase, the depth was 12-18 inches at all locations.

2. *Appendix E, Appendix F-1, Appendix F-2, Page 40: The Navy did not respond to these comments. A response at your earliest convenience is requested.*

   Appendix E: The Phase II RI Report will provide justification in the risk assessment text for the exclusion of samples from some human health risk assessment scenarios.

   Appendix F-1: Fish were not observed in the Area A Wetlands. However, an assessment for the presence of fish and other aquatic receptors will be included in our supplemental Step II investigation work plan for this area.

   Appendix F-2: The units for these tables, ug/kg or ppb, were inadvertently left off the copies reproduced as Appendix F-2.

RESPONSES TO EPA's COMMENTS ON HUMAN HEALTH RISK ASSESSMENT

General Comments

1. *Although a majority of the outstanding issues were discussed at the February 13, 1992 meeting in Boston, the Navy chose not to respond in writing to most of the issues raised in EPA's November 12, 1991 comment letter. Therefore, many of EPA's initial concerns with regard to the human health risk assessment are still relevant and the risk assessment portion of the draft IR report inconsistent with EPA guidance and policy.*

   Subsequent to the February 13, 1992 meeting, the Navy's response to EPA's comments on risk assessment were transmitted to TRC members on March 26, 1992. The Phase II RI Report will address issues that EPA Region I considers inconsistent with their guidance and policy. Specific issues that will be addressed include assessing risks due to ground water, collection of background samples for inorganics, and use of specific exposure parameters and toxicology data as required by EPA Region I risk assessors.

Specific Comments

1. ***Page 1, Response 3:*** *A quantitative risk assessment is necessary to establish a baseline assessment of potential risks to public health from exposure to site ground water. A comparison of ground water quality to MCLs does not adequately evaluate potential health effects due to the fact that: 1) MCLs are not solely health-based, 2) such a comparison does not take into account the combined effects of multiple chemicals present, and 3) MCLs may not be available for all contaminants detected.*

   The Navy agrees to perform a baseline quantitative risk assessment regarding ground water ingestion.

2. ***Page 2, Response 4:*** *As previously discussed, the collection of inorganic background samples for soils is an important issue, since without background data, the Navy must consider all inorganics detected as site contaminants. If it can be demonstrated that certain inorganics are naturally occurring (via comparison to site-specific background data), they need not be included in the risk assessment.*

   In addition, the draft IR report contains several references to inorganic levels in soil that are "below background levels". Such statements must not be included in the draft final IR report unless site-specific background data are available.

   The Navy agrees to develop background levels for soil.

3. *Page 2, Response 5: Some discussion on the distribution of the data should be provided in the text of the draft final IR report.*

The Phase II RI will include a discussion of data distribution.

4. *Page 4, Response 11: There appears to be confusion about the intent of this comment. Response (b) speaks specifically to average times in the risk assessment equation. The Navy response, on the other hand, addresses exposure frequency. Also, there appears to be a miscalculation in comment (d). The 1.2 l/day risk calculation is incorrect based on EPA's 2.6 hour per day and 0.13 l/day ingestion rate. Please revise.*

(b) Because the terminology in the 1991 draft IR report varied slightly from terminology given in EPA guidance (EPA, 1989) some confusion arose in the interpretation of the values given in Tables 6-3 to 6-23 regarding the averaging time for non-carcinogenic risks.

EPA Guidance Terminology	1991 Draft IR Report Terminology
Exposure frequency (EF)	Exposure duration
Exposure duration (ED)	Average lifetime exposure
Averaging Time (AT)	

Note how these parameters are slightly different. For example, EPA guidance gives the following equation to estimate daily intake due to the incidental ingestion of contaminated soil :

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times DF \times EF \times ED}{BW \times AT}$$

Where CS = chemical concentration in soil in mg/kg
IR = ingestion rate in mg/day
CF = a conversion of factor of 10^{-6} kg/mg
DF = a desorption factor
EF = exposure frequency in days/year
ED = exposure duration in years
BW = body weight in kg
AT = averaging time in days

For estimating daily intake of non-carcinogens for a utility worker, we used the following equation in the 1991 Draft IR Report:

$$\text{ADD or Intake (in mg/kg - day)} = \frac{CS \times IR \times CF \times DF \times Exp}{BW \times \text{Ave Period}}$$

Where:

Exp = the average number of days a year that an activity occurs
Ave Period = the number of days in a year (365)

Comparing the portion of the equations that differs demonstrates that both equations give the same result:

$$\frac{EF \times ED}{AT} = \frac{Exp}{Ave\ Period}$$

If for example, EF = 5 days/year and ED = 20 years, then AT = 20 years x 365 days/year in the EPA guidance calculation. In the 1991 Draft IR Report calculation, Exp = 5 days and Ave Period = 365 days. The resulting fraction given by both equations is 5/365.

(d) The surface water ingestion rate of 1.2 l/day for children swimming that was presented on Table 6-11 was adjusted in the spreadsheet calculations to account for the number of hours per day spent swimming. Therefore, the rate used in the risk assessment was correct. This will be explained and clarified in the risk assessment text of the draft final IR report and will be indicated on the tables and spreadsheets.

5. ***Page 4, Response 15:*** *Refer to comment on preceding page - page 1, response 13.*

   An assessment of risks due to contaminated ground water will be performed and included in the Phase II RI Report.

6. ***Page 5, Response 17:*** *The 100 mg/day ingestion rate for soil must be used and, therefore, the spreadsheets must be changed. A discussion in the narrative section of the report is insufficient. In addition, the zonal approach discussed in this response should be reiterated in the risk assessment text of the draft final IR report.*

   The Navy agrees to recalculate the spreadsheets using the recommended value. Use of the zonal approach will be discussed in the Phase II RI Report.

7. ***Page 5, Response 19:*** *There appears to be confusion with regard to the intent of this particular comment. EPA is concerned about the surface water ingestion rate reported, not the permeability constant. Please respond accordingly.*

   As stated for Page 4, Response 11(d), the surface water ingestion rate of 1.2 l/day for children swimming that was presented on Table 6-11 was adjusted in the spreadsheet calculations to account for the number of hours per day spent swimming. This will be explained and clarified in the risk assessment text of the draft final IR report and will be indicated on the tables and spreadsheets. The effect of using 4 hours per day as the time a child spends swimming rather than the 2.6 hours/day in the guidance is to provide a slightly more conservative assessment of risk.

8. ***Page 6, Response 23:*** *This response is inadequate. Were soils slightly below, at, and above the 15 foot depth included in the calculation of exposure point calculations?*

For the Phase II RI Report, we will check that soil samples from slightly below a depth of 15 feet (say to a depth of 17 feet) were used to calculate exposure point concentrations in areas where utilities may be buried at 15 feet. If such soil samples are available, they will be included in the calculations of exposure point concentrations for utility workers.

9. ***Page 7, Response 29:*** *The Navy's response indicates that there is some uncertainty with regard to the difference between exposure frequency, exposure duration or average time. EPA requests that the Navy submit complete equations and the parameters that were used for each calculation. The response for this comment clearly indicates that calculations for noncarcinogenic risks are incorrect.*

The calculations of non-carcinogenic risks were correct, but the explanation of these calculations that was given in response to EPA's comments of November 12, 1991 may not have provided enough detail. Please refer to the response to the comment (Page 4, Response 11(b)). The equations and parameters used will be presented in draft final IR report.

10. ***Page 7, Response 30:*** *As discussed at our February 13, 1992 meeting in Boston, the surrogate RfDs used by the Navy to calculate risk for compounds without RfDs are inappropriate for the reasons discussed below.*

The Navy claims that structure activity analysis was used for calculating surrogate RfDs. Current EPA guidance requires that the contractor submit all documentation supporting its proposed structure activity analysis approach to EPA's Superfund Technical Center (STC) in Environmental Criteria and Assessment Office located in Cincinnati, Ohio, through EPA Region I's risk assessor for approval prior to its use in performing a baseline risk assessment. This issue has been discussed with STC for the appropriateness of the surrogate RfDs assigned by the Navy. The STC has provided the Region with the technical papers for the provincial RfDs for the chemicals in question. A copy was sent to the Navy and its contractors. With the exception of methylnaphthalene, none of the information received to date supports the values presented in the draft IR report.

The use of incorrect surrogate RfDs does not make the baseline risk more conservative, rather, it misinterprets the risk. If the compound is already a carcinogen, the carcinogenic risk is more of a concern than the noncarcinogenic risk. The use of surrogate RfDs belies a degree of certainty that is misrepresentative to the reader and should not be inferred.

With regard to noncarcinogenic PAHs, it is EPA Region I's policy to use the verified RfDs on IRIS for noncarcinogenic effects. If the Rfd is not available, the HEAST annual FY 91 value of 4.00 E-3 mg/kg/day for naphthalene is to be used for all other noncarcinogenic effects of PAHs.

The spreadsheets will be re-calculated in the Phase II RI Report using only verified RfDs on IRIS. For non-carcinogenic PAHs that do not have verified RfDs, the HEAST annual FY' 92 value for naphthalene will be used. We pointed out during our discussions with EPA Region I that naphthalene was probably not an appropriate compound to use as a surrogate, based on available scientific data. However, we will conform to EPA Region I's request to use naphthalene as a surrogate.

11. *Page 8, Response 33: Refer to preceding comment - page 7, response 30.*

    Refer to response to preceding comment.

12. *Page 9, Response 34: Refer to preceding comment - page 7, response 30. In addition, these human health risk assessment issues must be resolved prior to the submission of the draft final IR report. Presentation of the "new CPF value for BaP" in the FS is unacceptable. EPA cannot review a draft FS until the outstanding RI (baseline risk assessment) issues can be resolved.*

    In addition, the 5.8 per kg/mg/day cancer potency factor for benzo(a)pyrene is for an oral route. It is inappropriate, therefore, to use this oral CPF or the old 6.1 per mg/kg/day inhalation CPF for an inhalation pathway.

    Refer to preceding comment regarding RfDs for noncarcinogenic PAHs - page 7, response 30.

    Refer to the response to Page 7, Response 30.

    In addition, the Cancer Potency Factors (CPF) for benzo(a)pyrene that are in IRIS at the time the report is completed will be used to calculate human health risks for the draft final IR report. If there is no benzo(a)pyrene CPF for the inhalation pathway, we will use the most up-to-date value in the HEAST tables. We will also discuss the implications of applying a relative potency approach for PAH compounds. This discussion will be part of the uncertainty analysis.

13. *Page 10, Response 35: EPA's comment addresses the inadequacy of deriving Rfd for lead from drinking water standards. In other words, the risk from lead exposure should be addressed qualitatively. As previously, this model should be used to estimate lead target cleanup levels in soil for areas with exposure scenarios where lead is an issue in the draft final IR report, not the FS.*

    We will use the IUBK model to discuss target cleanup levels of lead in soils. This information and the risks due to lead in soils will be discussed qualitatively in the Phase II RI Report.

14. *Page 11, Response 36: Please provide documentation that supports the Navy's finding that none of the RfDs or CSFs for the compounds of interest in this site have been changed. Has a comparison actually been conducted between the FY 90 and FY 91 HEAST?*

The values used for the Phase II RI Report will be the most up-to-date on IRIS or HEAST at the time the report is complete.

15. ***Page 11, Response 38:*** *Average time for the calculation of exposure dose for noncarcinogens is equal to exposure durations. It should be site-specific or 30 years. The Navy's response indicates that the calculations for noncarcinogenic risks are incorrect for this site. Whether the exposure duration is standard 30 years or site-specific, the average time should be the same as exposure durations for noncarcinogens. Please refer to EPA's guidance on human health risk assessment for additional information in regard to this matter.*

    As stated previously, the calculations of non-carcinogenic risks were correct in the draft IR report, but there was some confusion because it used slightly different terminology, particularly in regard to averaging time. Please refer to our response to Page 7, Response 29.

16. ***Page 11, Response 39:*** *The text of the risk assessment in the draft final IR report should include a discussion of the zonal approach.*

    A discussion of the zonal approach will be included in the Phase II RI Report.

RESPONSES TO EPA's COMMENTS ON ECOLOGICAL RISK ASSESSMENT

General Comments

1. *Overall, the response by the Navy to EPA comments pertaining to ecological risk assessment are adequate. It is obvious that further study of ecological impacts at this site is warranted, primarily in the Area A wetlands, downstream watercourses, and ponds along the Thames River.*

   Additional study of ecological impacts at this site are planned as part of a supplemental Step II work plan.

Specific Comments

1. ***Page 12, Response 42:*** *The discussion of potential ecological risk from environmental media at the CBU Drum Storage Area and OBDANE site should clarify the reference to "very low concentrations" and provide the rationale for excluding these sites from further ecological risk assessment.*

   The discussion of potential ecological risk from environmental media at the CBU Drum Storage Area and OBDANE sites that will be included in the Phase II RI Report will discuss what is referred to as "very low concentrations": and provide the rationale for excluding these sites from further ecological risk assessment.

2. ***Page 14, Response 49:*** *A recent site visit (March 31, 1992) to the downstream ponds and watercourses also found that these areas appeared barren and devoid of aquatic organisms (particularly in the lower pond). It is strongly recommended that a benthic invertebrate survey be developed and conducted within these areas in conjunction with the additional sampling efforts proposed for the Phase II RI work plan.*

   A benthic invertebrate survey will be developed and conducted in the Area A downstream ponds and watercourses as part of the additional sampling efforts proposed for the supplemental Step II work plan.

3. ***Page 14, Response 52:*** *It is hoped that with future consideration, the reason for the lack of species types and number associated with wetland A and downstream watercourses and ponds, will be addressed. A determination should be made, whether it be habitat requirement related or proven to be caused by contaminants, should be clearly assessed.*

   A survey of benthic and aquatic invertebrates will be developed and conducted in the Area A downstream ponds and watercourses as part of the additional sampling efforts proposed for the supplemental Step II work plan.

4. *<u>Page 15, Response 57</u>: Given that additional sampling is necessary in the areas concerned, the request for actual TOC determination to enhance the accuracy of the risk assessment seems reasonable. The questions of available data alluded to in the response could be eliminated in this manner.*

   The supplemental Step II work plan will include collection and analysis of pond, wetland, and downstream watercourse sediment samples for TOC.

5. *<u>Page 16, Response 59(b)</u>: The sampling location of the frogs allows for approximation of conditions in a small area of the actual wetland area. Further assessment should be conducted, not only in the Area A ponds, but in the downstream watercourses exiting from the wetlands area. This would provide a much better representation of the wetlands.*

   Sampling of additional aquatic receptors such as frogs will be included in the supplemental Step II work plan. This additional assessment will cover the ponds and downstream watercourses.

6. *<u>Page 17, Response 65</u>: Refer to above comment.*

   Sampling of additional aquatic receptors such as frogs will be included in the supplemental Step II work plan. This additional assessment will cover the ponds and downstream watercourses.

7. *<u>Page 19, Response 77</u>: The Navy's response only addresses terrestrial exposure assessment issues. Although it is acknowledged that at this time it may not be possible to assess every exposure, it would be appropriate to examine the other major exposure scenarios, i.e., surface water and sediment ingestion.*

   A qualitative discussion of other exposure routes for mammals, birds, and aquatic birds will be included in the Phase II RI Report.

NAVY'S RESPONSE TO EPA'S COMMENTS OF NOVEMBER 12, 1991 (MARCH 20, 1992)

NAVY RESPONSES TO EPA'S COMMENTS (NOVEMBER 12, 1991 ON DRAFT IR REPORT (AUGUST 1992)

SECTIONS 1.0, 2.0, 3.0, 4.0, 5.0, 8.0 & PRELIMINARY REMEDIAL TECHNOLOGY

General Comments

1. *Torpedo Shop: MW3, TB3 and TB4 locations are all shifted from the proposed plan.*

   The 7TB3 and 7MW3 locations were switched so the well could be located within the central portion of the septic system as a better screening of ground water quality. The 7TB4 location was slightly revised due to an elevated soil gas reading at SG15.

2. *Goss Cove: An upgradient well was proposed, but none was installed. Of all the borings and wells proposed, only TB-3 was installed at the proposed location.*

   An upgradient well could not be installed as proposed because bedrock was encountered and ground water was not present; it was replaced with a test boring. A bedrock well was outside of the scope of the Step I investigation. Although other well and boring locations were modified, the same spatial distribution of testing was achieved. Locations were changed predominantly due to utility and land development conflicts.

3. *Spent Acid Storage Area: GPR and probing of the tank was proposed, but results of those activities are not documented in the report.*

   The GPR testing was conducted in the area previously thought to be the underground tank; no tank was found and these results are provided in the Geophysical Report. Subsequent to the GPR testing, the actual tank was visually located in the field at the locations indicated in this report. One sample was collected from within the tank as described on page 4-47.

4. *Area A: Two soil samples were supposed to be collected from each of five borings, but only one was collected from MW7.*

   A soil sample was collected from 2LTB2, in an area of elevated soil gas measurement. A sample from 2LTB2 was not planned, and replaced one sample from 2LMW7.

5. *Area A Wetland: Two surface water samples were specified in the Plan of Action, but based upon review of the report, none were discussed in the report.*

   Refer to pages 2-33, 4-66 (Figure 4-16), 4-118, and 4-121 of the report, which indicate that two samples were collected.

6. *Area A Wetland: Five soil samples per boring were proposed for borings 2WTB1 to 2WTB8 (for a total of 40 samples), but only 24 were collected, according to Table 4-24.*

Boring 2WTB4 was located on a bedrock knoll within the wetland area, and only one sample was collected above the bedrock surface. Borings 2WTB7 and 8 encountered refusal prior to original planned depth, therefore, the number of samples were reduced. Several other borings encountered water and root matter in the 0 to 4 foot interval, therefore no samples could be collected.

7. *Area A Downstream: Only one surface water/sediment sample was collected at North Lake, rather than two as indicated in the Work Plan.*

The second sample planned for North Lake was relocated to a location near Triton Avenue to provide better coverage of that watercourse. Other Navy analytical data was available for North Lake which was used to assess the lake.

8. *DPDO (DRMO): The two battery storage area surface soil grab samples and eight of the proposed borings were not performed as specified in the Field Sampling Plan.*

The two surface soil samples (6SS3 and 6SS4) were collected; these locations were revised slightly based on site conditions. All borings proposed were completed at this site.

9. *Lower Subase: Of all the wells proposed, MW-1, 2, 3, 7, 10, 14 and 15 were placed in their proposed locations, the rest were not. Of all proposed ground water samples, sample WE2 was omitted. A 48-hour pumping test was proposed, but was not performed.*

The locations of most wells at this site were adjusted due to extensive utility conflicts in this area. Ground water sample WE2 was omitted because the well had been destroyed. A pumping test was proposed because it was anticipated that a product recovery system was likely required at this site. Based on the lack of measurable oil product encountered, this test was postponed and may ultimately be eliminated.

10. *The Navy indicated to EPA in the March 6, 1991 response to comments letter, that a study of tidal fluctuations was performed (comment DPDO 3, page 5). These results and the methodology used should be included in this report.*

The tidal cycle survey is discussed on pages 3-42 and 3-48 of the report.

Page Specific Comments

SECTION 1.0 - INTRODUCTION

1. *Page i, Table of Contents: Section 1.2.5.8 should indicate the Area A Landfill, Area A Wetland, and Area A Downstream Watercourse.*

   Section 1.2.5.8 of the report is Area A; the landfill, wetland and downstream watercourses are unnumbered subsections of 1.2.5.8, and therefore do not require inclusion in the Table of Contents.

2. *Page 1-1, ¶ 3: This paragraph should indicate that NSB-NLON was proposed for listing on the National Priorities List on October 26, 1989 and was listed on August 30, 1991.*

   The change will be made.

3. *Page 1-5, Section 1.2.3.1: Is there a map or a better definition of which areas of the base fall under the different ground water classifications?*

   A map can be prepared to delineate the ground water classification and included in the report.

4. *Page 1-6, Figure 1-3: A legend on this figure should be included to indicate current public water supplies.*

   The two water supply wells shown are current and active; a legend will be added for clarification.

5. *Page 1-7, Section 1.2.5: The report should indicate that five (5) sites were dropped from the IAS and the reasoning for their elimination.*

   The IAS identified 16 sites of potential contamination. The hazardous waste storage facility, the oily wastewater tank and the hospital incinerator, Sites 5, 9, and 16, respectively, were operational at that time and were dropped from the IR program. Since that time, Sites 9 and 16 have been taken out of service and will become a part of the study.

   Three lower base sites, the fuel oil storage tanks, the power plant oil tanks and building 79, waste oil pit, Sites 10, 11, and 13 respectively, have all been identified as one site, Site 13. The type of investigation required was the same for all of then and due to their close proximity it was determined to combine the investigation of these three sites into one.

6. *Page 1-9, Section 1.2.5.2: The approximate size of this site should be included in this text.*

The size of this site is approximately 15 feet in width by 30 feet in length. This will be added to the text.

7. *Page 1-13, Figure 1-7: This figure refers to both the north and south system leaching fields, but there is nothing in the text in Section 1.2.5.3 on page 1-12 which identifies these systems. Please clarify.*

The text will be clarified to provide approximate reference to these systems.

8. *Page 1-16, ¶ 1: This paragraph should include a brief statement when construction of the Nautilus Museum occurred.*

This will be provided.

9. *Page 1-21, ¶ 3: (a) This paragraph indicated that based on the IAS report, the landfill opened sometime before 1957. However, this office is in receipt of aerial photographs, one of which is dated April 10, 1957, copies of which have been forwarded to your office. Review of this aerial clearly indicates that there is no activity in the landfill area in 1957.*

The report will clarify that although the IAS report indicated landfilling prior to 1957, aerial photographs indicated a somewhat later startup date.

10. *(b) This is the first mention of the base incinerator. A very brief discussion of the incinerator should be included, e.g. location, type of wastes burned, etc.*

The incinerator was discussed in the IAS report, but a brief discussion will be provided in this report.

11. *Page 1-21, ¶ 5: The report provides information relative to a concrete pad. Is the pad still existing? Is the pad located at Building 373? This information should be provided in the report.*

The pad is still in existence. The pad is located adjacent and to the northeast of Building 373, and south of the dirt road that extends through the area.

12. *Page 1-21, ¶ 6: This paragraph should also make reference to information contained on page 1-3 in the Step IA Verification Study, namely, that "When a battery was overhauled, spent sulfuric acid solution was transferred to barrels and transported to Area A for disposal. The acid was pored into trenches dug with a bulldozer and subsequently covered with soil."*

This addition to the report will be made.

13. *Page 1-23, ¶ 1: As noted in a previous comment, review of the April 1957 aerials did not indicate any activity in this area. Also, is the approximate quantity of dredge spoils which were deposited in wetland known?*

The text will be revised to indicate disposal sometime in the late 1950s. There is no records of approximate quantity of dredged material. Estimates of the total volume of sediments in the wetland, based on the boring log information, is 1,170,000 cubic yards.

14. *Page 1-23, ¶ 5: During a previous site visit, the condition described in this paragraph relative to the potential for ground water from the stream to discharge to North Lake was examined. I had questioned the need for this overflow, since there exists another overflow structure on the southwestern corner of North Lake. It was felt that the possibility of water from the stream discharging to North Lake should be eliminated through the capping pipe.*

    This condition has been previously acknowledged and a recommendation will be added to Section 8.0 to provide for eliminating this overflow pipe.

15. *Page 1-38, last ¶: This section should also note that during the summer season, the water in North Lake is chlorinated.*

    This addition to the report will be included.

16. *Page 1-44, Table 1-6: A figure should be included to show the sampling locations at North Lake.*

    The exact locations of the previous Navy sample results is not known. The water/sediment samples were obviously collected from within the lake, which is rather small (less than 300 feet in diameter). The beach sand samples were collected from the beach on the east side of the lake.

SECTION 2.0 - SITE INVESTIGATION

1. *Page 2-2, ¶ 4: This paragraph states the detection limits for volatile organic and semi-volatile organic compounds using CLP methods are 1 ppb for aqueous samples. However, sample quantitation limits of 5 to 50 ug/L (ppb) are listed in Table 2-1. Although some analytes are detectable below these concentrations, it should be noted, that several analytes, notable vinyl chloride and substituted phenols, will likely not be detected at 1 ppb without significant modification to the method. Additionally, historical precision and accuracy data is not applicable to concentrations below the quantitation limit.*

   The report will be modified as follows:

   "Actual laboratory detection limits are in some cases lower than the CRQLs listed in Table 2-1 due to instrument capabilities. Values reported between this level and the CRQL are estimated by the laboratory."

2. *Page 2-2, ¶ 5: It is unclear whether the detection limits used in the risk assessment (non-detect samples) were those stated in this paragraph or those provided in Table 2-1 (page 2-3). In some cases, the difference in detection limits is an order of magnitude (i.e., 1 vs. 10).*

   Treatment of non-detects for the risk assessment is described in Section 6.1.1. Values used varied based on the media of concern and in some cases chemical constituents. CRQLs from Table 2-1, when available, where used in the risk assessment.

3. *Page 2-10, ¶ 1: This office was not able to review the results of the geophysical investigations, since this report has not been made available. It is recommended that the Navy provide this report to EPA for review.*

   This report will be provided.

4. *Page 2-11, ¶ 1: Soil gas calibrations for VOCs were performed using non-standard techniques which were not specified in the Plan of Action. Atlantic prepared calibration standard using either a benzene in air standard or a headspace standard of a mixture of components in water. The use of headspace aqueous mixtures is not advised. A standard mixture of volatile components in air should be utilized to calibrate the instrument for future soil gas investigations.*

   Samples were compared to headspace standards so data could be used qualitatively, i.e. compound identification be retention time comparison. Values provided for various components were used for purposes of relative quantitation, i.e., there is more VOC contamination at Point A than Point B. It was stated in the Plan of Action that headspace aqueous standards would be used. It was also stated that soil gas would be used as a screening tool for refinement of the boring program; this was accomplished. Per your request, Atlantic will utilize a wider range of compounds of interest in air during any future soil gas investigations at the Navy.

5. *An estimate of the approximate air concentrations (ppb v/v) of the aqueous headspace*

standards should be provided to EPA to allow a review of the data generated from soil gas surveys conducted to date.

This was not specified in the work plan and would not provide a significant contribution to the project at this time. Exception is taken to this request.

6. *This section describes the component identification and quantitation technique. This discussion should be expanded to describe how data from the quality control samples was utilized, including acceptance criteria for duplicates, background samples and calibration standards. The text should be expanded to include component identification criteria.*

Background and calibration blank samples were considered acceptable if no peaks were generated. Duplicate samples were judged subjectively due to the impossibility of collecting a soil gas duplicate with a great degree of precision. Acceptance criteria for standards do not exist because retention times and response factors are rate dependent. These are variable with a system that operates in different weather conditions and must be set-up and shut-down on a daily basis. Due to this, standards were run frequently, averaging one per five samples analyzed.

Since soil gas was used primarily as a screening tool, vigorous QA/QC was not undertaken. However, the QA/QC which was performed exceeded that stated within the work plan. Compound identification was made subjectively based upon a close match of retention times. Retention time windows have not been established due to potential fluctuations based upon weather and instrument flow conditions.

7. *The calibrants did not include either 1,2-dichloroethene isomers or vinyl chloride which are major degradation products of tetrachloroethane and trichloroethane. Since the latter were found at some of the sites surveyed, the impact of this omission on the reported soil gas data should be evaluated and discussed.*

The soil gas GC is used in the field as a rapid cost effective screenage tool. For this reason the GC parameters are set such that runs were not excessively long, without compromise regarding peak separation. Vinyl chloride would be an early-eluting peak and would come out too early to distinguish it form other, unknown, early-eluting peaks. 1,2-DCE would be very difficult to distinguish from 1,1-DCE, which was one of the standards used.

Generally speaking, vinyl chloride and 1,2-DCE are often found concurrently with solvent products, as indicated in sample 6TB4 (6-8) at DRMO. It is possible that the extent of solvents were not accurately delineated by soil gas due to the difficulty of detecting vinyl chloride and 1,2-DCE as described above. However, the primary goal of the soil gas survey was to find "hot spots" of contamination as a site screening.

8. *The last paragraph states that soil gas quantitation "...took all soil gas peaks into account." It is unclear whether peaks which did not match calibration standard retention times were also included in the reported concentration.*

Unknown as well as identifiable peaks were taken into account. This provided a simple

method for giving a total volatile organic vapor reading for each sampling point. However, very early-eluting peaks (pre-1,1-DCE) were not included due to the possibility of producing a falsely high soil gas hit due to natural rather than contaminant organics.

9. *Page 2-12: The relationship of peak area to analyte concentration (v/v in air) should be provided in addition to the absolute peak area and concentration classifications shown in the table at the top of the page. Assignment of an air concentration allows the data to be compared to that obtained at other Superfund sites.*

Refer to response for Item 5.

10. *Additionally, Appendix A should be revised to include all standard and sample chromatograms for the soil gas survey. This data should be provided to EPA to allow verification of the conclusions of the surveys.*

Atlantic will provide all sample and standard chromatograms to EPA. Due to the volume of this data, this information will be given to EPA and any other interested parties, rather than included in Appendix A. This information is provided to the EPA as Attachment 1 to these responses.

11. *Page 2-12, ¶ 6: The sentence states that <1 ½-inch hollow stem augers were used to drill soil borings, but does not state whether this dimension is inside or outside diameter. The difference is important in determining the drilled diameter for inputing slug test analysis models.*

The hollow stem augers used to drill soil borings were 4.25 inches inside diameter and had an outside diameter of approximately 8 inches. Appropriate modifications to the text will be made.

12. *Page 2-13, ¶ 3: The rationale for the selection of each subsurface soil sample sent out for laboratory analysis should be provided. It should be brief and possibly be supplied in table form.*

The rationale for selection of the subsurface soil samples for laboratory analysis are provided under the comment heading in the tables summarizing the soil sampling program in Section 2.0

13. *Page 2-23, Section 2.8: The following are general comments relative to the ground water investigation that was conducted at the NSB-NLON:*

    (1) *The fragmentation of ground water information according to individual sites or study areas creates confusion. It is recommended that the Navy approach the project by first looking at the base as a whole. Divisions within the base should be on the basis of the Northern Subase Watershed Area and the Central/Southern Subase Watershed Area (see Fig. 3-5) Then each site should be appropriately discussed in light of its location and impact on the watershed in which it exists.*

(2) *Consistent with the above comment on base and basin-wide approaches to the project, the ground water investigation (Section 2.8) would be greatly improved if ground water potentiometric surface maps were constructed for the base as a whole and for the individual basins. These maps should also include the following:*

(a) surface elevation data from ponds located within the mapped areas;

(b) ground water level data from wells located outside the base property; and

(c) plots of ground water divides (to determine whether the ground water divides coincide with the surface water divides.

Further discussion will be provided in the text regarding specific site locations within the two watershed areas. This will be based on known ground water flow direction supplemented with assumptions on ground water flow based on available topographic and subsurface geologic information. However, the Navy takes exception to developing a ground water flow map for the entire base, which would require significant additional data on ground water elevations, which we feel is not necessary to accurately characterize the investigations at the site. Further ground water monitoring wells are proposed for Area A and the Torpedo Shops, and for the Step I sites recommended for Step II investigation, which will further establish ground water hydrology and quality.

14. *(3) The Navy should install continuous water level recorders in the following areas:*

(a) in places along the borders of the base that may be within the areas of influence of nearby private wells; and

(b) in wells near North Lake to determine whether North Lake is a discharge area for contaminated ground water.

Further assessment of ground water flow has been recommended for Area A. These comments will be considered in the preparation of the Field Investigation Plant for this work.

15. *<u>Page 2-26</u>: The water level and bedrock elevations on this table should also be displayed using a contour map. If additional water level measurements were collected on subsequent days, these data should also be reported.*

Refer to comment 13 for this section and comment 2 for Section 3.0. In Atlantic's review of this table, several errors in bedrock elevation were noted which will be corrected. No other ground water measurements data have been collected.

16. *Due to the proximity of the NSB to the ocean, it is likely that variation in water level elevations occurs continuously throughout the day. The text of this report does not describe what efforts were made to quantify this behavior or to correct ground water elevation data for it.*

Refer to General Comment 10 on tidal survey. The only sites projected to have water level impacts due to tides are DRMO, Lower Subase, and Goss Cove. Our evaluations of the Lower Subase indicates tidal effects are limited to approximately 200 feet inland from shoreline.

17. *Page 2-27: The screen length and screened interval shown for well 2DMW16S do not agree. These values should be corrected.*

Upon review of the original boring logs, it has been determined that a ten foot screen was used in 2DMW16S and, therefore, the elevation of the top of the screened interval is 13.91 and not 24.91 as previously stated. A change to the report will be made.

18. *Page 2-29, ¶ 1,3 and 4: Boring log and well construction information has not been provided for the bedrock wells. Thus, refinement of the subsurface bedrock system beyond the U.S.G.S. reconnaissance mapping is apparently still lacking after this field effort.*

Bedrock core data have been added to the boring logs. Well construction details and boring logs have also been constructed for the deep bedrock monitoring wells.

19. *Page 2-29, ¶ 2: (a) This paragraph states that all overburden monitoring wells were completed with a sand pack around the screen below a bentonite seal. However, six wells at the lower subase, 13MW8, 9, 15, 16, and 17 were all completed with backfill around the screen without a clay seal, according to the logs (despite the fact that the soil was contaminated). Atlantic provides no explanation for this deviation in the text of the report.*

These wells were installed in existing "sand manholes". They were installed in accordance with the detail provided in the Appendix to the FSP.

20. *(b) Although we understand the need to accurately define the water table, we disagree with the Navy's approach of screening wells over several stratigraphic units (e.g., 7MW3S). Future screens should be set to characterize individual stratigraphic units. We do not see why well screens can not be smaller than 10 feet.*

The well screen was set to provide a general screening of water quality in the water bearing stratigraphic units. The comment will be considered in future field investigations.

21. *Page 2-29, ¶ 3: The procedure for drilling bedrock wells should describe the criteria for when drilling ceased.*

Bedrock drilling continued until a sufficient water bearing fracture was encountered. A flow rate of approximately one gallon per minute or greater was considered adequate flow.

22. *EPA typically discourages the use of mud rotary drilling, especially through intervals in which a screen will be placed (e.g., an adjacent overburden well). The text should indicate whether mud was utilized through screened intervals in the well being installed or adjacent wells.*

This issue was addressed in the Navy's March 6, 1991 response to EPA's comments on the POA. The text will be clarified as follows ..."The mud rotary technique was used to maintain the opening in the overburden to allow the placement of the bedrock casing. The mud did not come in contact with the open hole within the bedrock and will not have any impact on the water quality. The shallow wells were not installed directly adjacent to the bedrock wells and, therefore, the mud should not affect the water quality."

23. *Page 2-29, ¶ 7: The text states that bedrock wells were developed using compressed air, but that two wells were developed with a submersible pump. The reason for the different development method should be stated.*

Due to low flow rates realized during drilling, a submersible pump was used to develop two of the bedrock wells; compressed air development of these wells would not have been effective.

24. *Page 2-30, ¶ 6: The text states that for the purpose of evaluating bedrock well slug test data, the saturated thickness of the bedrock aquifer was assumed to be 150 feet. Later in the document (p. 3-16, ¶ 1), the explanation for this assumption is that the average depth of most residential wells is 150 feet. This assumption is not necessarily correct. Most residential wells are only drilled to sufficient depth to establish the minimum necessary production required or the dwelling supplied by the well. Productive fractures often lie deeper; therefore, a 150 foot limit on bedrock aquifer thickness is probably not valid.*

Field observations, driller's experience, and several studies indicate that water-bearing fractures in crystalline bedrock in Connecticut tend to become tighter and more widely spaced with depth (USGS, 1968). The USGS indicates that there is only a slight probability of encountering a significant water-yielding fracture at rock depths greater than 200-250 feet (USGS, 1968). Therefore, the average saturated thickness of 150 feet used seems reasonable. Since the transmissivity is equal to the product of the hydraulic conductivity and the thickness, increasing the assumed average saturated thickness of the bedrock from 150 feet to 250 feet would increase the transmissivity proportionally.

25. *The description of hydraulic conductivity test procedures does not explain why a drilled radius of 0.25 feet (3 inches) was used in the hydraulic conductivity calculations. Since the report had previously stated that the auger diameter was 4.5 inches (presumably inside diameter), the auger outside diameter is probably at least 8 inches and probably larger.*

The well radius (r_w) was corrected from 0.25' to 0.33'. The table in Appendix D and the drawdown versus time graphs were modified to reflect this correction. In addition, if the casing radius (r_c) required adjusting in the hydraulic conductivity calculation, the valve was changed from 0.15' to 0.19' as a result of the r_w correction.

26. *(b) On this page and Appendix B, the numerical raw data needs to be provided for the hydraulic conductivity tests.*

Copies of the original time-drawdown data have been made for each well tested.

27. *Page 2-31, ¶ 2: The text should indicate the minimum time interval between well development and ground water sampling.*

The minimum time interval between well development and ground water sampling was two weeks as stated in the original Plan of Action. This addition to the report will be made.

28. *Page 2-31, ¶ 3: (a) This paragraph indicates that samples for metals analysis were field filtered. No mention is made here or in other sections of the report of collection and analysis for total metals. All data reporting tables throughout the report should be relabeled to show that results represent dissolved metals only. Future investigations, designed to collect risk assessment quality data, should include analysis for total metals.*

All analysis was conducted per the Plan of Action. This comment will be considered for future ground water analysis.

29. *(b) Future ground water sampling events should utilize an interface probe in all wells prior to purging.*

Prior to the extraction of any ground water, the depth to water was measured to the nearest 0.01 feet using a Solinst electronic water level indicator. At the Lower Subase, where oil was an issue, product thickness measurements were made.

30. *Page 2-41: DQO Level 4, as defined by EPA RI/FS guidance can only be achieved by applying EPA guidance for data validation. The latter is provided in the November 1, 1988 revision of the "Region I Laboratory Data Validation Guidelines for Evaluating Organics Analysis."*

EPA data validation requires verification of a percentage of sample calculation from the analytical raw data. This verification is not required by NEESA Level C validation. Since EPA requires data used in risk assessments to satisfy Level 4 DQOs, additional validation of the reported analytical data is necessary.

DQO Level IV was not defined as the level of QA/QC for this site. Navy Level C (DQO Level III), as defined in the NEESA document "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program," was chosen for all work on this site, as specified in the Plan of Action. Additionally, DQO Level C does not produce the necessary laboratory forms for Level IV validation, thus Level IV validation is not achievable using current laboratory data packages.

Regarding the DQO level required for risk assessments, the EPA document entitled "Data Quality Objectives for Remedial Response Activities" dated March 1987 states in Tables 4-3 and 4-4 that DQO Levels III, IV, or V may be used for risk assessment purposes. Since Navy Level C is equivalent to EPA Level III, the level of QA/QC performed for this project is sufficient for risk assessment purposes.

31. *The last paragraph in Section 2.11.3 refers to completed data review checklists which supply sample-specific validation information. These completed checklists are not provided in*

Appendix C, as implied. Data evaluation summaries, listing specific data qualification actions taken for all analysis, should be prepared and submitted to EPA as part of the data validation process. Additionally, data quality tables should be prepared to summarize all surrogate and matrix spike recovery data, all field duplicate and laboratory duplicate data and all field blank data.

A separate appendix summarizing all validated analytical results should be prepared. Additionally, a second data summary appendix, sorted by site and medium, should be submitted. Together with data validation summaries, these two appendices should provide sufficient data for EPA to verify the values presented in risk assessment tables.

The first sentence of Section 2.11.3 has been changed to "A checklist was developed to facilitate the review of analytical data reviewed under Navy Level C requirements (DQO Level III)." There was a mistake in the NEESA document used to develop QA/QC requirements for this project in correlating Navy to EPA QA/QC levels.

Atlantic has provided complete checklists for each data package and the associated validated Form I sheets for each sample to the USEPA as Attachment No. 2 to these responses. Analytical data by site and media is provided in the report. Further summaries of the validated data cannot be provided.

32. *The DQOs listed in Section 2.11.4 are not consistent with those provided in Appendix C. For example, the DQO for precision is listed as 20 percent difference in Section 2.11.4 and as 30 percent (aqueous samples) and 50 percent (soil samples) on page 11 in Appendix C. Similarly, accuracy objectives in Section 2.11.4 do not correspond to those in Appendix C.*

The report will be corrected as follows: "Precision is considered acceptable if the relative percent difference (RPD) between two duplicate samples is within ± 30 percent (aqueous samples) or ± 50 percent (soil samples)."

Although the QA/QC plan states ± 20, this was not correct and is not consistent with the Data Validation checklist. "This correction will be made in both Section 2.11.4 and Appendix C."

Atlantic was unable to see inconsistencies between accuracy objectives in Section 2.11.4 vs. Appendix C.

33. *Page 2-43: The derivation of the completeness for the investigation should be expanded either here or in Appendix C to allow for independent verification of the reported percentage. The number of valid results based on surrogate, matrix spike and duplicate data should be itemized.*

This can be provided.

SECTION 3.0 - CHARACTERISTICS OF STUDY AREA

1. *Page 3-2, ¶ 3: In discussing SCS soil descriptions, the text should state that 1) SCS soil grain size ranges are different from those used in geological and engineering practice; 2) SCS descriptions are only based upon the first five feet of soil from the surface; and 3) descriptive permeability ranges for a given soil type correspond to specific numerical values.*

   The report will include the suggested comment.

2. *Pages 3-5 and 3-6: With regard to Sections 3.3 Bedrock Geology and Sections 3.4 Surficial Geology, the following should be undertaken:*

   (a) construct larger scale base-wide and watershed maps of the surficial and bedrock geology based on literature and observations (including boring log information); and

   (b) the bedrock map should include:

   (i) topography of the bedrock surface. For example, the description on p. 3-27 (2nd para. from bottom) is not adequate characterization of the complicated bedrock surface in the area of the Area A and the OBDA;

   (ii) symbols that identify the orientation of joints and fractures in the bedrock outcrops; and

   (iii) the location of wells and borings.

   We do not feel that developing a larger scale base-wide bedrock contour map and surficial geology maps is necessary. This would require significant additional field investigation to characterize bedrock elevation and subsurface conditions which we feel is not required to adequately characterize the sites under study.

   An approximate bedrock contour map of Area A and adjacent areas, including Torpedo Shop, OBDA, CBU, OBDANE, and Bunker A-86 will be developed from the available data. Existing data on orientation of joints and fractures in bedrock outcrops will be provided on this map. This map will be at the same scale as the Plates provided in Section 3.0.

3. *(c) Important hydrogeologic features of the site should be labeled on all maps and cross-sections.*

   Please clarify what you consider important hydrogeologic features.

4. *Page 3-9, Figure 3-4: This figure needs to be clarified with respect to ground moraine deposits which appear as both stippled and hatched areas, some of which are adjacent to each other. Also, no description is present in the legend for the latter deposit.*

A legend which describes the hatched area as bedrock was provided on Figure 3-4. With regard to the comment on ground moraine deposits, the map will be revised with respect to a misplaced label.

5. *Page 3-12, Section 3.6: (a) The use of the term "obtained" is unclear. This sentence should simply state that ground water is "present" in stratified drift, till and bedrock.*

The report has been changed to reflect the requested wording change.

6. *(b) The fine-grained stratified drift aquifer appears to be a major site feature. Therefore, the following needs to be mapped:*

   (i) the edges of the aquifer;

   (ii) the thickness of the aquifer;

   (iii) the former location of Crystal Lake;

   (iv) the locations of wells within the aquifer; and

   (v) ground water potentiometric surface and flow directions.

A map from existing published sources showing Items i - iv will be provided. Data on Item v, beyond what is known for the site studied as part of this investigation, is not known. Refer to Section 2.0 Comment 13.

7. *Page 3-12, Section 3.7: The following are general comments of items that appear in this section:*

   (a) the bedrock surface is mapped in many cross sections as the point of auger refusal. The text and cross sections should note that refusal does not necessarily mean that the top of bedrock was encountered;

   (b) a key needs to be provided for the lithology symbols used in the boring logs and cross-sections;

   (c) the cross-section views should also indicate the water elevations in the wells and the interpolated water table surface; and

   (d) the cross section lines in map view should connect the actual boring points because the areas represented in the cross sections are in many cases different from the line drawn.

The requests for Items a, b, and c will be complied with. Regarding Item d, a review of the cross-sections will be made and any changes regarding horizontal scale differences will be addressed.

8. *Page 3-12, Section 3.7.1 Torpedo Shops: (a) In the first paragraph on page 3-15, borings should be undertaken to determine the contact between the Mamacoke Fm and the Sterling Plutonic Group. This contact may be fault-controlled and may be a preferred pathway for migration of contaminated ground water.*

This suggestion will be considered for further investigation at this site.

9. *(b) A boring log or a monitoring well construction detail not provided in the Appendix for well 7MW1.*

A boring log providing well construction details will be provided for 7MW1.

10. *(c) The text in the third paragraph on page 3-15 states that Atlantic personnel measured the bedrock outcrops at the torpedo shop. The measurement locations should be posted on the site map. The measurement data should be included in the report appendices.*

This data will be provided in the appropriate report figures.

11. *(d) The text appears to omit a description of the western part of the site. Here the boring log data indicates a discrepancy where silt and sand deposits overlie sand and gravel deposits at boring 7TB1 rather than reversed as shown in boring logs for 7TB2 and 7MW2S and the cross section of Figure 3-7. This discrepancy further questions the actual presence of the predominant sand and silt deposits shown to exist between 7MW2S and 7TB5 in Figure 3-7.*

Upon review of the logs and cross-sections of this area, it has been concluded that the logs and cross-sections represent the actual field conditions. The boring and well locations for this area primarily exist within areas of fill (i.e., septic system leachfields), which may be the primary reason for the apparent reversal of data. The soils were not described as fill in the borings logs or cross-sections unless there were distinct features (i.e., wood, glass, etc.) that positively identify fill.

12. *(e) The boring log for 7MW3S is not consistent with the cross section view (Fig 3-7).*

A change to the cross-section will be made to separate the fine sand units from the fine to medium sand unit.

13. *(f) The drainage swale is a significant hydrogeologic feature in the torpedo shops area and should be included in the cross section view (Fig 3-7).*

The drainage swale will be shown on the cross-section.

14. *Page 3-24, Section 3.7.5 Area A and OBDA: (a) On page 3-27, ¶ 5, this paragraph describes cores drilled in selected bedrock wells at Area A. Appendix B provides no descriptions of these cores, other than the interval cored. A complete log of the cored interval should be included as a standard of the boring log so that the log can be compared to the description in the text.*

The core descriptions will be provided for applicable bedrock monitoring wells.

15. *(b) On page 3-27, ¶ 6, this paragraph discusses bedrock topography based upon boring data at Area A. Atlantic should prepare a bedrock topography map based upon well control, geophysics, and rock outcrops.*

As stated in Comment 2 of this section, Atlantic will prepare a bedrock contour map for Area A. Note that the geophysical surveys were not designed to assess bedrock elevation.

16. *(c) On page 3-27, ¶ 7, the text states that Atlantic personnel measured the bedrock outcrops at Area A. The measurement data should be included in the report appendices. The paragraph has no discussion of how these measurements tie into know data on rock structure in this area, or whether the joints in the outcrops show any correlation to foliation orientation, as fractures in the cores described in paragraph 5 seem to do.*

The measurement data will be included in the report. Dip angles measured in core fractures did not consistently correlate to dip angles measured in bedrock outcrops in Area A. Although there are no general trends linking the bedrock outcrops to the core data, the dominant core fracture dip angles were 45°.

17. *(d) In Figure 3-16, the north arrow on this figure is rotated approximately 44 degrees east of its actual orientation. Bedrock joint strike and orientations plotted on this figure therefore may not be correct and should be checked.*

The north arrow on the figure will be corrected. The bedrock joint strike and dip orientation are correct.

18. *There are many more bedrock outcrops in the area which should be surveyed for fracturing and jointing orientations.*

This comment will be considered for future work efforts in this area.

19. *(e) In the second paragraph on page 3-33, Figure 3-4 does not clearly show the features described here. Again, basin-wide geologic maps would be very useful.*

Refer to Comment 2 of this section.

20. *(f) The following two comments are relative to Figure 3-18 and Appendix B:*

    (1) the locations of auger refusals at shallow depths should be re-drilled a few feet away before that location is exited. For example, boring 2WTB4, located in a difficult area in the center of the Area A Wetland, was drilled only to 0.83 feet. No effort seems to have been made to confirm whether this refusal was a local anomaly (e.g., a boulder).

On occasion auger refusal was reached at relatively shallow depths; it was standard

practice for Atlantic personnel to relocate the boring and attempt to drill several feet away from the original location. If refusal was again shallow, the boring would have would have been relocated until the hole was properly advanced, or it was determined that the original hole was representative of actual conditions and not a local anomaly. This procedure was followed at 2MTB4.

21. *(2) the draft report should explain the rationale behind the placement of approximately 25 feet of sand filter pack material below the well screen in 2LMW9S. The representativeness of the data collected from this well is likely to be very uncertain.*

Data for 2LMW9 was incorrectly entered into the boring log program (i.e., wrong fill pattern was given, etc.). Upon review of original field log book, it has been determined that bentonite was used to seal the hole below the sand pack in 2LMW9S. The boring log will be revised.

22. *(3) cross-section B-B' would better represent conditions if the following were done:*

(a) 2LTB5 was not utilized because this point creates the illusion of an undulating bedrock surface which may not exist.

(b) 2LTB1 should be utilized, since it is actually located on line B-B'.

However, it is recommended that cross-section B-B' be redrafted along the line of borings labelled 2LMW13S, 2LMW13D, 2LMW9S, 2LMW13D, 2LTB1, 2WTB1, 2WTB6 and 2WTB7.

Based on EPA's recommendation, cross-section B-B' will be redrafted to include 21MW13S, 13D, 2LMW9S, 2LTB1, 2WTB1, 2WTB6 and 2WTB7.

23. *(g) The following comments are relative to Figure 3-19 on page 3-32.*

(1) In cross-section C-C' on page 3-32, data from 2LMW7 (approximately 120 feet away from line) is used rather than 2WTB2 (approximately 20 feet away from line). The hydrology varies between these points, for example:

(a) fill is absent at 2WTB2 while 2LMW7 identifies 16 feet of fill.

(b) topsoil is identified below the dredge spoil at 2WTB2, yet this top soil is absent at depth at 2LMW7S.

Refer to response to Comment 24 below.

24. *(2) In cross-section C-C' and the text both 2LTB3 and 2LTB1, which are located between 2LMW7 and 2LMW9, encountered refusal at 66.6 feet MSL and 64 feet, respectively, while 2LMW7 encountered bedrock at 53 feet MSL and 2LMW9S encountered refusal at 42.5 feet MSL. Either the cross-section conceptualization is incorrect or refusal within the dredge*

spoil cannot be assumed to be the top of the bedrock.

Cross-section C-C' will be reconstructed and will include the following borings:

The borings 2LTB3 and 2LTB1 are not included in the cross-section C-C'. It is assumed that refusal for these two borings must have been on large boulder fill and not bedrock, therefore, cross-section C-C' does indicate a deeper depth to bedrock between 2LMW7 and 2LMW9.

25. *(3) Boring 2LMW9S identifies several units below the dredge spoil which strongly suggest the presence of fill rather than "natural" sand and gravel. Cross-section C-C' should reflect this condition.*

Cross-section C-C' will be revised to address this comment.

26. *(4) The use of 2MW16 next to 2MW15 in cross-section C-C' may be misrepresenting the local geology in light of the topographic high between the two borings.*

Boring 2WMW16 will be removed from cross-section C-C'.

27. *Page 3-35, ¶ 1 A rationale for the procedure used to measure ground water elevations in offsite wells needs to be provided. Why was an initial measurement taken, the well pumped, remeasured and the lowest measured used?*

The lowest well measurement (lowest elevation) was used because this represents a worst case condition with respect to ground water gradient from offbase wells to on-base wells (e.g., does well drawdown create a condition where on-base ground water contamination could migrate to offsite wells). This explanation will be added to the text.

28. *Page 3-36, ¶ 1 (a) Vertical head gradients are discussed in this paragraph, but no calculations are included in this report. The text mentions a ± 1 foot upward gradient in one case, but it is not clear if the 1 foot is the head difference between the two wells or a gradient of + 1 ft/ft.*

The text will be changed to reflect that the ± 1 foot upward gradient is more accurately a ± 1 foot vertical head difference.

29. *(b) We don't believe that one round of ground water elevation is sufficient to conclude that bedrock ground water does not discharge into North Lake. Continuous recorders should be installed at the 2DMW16 wells in addition to head measurements in North Lake to determine ground water/surface interactions between North Lake and the ground water system.*

This comment will be considered in the development of the plan for additional work in Area A. We may elect to manually collect water level measurements on a pre-determined time interval and duration.

30. <u>Page 3-38, 39</u> *These two cross-sections, which intersect at 6TB3, do not match. 6TB3 has different stratigraphy in each cross-section and for other wells, the stratigraphy is incomplete. For example, silt and clay on the logs is shown as sand and silt on the cross-section. The length of cross-section B-B' in Figure 3-23 is 565 feet, but the cross-section line in Figure 3-21 is 458 feet.*

The cross-sections will be revised to further separate the units. The horizontal scale on the cross-section B-B' will also be revised.

31. <u>Page 3-40, ¶ 5</u> *A review of the abbreviated single well pumping test for well 6MW2 shows that the well was not pumped long enough to get meaningful data. The transmissivity was calculated from early time data only (0.001 minutes to 10 minutes). However, review of the semi-log plot shows that the rate of drawdown increased after ten minutes. This delayed yield is usually due to dewatering effects in an unconfined aquifer, thus early time data is not representative of overall aquifer conditions. Had the pumping test been run out to 1000 minutes instead of 62 minutes, a greater Δs for use in the time-drawdown analysis would have been calculated.*

By using the Δs for the data from 10 to 62 minutes, a T of 1058 ft^2/day and a K of 53 ft/day can be calculated using the time-drawdown method. This result is much closer to the textbook value of 50 ft/day that Atlantic ultimately relies on for their estimates of flow velocity and aquifer discharge to the Thames River. In reality, had the pumping test been run to 1000 minutes, the drawdown data would have to have been corrected for the effects of an unconfined aquifer or the time-drawdown method would not have been a valid analysis.

The comment is noted, however, no changes to the report appear to be required.

32. <u>Page 3-41</u> *Given the massive bedrock outcrop and rapid elevation change east of the railroad tracks, the elevation 2 foot and especially the 3 foot contour (above ground elevation 70) in the overburden aquifer shown in this figure are suspect and should be reviewed.*

Upon review of Figure 3-24, it is apparent that the contours on this figure should be revised. The contours will be changed to more accurately follow topography.

33. <u>Page 3-42, Section 3.7.7, Lower Subase</u> *With regard to this section, the construction of wells with backfill filter packs in wells 13MW8, 13MW9, 13MW15, 13MW16, and 13MW17 deviates from the April 1989 Final Plan of Action (Appendix B) and description of work in the Draft Report (i.e., the "clean washed Ottawa sand" p. 2-29, 2nd para.). The rationale for this deviation needs to be provided.*

Refer to Comment 9 in Section 1.0. Sand manholes are constantly being replenished with sand due to washout underneath the bulkhead. Therefore, if a sand pack was used during installation of the monitoring well, it would have only been a temporary condition facing eventual washout.

SECTION 4.0 - NATURE AND EXTENT OF CONTAMINATION

1. *Page 4-2, ¶ 4 The statement for ARAR and TBC using arsenic as an example is inappropriate.*

This paragraph merely explains the rationale for selection of values to be included in Table 4-2. Atlantic feels its inclusion is necessary to explain Table 4-2. Table 4-2 is a summary table, which Atlantic prepared to show the values of chemical-specific ARARs. In any particular site the procedures described Appendix D must be used. This specific characterization will be made in the feasibility study after remedial action objectives and general response actions have been developed.

2. *Page 4-2, ¶ 6 The use of the published background values for inorganic concentrations in soil is not acceptable. The reference cited includes background concentrations calculated from the entire Eastern United States. All efforts should be made to obtain actual samples for the determination of background values. The objective of this is to analyze "clean" samples specifically associated with the site. The use of USGS survey information may be used as a last resort only.*

A wide range of inorganic concentrations are found throughout the region, as soil types and bedrock geology varies. Furthermore, use of the "95 percent value limit" as a typical background concentration is not reasonable; this implies the assumption that subase soils, in the absence of site-specific contamination, have some of the highest inorganic concentrations found in the Eastern United States. Uncontaminated local background samples should be collected.

These values were used for illustrative and comparative purposes. Even if we complied with this request, it would not affect the conclusions of the study with respect to human health or environmental impact. Actual metals concentrations were used in these assessments and in the calculation of risk. We would propose to add a discussion to indicate that actual background concentrations at this site are less than the USGS published values.

3. *Page 4-3 These tables on ARARs are currently being reviewed by the Office of Regional Counsel.*

Noted. When is the Office of Regional Counsel going to submit their comments?

4. *Page 4-3 This table would be more useful if it contained citations for each requirement. At this stage of the investigation, the Navy should be able to explicitly reference specific citations for sites especially for chemical- and location-specific ARARs. The broad references to regulations will make it difficult to determine which aspects of each regulation is ARAR/TBC criteria.*

The notes section at the end of this table will be revised to show explicit statute or regulation citations.

5. *A number of these ARARs should also be included in the action-specific listing if they apply to the use of technologies and allowable discharge/emissions limitations (i.e., CAA, NESHAP, etc.).*

We had grouped federal ARARs as presented in Part II of the CERCLA Compliance With Other Laws Manual, however, we agree the NESHAP requirements should be listed as action specific ARARs. NPDES and NSPS are presently listed as action specific ARARs.

6. *It is unclear why the RCRA Solid Waste Standards are categorized as "Not ARAR" instead of "Potential ARAR". Appendix D states that Bunker A-86 is one of six areas which contain solid waste. Similarly, it is also unclear why this table categorizes the Federal RCRA UST Standards and state UST regulations as "Not ARAR". Again, Appendix D (Page D-2) states that the Torpedo Shops site is one of three sites that contain underground petroleum storage tanks. This table should be corrected accordingly to reflect the status of ARARs as explained in Appendix D.*

Agree, tables will be revised. See response No. 10 below for further explanation regarding UST standards.

7. *The Toxic Substances Control Act (TSCA) should be categorized as "TBC" for the Torpedo Shops since PCB contamination has been detected in this area.*

Agree, table will be revised. TSCA standards where not originally characterized as a potential ARAR as no TSCA regulated PCB items are known to have been present at this site.

8. *Page 4-3 The analytical methods utilized for this study do not provide aqueous detection limits suitably low for several of the ground water ARARs or TBCs listed in Table 4-2. Of particular concern are the volatile organics vinyl chloride, benzene, chloromethane and 1,2-dichloroethane and several semi-volatile organic polynuclear aromatic hydrocarbons (PAHs).*

The April 1989 Final Quality Assurance/Quality Control and Data Management Plan, prepared for the Navy by Atlantic, provided a summary of analytical methods in Table 5-5. The table listed EPA's "Methods for Determination of Organic Compounds in Finished Drinking Water and Raw Source Water" in addition to EPA "SW-846 Test Methods for Evaluating Solid Waste" as methods to be employed in addition to the CLP SOW protocol. The EPA drinking water Method 524.2 and SW-846 Method 8310 provide aqueous detection limits more appropriate to the study objectives than CLP methods.

Refer to comment #26 in Section 2.0. The suggested revised laboratory protocol will be incorporated into future sampling at this site.

9. *Page 4-4 For presentation purposes, it is recommended that the Navy separate Area A and OBDA as discussed in previous discussions. This column is misleading when, for example, TSCA is considered TBC for Area A but not for OBDA.*

Atlantic does not feel this distinction is necessary. For presentation purposes OBDA was considered to be part of Area A Downstream, and the Area A wetland and landfill were presented as separate areas.

10. *Page 4-7 It is unclear why the Navy categorizes federal RCRA and state UST Standards as "Not ARAR" for the Torpedo Shops. Appendix D states (1) (Page D-2) that the Torpedo Shops site contains underground petroleum storage tanks, and (2) (Page D-14) the Naval Installation Program does address oil and petroleum contamination.*

Agree, table will be revised to show UST standards as potential ARAR. The UST standards were not originally characterized as a potential ARAR as there is no evidence of petroleum contaminants from the UST, and no remediation under UST regulations is anticipated.

11. *It is also unclear why the Navy categorizes the federal RCRA and state Solid Waste Regulations as "Not ARAR" for the Rubble Fill at Bunker A-86, and why the Navy categorizes the state Solid Waste Management Regulations as "Potential ARAR" for the CBU Drum Storage Area. These categorizations are not consistent with discussions in Appendix D which state that these regulations are potentially applicable for the Bunker A-86, and not applicable for CBU Drum Storage Area. This table should be corrected to reflect discussions in Appendix D.*

Agree, table will be revised to reflect discussions in Appendix D.

12. *It is unclear why the Navy categorizes the PCB Regulations under TSCA as "Not ARAR" for the Torpedo Shops Site. Appendix D (Page D-15) states that "It is believed that the PCB contamination in Goss Cove, DRMO, and Area A Landfill resulted from the storage of transformers containing greater than 50 ppm of PCBs. At the Torpedo Shop, the source of PCBs is unknown." Since these standards regulate the disposal and cleanup of PCBs, the Navy should include the federal PCB regulations as ARAR.*

See Atlantic's response and Comment 7 in this section. TSCA should only be listed as a TBC at the Torpedo Shops, as the regulations adopted under TSCA regarding PCBs (40CFR 761) only apply to PCBs in concentrations above a specified level (40CFR 761.1(b)). There is no evidence that there are any items at the Torpedo Shop above the specified level. Clean-up standards under TSCA regulations (40CFR, Part 61, Subpart G) are only policy guidelines and therefore can not be classified as ARARs.

13. *The Navy should also categorize the Connecticut Siting Council Hazardous Facility Siting Regulations as "Potential ARAR" for all sites since the need for construction of any new hazardous waste disposal facilities has yet to be determined.*

The regulations are only applicable to hazardous wastes as defined in these regulations. For sites that do not contain hazardous waste, these statutes are not potentially ARARs. Only sites that contain hazardous waste should have these regulations listed as potential ARARs. As stated in Appendix D, these sites are Lower Base, DRMO, and Spent Acid Storage and Disposal.

14. <u>Page 4-9, Table 4-2</u> *The following revisions are necessary relative to ground water:*

(1) Barium has a proposed MCL and MCLG of 2000 ppb.
(2) Cadmium has a final MCL and MCLG of 5 ppb.
(3) Chromium has a final MCL and MCLG of 100 ppb.
(4) Copper has a proposed MCL and MCLG of 1300 ppb.
(5) Lead has a final action level of 15 ppb based on treatment technique. FR. (Vol. 56, No. 110, 6/7/91).
(6) Silver does not have a final MCL.
(7) Gross Alpha MCL is 15 pCi/L.
(8) Chloroform does not have a final MCL.
(9) 1,2-Dichloroethene has a final MCL of 70 ppb.
(10) Ethylbenzene has a final MCL of 700 ppb.
(11) Tetrachloroethene has a final MCL of 5 ppb.
(12) Xylene has a final MCL of 10000 ppb.
(13) Endrin does not have a final MCL of 0.2 ppb.
(14) Methoxychlor has a final MCL of 40 ppb.
(15) PCBs should be corrected to PCBs.

Due to recent changes in the federal drinking water regulation, Atlantic agrees that several of the above listed values should be listed in Table 4-2 with the following exceptions based upon State of Connecticut Drinking Water regulations where they are more stringent: barium = 1,000 ppb, chromium = 50 ppb, copper = 1000 ppb, silver = 50 ppb, gross alpha = 5 pCi/L, chloroform (total trihalomethanes) = 100 ppb, endrin = 0.2 ppb.

15. <u>Page 4-9, Table 4-2</u> *The additional revisions to this table are necessary:*

(1) Soil does not have chemical-specific ARARs or TBCs. It is not understandable why the same number presented as ARARs for ground water are also presented as TBCs for soil for some compounds. Also, the values presented for PCBs and dioxin and TCLP values for some compounds may be action-specific rather than chemical-specific ARARs and TBCs.

The soil TBCs were based upon written guidance that the State of Connecticut has developed; see page D-8 of Appendix D for further explanation. To the extent that these values have been used as clean standards at sites throughout Connecticut, they should at least be considered in selection of a final remedy. However, we agree that it is unlikely that these values will become remedial action objectives.

16. *(2) What is the purpose of listing marine AWQCs for inland surface waters?*

The Thames River is a marine estuary not an inland surface water.

17. *(3) It is not appropriate to compare AWQC to ground water.*

EPA guidance (EPA/540/G-89/006) states that water quality criteria adjusted to reflect only exposure from drinking the water may be useful in selecting a cleanup level when

a promulgated MCL does not exist. This adjustment generally does not substantially change the AWQC value. However, the table will be revised to use corrected AWQC values regarding ground water for consideration when an MCL has not been promulgated.

18. *Page 4-16 References to ARARs should include dates, since these are updated regularly.*

Dates will be added to the references in the notes section at the end of the table.

19. *Page 4-18, Section 4.5 (a) In the 3rd paragraph, the values of TCE and PCE are compared to the TBC values. As previously noted, there are no TBC values for soil.*

Refer to Comment 15 in this section.

20. *(b) It is indicated on page 4-25 that pesticide "blocks" were placed on the wetland ice and dispersed via melting of the ice. The detection of delta-BHC and methoxychlor may indicate disposal in this area and should be further examined.*

Conversations with Navy personnel indicate that pesticides were also applied by spraying. Based on the fact that the pesticides were detected in shallow soil samples and at relatively low concentrations, pesticide disposal in this area is not expected.

21. *Page 4-25, Section 4.6 (a) There is no discussion of the results from samples of surface water and sediment samples from the Torpedo Shop area (e.g., 7SW and 7SD). These items must be included in this section.*

In ¶ 2, it states that sediment and surface water analysis results are included in the Area A discussion. This was done because these drainage swales/intermittent watercourses are part of the Area A Downstream Watercourses system.

22. *(b) The septic tanks from the torpedo shops should be sampled in future phases of the work.*

Atlantic intends to include septic tank sampling in future investigations at this site.

23. *Page 4-26, Figure 4-3 The Navy indicated that soil borings and wells would be positioned based on the results of soil gas surveys in a March 6, 1991 response letter to EPA (response 1a, page 1). However, there is no soil sample, boring or well located at the soil gas "hot spots" which were observed at the north leachfield. This omission should be explained, and if possible, a soil boring should be advanced at the location of the hot spot in subsequent field investigations.*

Accessibility in this area was difficult with a drill rig. Well 7MW2 was downgradient of this location, and significant solvents were not detected in the ground water. A soil sample collected by hand auger will be considered for future investigation.

24. *Page 4-35, Section 4.7.3 Trace to low levels of 1,2-dichloroethane and TCE were found at SG1 and SG9 which appear to be outside the extent of the previous fill areas. Also, high*

levels of PAHs were found in 8TB3 which also appears to be outside of these areas. Future work will have to expand investigations in that area.

As stated in Section 2.6.2, only moderate to high soil gas detections are normally associated with potential source areas. An upgradient well will be planned in future field investigations in the SG1/SG9 area to assess ground water quality, which could result in the detection of low levels of solvents in the soil gas. Further sampling in the 8TB3 area will also be considered.

25. *Page 4-38, Figure 4-6 The text should indicate why soil borings were not located within the areas of soil gas hot spots which are indicated on this map.*

Refer to Comment 2 under the general comment section.

26. *Page 4-63, ¶ 1 The separately bound geophysical report should be provided.*

This will be provided.

27. *Page 4-64, Section 4.11.1.4 On page 1-21, reference is made to a concrete pad where drums, etc. were stored. However, review of the sampling locations does not appear that any borings or sampling was performed in this area. Please provide the rationale.*

Surface soil samples 2LSS1 and 2LSS2 were collected adjacent to the concrete pad. Also, refer to recommendations for additional sampling in this area (page 8-18).

28. *Page 4-102, Section 4.11.4 This office does not agree with the third sentence in the fourth paragraph which commences with "As discussed in Section 3.0, the..." for the following reasons:*

(a) Section 3.0 (p. 3-36) states that "bedrock ground water likely does not discharge into North Lake." Whether or not bedrock ground water discharges into North Lake has not yet been conclusively determined because the Navy's presumption is based on one round of water level measurements from one well pair.

Refer to Comment 29 in Section 3.0.

(b) The water table was found to be 1.3 feet below ground surface during the 3/21/91 water level measurement event. At this elevation, ground water from the overburden aquifer can be expected to be discharging into North Lake. If an when the lake is emptied out, then the chances are even greater that ground water will discharge into it.

The text will be clarified to acknowledge this comment.

29. *(c) It appears that the Plan of Action was not followed by having only one of two planned soil lab analyses from 2LMW7S and, instead, having one unplanned lab soil analysis for boring 2LTB2. The rationale for this deviation and for the selection of all other subsurface soil sample locations need to be provided.*

Refer to Comment 4 in the general comments section, and to Comment 12 in Section 2.0.

30. *(d) Analytical data for well 2LMW13S is not provided in Tables 4-32 and 4-33 or Plate 4-2, yet it is described in the text as a location where cadmium was detected (p. 4-102). The data for this well needs to be provided.*

As noted in Table 2-2 on page 2-33, this well was dry and was not sampled (i.e., no ground water in overburden). The text will be revised to clarify that elevated cadmium was detected at 2LMW13D.

31. *(e) A boring log for 2WMW4S needs to be provided.*

The proposed monitoring well 2WMW4S was not installed due to existing site conditions, as well as complications involving Navy regulations regarding the Weapons Storage Area. The drilling rig was gasoline-operated and, therefore, was not permitted to enter the weapons storage area due to safety reasons. During installation of 2WMW4D, attempts to push split-spoon samplers using the drilling rods were unsuccessful due to boulders and cobbles in this area, therefore, no boring logs could be developed. Bedrock was encountered at approximately 9.0 feet; ground water was not observed within this interval.

32. *Page 4-145, Figure 4-32 Based upon the text, it is unclear how the soil contamination limits shown in the figure were defined.*

The figure was an approximate delineation of "hot spots" of soil contamination for illustrative purposes. In the Feasibility Study, a more detailed assessment of risk based contaminated soil areas and volumes will be made.

33. *Page 4-147, Table 4-51 Radiological screening values were exceeded at the Goss Cove Landfill, Area A and the DRMO; exceedances were attributed to natural sources at these sites. Additional radiological screening at sites believed to represent typical background conditions for the area is necessary to support this hypothesis given the possibility of radiological contamination based on site history.*

This work is underway.

34. *Page 4-151, ¶ 1 Additional investigations and collecting of surface water and sediment samples may be required to fully evaluate potential impact of the lower subase site on the Thames River. While no seeps were observed during a waterfront inspection, contamination was found in other media, and seeps are likely to be periodic.*

This work was already recommended in Section 8.0 of the IR report (page 8-25).

SECTION 5.0 - CONTAMINANT FATE AND TRANSPORT

1. *Page 5-1, ¶ 4 The text acknowledges that solubility, vapor pressure, Henry's Law constant, K_{oc}, and K_{ow} are dependent on temperature. The applicable temperatures for these parameters should be provided in Table 5-1.*

   The reported temperatures for these properties are usually in the range of 20° to 30°C. This can be added to the table as a note.

2. *Page 5-1, ¶ 6 The last sentence of this paragraph indicates that solution into the liquid phase will control the rate of volatilization for some materials. This sentence is not clear. Henry's Law is an equilibrium coefficient and the rate of solution into the water phase will not influence this parameter. This sentence should be clarified.*

   The sentence referred to does not say that solution into the water phase influences the Henry's Law coefficient. The sentence can be modified to read: "However, for compounds with low solubilities and high values of the Henry's Law coefficient, resistance in the liquid phase controls volatilization."

3. *Page 5-4, Footnote (c) K_{oc} values are estimated by the method presented by Lyman et al. (1982). The last sentence on page 7-11 provides a method of estimation of K_{oc} attributed to Markwell et al. (1989). A consistent method of estimation of all of the mobility parameters should be used.*

   The notes on page 5-4 are a key to the references from which the chemical properties were taken and refer to the reference column in Table 5-1. Most of the chemical properties were reported in reference a, the Superfund Public Health Evaluation Manual (1986). Only where compounds were noted with a "c" in the reference column, were K_{oc} values estimated from Lyman et al., 1982. These are compounds that did not have reported K_{oc} values in the Superfund manual.

   The next to the last sentence on page 7-11 states that we used K_{oc} instead of K_{ow} in Markwell's equation. We used the same K_{oc} values in this equation that we reported in Table 5-1.

4. *Page 5-5, ¶ 3 Soil characteristics such as porosity, soil water content and soil bulk density are discussed as parameters which are important in determining the mobility of contaminants at NSB-NLON. Organic carbon content, pH, eH, cation exchange capacity, particle size distribution, clay content are also important. However, it does not appear that these parameters have been measured at the site. These parameters should be measured. If they are already known, they should be discussed in this section.*

   Of these parameters, only organic carbon content was used in the risk assessment. If field measurements are made, it is only necessary to measure this parameter for the purpose of the ecological risk assessment. In our assessment, we estimated a conservative value of 5%. If any of these other parameters are determined to be needed to supplement the Feasibility Study evaluation, recommendations will be made at that time.

5. *Page 5-5, ¶ 3,4* *The movement and mobility of light and dense non-aqueous phase liquids should be discussed in these sections.*

A few paragraphs regarding NAPL and DNAPL will be added to this section.

6. *Page 5-9, ¶ 4* *Dibenzofuran is measured as part of the semi-volatile analysis. In locations where dibenzofuran was detected, an analysis for all chlorinated dioxin/furan compounds should be performed.*

This request is under evaluation and will be further discussed with the USEPA.

7. *Page 5-11, ¶ 1* *The last sentence in this paragraph should be amended to include the presence of other metals which will also influence the mobility of metals in the environment.*

This sentence can be amended to read: "Environmental factors influencing the mobility of metals in the environment include pH, eH, the presence or lack of oxygen, the presence of other metal compounds such as iron oxides, and the presence of anions and complexing agents."

8. *Page 5-12, Section 5.2.1.1* *A conceptual model for each site should be presented or referenced in this section to illustrate the various exposure routes resulting from contamination at each site. This would clarify the presentation of exposure routes and ensure that all exposure routes are considered.*

Conceptual models will be prepared for each Step II site and generically for the Step I sites.

9. *Page 5-13, Section 5.2.1.3* *Some discussion on the phenomena of precipitation of dissolved metals in estuaries should be mentioned. This phenomena occurs when metals which are in equilibrium with fresh water encounter elevated levels of anions present in salt water. Flocculation and precipitation of these metals has been demonstrated in these situations. This mechanism should be considered and the possibility of contaminant accumulation in the estuary should be discussed.*

The following wording will be added: "The section of the Thames River near NSB-NLON is an estuary. Within an estuary the changing of the river from fresh to salt-water conditions has substantial effects on suspended and dissolved material in the river. Destabilization of colloids, alternation of adsorption equilibrium and precipitation of cationic species are among the commonly observed changes. There is a general tendency for trace metals, and potentially hydrophobic organic compounds, to be trapped in estuarine sediments as a result of these processes.

10. *Page 5-14, last ¶* *The statement "... and the following inorganics above MCLs: barium, sodium, iron and manganese" is confusing, because only barium has a current MCL of 2 ppm.*

This sentence will be revised to make it clear that MCLs were exceeded only for barium, and that the state notification level for sodium was exceeded. Iron and manganese will not be classified as TBC values.

11. *Page 5-15, ¶ 3 It is not clear if the metals concentration presented for the ground water is determined using filtered or unfiltered ground water samples. Both filtered and total metals should be measured in the ground water. This will allow the evaluation of the presence of metals in the colloidal size material. Facilitated transport of colloidal material by ground water has been demonstrated as a mechanism of transport for otherwise insoluble and immobile materials.*

    This same paragraph indicates that metal compounds are tightly bound in the soils. This is inconsistent with the fact that arsenic, cadmium, chromium and lead exceed TCLP TBC values. This sentence should be modified to include this information.

    All ground water samples for total metals analyses were filtered. Although facilitated transport may be a transport mechanism at NSB-NLON, a total metals analysis may be representative of formation materials. Drilling, development and purging activities may be the source of some colloidal material in ground water samples rather than the metals being representative of the colloid suspensions in formation ground water.

    Future work plans will consider provisions for total and filtered metals analysis, and include the most recent procedures regarding well purging and sample handling designed to collect colloid suspensions, however, any data generated by itself will not demonstrate conclusively whether or not facilitated transport is a significant transport mechanism at this site. As mentioned above, it is probably not possible to distinguish between actual mobile colloid suspensions and those caused by well construction, development and purging activities.

12. *Page 5-16, Section 5.2.2.8 The statement, "The following other organics were measured above ARAR or TBC values: iron, manganese, sodium and aluminum" is inappropriate. For ground water MCLs and MCLGs are ARARs and drinking water Health Advisories are TBCs. For the four metals listed above, only sodium has drinking water equivalent level which may be considered as TBC. Secondary MCL for the other three inorganics are neither ARARs or TBCs unless there are state standards for these compounds. Based on this statement and other previous statements in the documents that, when it comes to compare contaminant concentrations to ARARs and TBCs, it is not clear what standard the values are being compared to.*

    In our identification of ARARs and TBCs, secondary MCLs were incorrectly classified as TBCs. The report will be revised so that secondary MCLs will not be TBCs. Sodium had a state MCL that has recently been changed to a notification level.

13. *Page 5-17, ¶ 2 Variability of transmissivity in the fractured bedrock is mentioned in this paragraph. The significance and impact of fractured material on contaminant transport should be mentioned in Section 5.2.1.2.*

Section 5.2.1.2 will be revised to include a discussion of contaminant transport in fractured bedrock. Bedrock fractures offer a preferential flow path for contaminated materials. Depending on the fracture network orientation degree of fracturing, transport rates in bedrock could exceed those in overburden materials. Transmissivity values ranged from 4.2 to 250 square feet per day, indicating a high variability of transmissive properties within the fractured bedrock and that migration in bedrock fractures potentially is a significant contaminant migration pathway.

14. *Page 5-18, ¶ 1 As noted in a previous comment, the recommendation was made to plug the invert in order to eliminate the possible condition of water from the stream discharging to North Lake at times of high flows. This comment should be reiterated in this paragraph.*

The referenced comment will be reiterated in ¶ 1 on page 5-18.

15. *Page 5-18, ¶ 2 Lead and copper are identified as contaminants of concern in surface water. The suspected source of this material should be identified.*

Copper and lead are present in upgradient surface water and ground water and are present in above background concentrations in Area A landfill soils. The copper and lead apparently originate from natural and anthropogenic sources upgradient of Area A and from materials in Area A landfill. The contribution from Area A Landfill is not believed to be very significant as upgradient levels are relatively high and as concentrations in landfill soils only slightly exceed soil background levels.

16. *Page 5-18, ¶ 5 This paragraph states that not enough data is available to define the most significant pathway for cyanide.*

This argument is used several times in the report and strongly indicates that additional data is required at these sites. See comment for Page 5-5, ¶ 3 for additional data requirements. An aqueous geochemistry model should be used to evaluate the speciation of all inorganics of concern. This will allow an evaluation of the mobility of the inorganics at the site in light of site-specific aqueous geochemistry.

The comment in ¶ 5 refers primarily to a lack of information regarding the speciation of cyanide, not in regard to lack of information regarding soil characteristics, although, soil pH in addition to cyanide speciation would be helpful in predicting the fate of cyanide in soil. Please refer to response to comment for page 5-5, ¶ 3 regarding soil characteristics. Cyanide may occur in several forms including: hydrogen cyanide, alkali metal salts, or metallocyanide. Each form has distinctly different physical/chemical characteristics. For example, solubility in water ranges from insoluble to completely soluble for different forms of cyanide.

The report recommends additional investigation regarding this cyanide contamination. The recommendation will be made more specific and state that future investigation attempt to identify the forms of cyanide present by laboratory analysis.

17. *Page 5-18, ¶ 6 The presence of chlorinated dioxin at this site should be investigated. See comment for Page 5-9, ¶ 4.*

Refer to response to Comment 6 in this section.

18. *Page 5-19, ¶ 4 Reduced conditions are indicated as the possible mechanisms for precipitation of metals. The eH of the soils and ground water at each Step II site should be measured.*

Oxidized conditions are indicated as the possible mechanism for precipitation of metals and reduced conditions are indicated as a possible mechanism for leaching iron and manganese from native soils.

The report recommends an additional round of ground water samples; eH measurements will be included.

SECTION 6.0 - HUMAN HEALTH RISK ASSESSMENT AND

SECTION 7.0 - ECOLOGICAL RISK ASSESSMENT

These comments were discussed with the USEPA at the meeting held on February 13, 1992. A separate response for these sections will be forthcoming.

SECTION 8.0 - SUMMARY AND CONCLUSIONS

1. *Page 8-1, Section 8.0: The cover of Section 8.0 states "Summary and Conclusions" while the text inside states "Summary and Recommendations". The purpose of Section 8.0 should be clarified.*

   The cover will be modified to state "Summary and Recommendations".

2. *Page 8-1, Section 8.0: (a) The ARARs and TBC mentioned throughout this section are confusing. It is necessary to indicate the exact value and the exact standard or criterion the concentration of the contaminant of concern is compared with.*

   A general statement will be added after the first paragraph referring the reader to Section 4.0 for an explanation of specific ARAR/TBC values. The Navy disagrees with the request, and feels that including the regulatory standard and reference for every discussion of a specific chemical, in itself, would be confusing. Section 8.0 is a summary which likely will be used by the TRC members and the general public. For this reason, it was purposely kept general.

3. *(b) It is necessary to state the exact risk based on the risk characterization. The term (de minimum risk" or "within one in one thousands risk" give a very vague description of the results of risk characterization.*

   A statement will be added after the first paragraph explaining in general the risk terminology.

4. *Page 8-1, ¶ 1: The fact that analytical results from a particular site did not result in contaminant values that exceeded ARARs or risk-based criteria, is not a sufficient means for determining whether the site should undergo further investigations.*

   The CERCLA criteria for determining whether an RI/FS should be performed on a particular site does not consider ARARs or risk based values. Generally, the amount of sampling which is performed for a PA/SI (Step I investigation) is only sufficient to determine the presence of contaminant, not the nature or extent. Furthermore, all media are not typically sampled in the PA/SI phase.

   The PA/SI relies on "indicators" of a release to determine if further investigation is necessary. If evidence of a release is noted, and the Hazard Ranking Score is higher than a predetermined threshold value, the site is listed on the National Priorities List and must undergo the RI/FS process. In the case of the three sites which the Navy proposes for No Further Action, evidence of a release was noted at all three sites, and therefore the sites should continue to be investigated.

   The Navy recommends that all Step II sites proceed to the Feasibility Study stage; however it is not clear that sufficient data have been collected for the three Step II sites.

   We feel the site has been adequately investigated and assessed to support the no further action recommendation. Further discussion on this issue is suggested.

5. *Page 8-1, Section 8.1.1.1:* *Since, as the Navy indicates, "a small release may have occurred" at this site, additional investigation should be performed to determine the nature and extent of contamination, and to perform a quantitative risk assessment.*

Only one soil analysis for inorganics was performed. Given that the sample contained concentrations of lead which may be related to waste stored at this site, additional soil samples should be collected.

Volatile organics and semi-volatile organics were detected in composite surface soils at this site. Since compositing can dilute contaminated samples by adding uncontaminated sample to the composite, additional subsurface sampling should be performed for volatile and semi-volatile organics. Ground water sampling should also be performed to assess concentrations of organics and inorganics. Analytical methodologies for both media should be chosen to provide detection limits below the ARARs/TBCs.

We feel the site has been adequately investigated and assessed to support the no further action recommendation. Further discussion on this issue is suggested.

6. *Page 8-3, ¶ 4:* *Additional ground water analysis for PCBs and pesticides should also be performed.*

We would intend that the recommended further ground water analysis conducted at the Torpedo Shop will include PCBs/pesticides.

7. *Page 8-5, ¶ 10:* *Soil sampling for dioxins and furans should be performed to assess potential contamination in incinerator ash.*

Refer to comment 6 in Section 5 for a response to this request.

8. *Page 8-6, ¶ 2:* *Additional further investigations that should be performed include:*

- *borings and/or wells placed at the location of soil gas hot spots;*
- *soil sampling below ten feet near 8TB2 and 8TB3 due to the high levels of PAH detected; and*
- *soil and ground water analysis for organics and inorganics.*

These comments will be considered in the development of the work plan for future investigation at this site.

9. *During our previous site visit on October 8, 1991, booms were surrounding the three outfalls which discharge in the Goss Cove area. It was noted that on occasion, oil residues, both No. 2 and No. 6, flow from these drainage pipes. The source of this oil was said to be storage tanks underneath the baseball field. The sediments along the shore in this area should also be examined.*

This comment will be considered in the development of the work plan for future

investigations at this site.

10. *Page 8-6, ¶ 6: Only one soil location was sampled for inorganics and two locations for organics. At least three samples should be collected and analyzed for full TCL/TAL prior to recommending this site for no further action.*

    Additionally, ground water should be analyzed for organic and inorganic constituents.

    We feel the site has been adequately investigated and assessed to support the no further action recommendation. Further discussion on this issue is suggested.

11. *Page 8-7, ¶ 7: The Step I investigation did not include any soil borings advanced to the water table, although the most likely release mechanism and pathway at this site would be a UST leaking and infiltrating down into the ground water. EPA can not concur with the Navy's no further action recommendation for this site until such soil sampling is performed, and ground water samples are collected.*

    Our recommendation includes tank removal and confirmation soil sampling directly below the tanks. This will be the most direct way to confirm that no tank leakage occurred. If contamination is found to have occurred, soil remediation will take place as well as ground water assessment. However, if no contamination is identified at that time, no future action will be taken.

12. *Page 8-10, ¶ 5: This paragraph implies that the origin of the VOCs detected in the dredge spoils is the Thames River. It is unclear how such contamination could be present in the river sediments. Regardless of the original source, the soils are now themselves a contaminant source.*

    Residual levels of VOCs would likely be associated with Thames River sediment, due to the industrial nature of the watershed.

13. *Page 8-13, ¶ 2: The text discusses a plume at Area A in the bedrock. A figure showing the estimated extent of the plume should be presented.*

    Plate 4-1 in Section 4.0 will be used to illustrate the approximate extent of ground water contamination.

14. *Page 8-13, ¶ 5: A series of cross-sections showing the flow field and the contaminant distributions should be presented in this discussion.*

    We do not feel that providing this information will add to the understanding of site conditions. The ground water quality data ia already summarized on Plate 4-1.

15. *Page 8-14, ¶ 3: The text states that "...it is indeterminate if these [offbase residential] wells are upgradient or downgradient of the western portion of the Area A Landfill. From the ground water contour maps, it appears that these wells are "side gradient" from the landfill, an alternative possibility to consider.*

Your comment is true. We have proposed the additional sampling to confirm the ground water flow in this questionable area.

16. *Page 8-18, Landfill Soils: Landfill soils should also be sampled for chlorinated dioxins and furans to assess contamination from incinerator refuse.*

Refer to the response to comment 6, provide in Section 5.

17. *Page 8-19, North Lake: During our previously noted site visit, ground water seepage at the east end of the lake was evident. Sediments at this point as well as ground water should be analyzed for the TAL and TCL.*

An additional recommendation should be to cap or remove the eastern overflow pipe which may allow some of the drainage from the Area A to enter North Lake.

We will consider analysis of the ground water seepage in supplemental field investigations.

The latter recommendation has been added to the text.

18. *Page 8-19, Downstream Watercourses and Pond: Two unnamed ponds to the Northeast of North Lake were visited and appeared to be lacking in wetland ecological activity. Some benthic surveys should be performed to evaluate benthic populations. In conjunction with this, toxicity testing should be performed on the sediments at depositional areas of downstream water courses and the two above-mentioned ponds.*

Additional sediment sampling and analysis for TCL and TAL is needed for the "lower" pond on the north side of downstream area "A". One sample is not sufficient to characterize the pond. On all sediment results, units should be indicated as being on a dry or wet basis.

With the possibility of wetland remediation, there is the need to properly delineate the wetlands on the Navy property as well as those that are affected by contamination whose source lies within naval property boundaries. This must be done as described using the Federal Manual for Identifying and Delineating Jurisdictional Wetlands.

On page 8-19, additional assessment of the biological community in this area was recommended. Your specific comments will be considered in the design of this program.

Additional sediment sampling will be considered as part of our recommendation of additional surficial soil sampling in this area.

We are aware that wetlands exist in Area A; and the general boundaries are known. The wetlands regulations will be considered as an ARAR. Following the Feasibility Study, and as part of any remedial design, specific wetlands procedures will be established at that time.

19. *Page 8-22, ¶ 8: Since the DRMO was reportedly used as a burning ground, the near surface soil should be sampled for the presence of chlorinated dioxins and furans.*

Refer to the response for comment 6 in Section 5.

20. *The outflow labeled 2DSD12 on the DRMO had considerable output. There is a need for additional sampling along the shore line of the Thames River upstream, downstream, and outward. There is also a potential for periodic flooding of the river on to the DRMO causing further contamination which should be examined.*

Recommendation #1 on page 8-22 included additional sampling in the Thames River. We do not believe that flooding of the site by the Thames River is of significant concern as a contaminant source, and do not feel that further evaluation of this issue is required, other than to address erosion of contaminated soils from DRMO to the Thames River.

21. *An additional recommendation should be to install monitoring wells in the areas where high "hits" were recorded, such as in the vicinity of 6TB4.*

This will be considered for future field investigation.

APPENDICES

Appendix A

The depths of the soil gas samples should be provided in the Appendix A tables.

The depth was approximately three feet, except at the Lower Base where the depth is 12-18 inches due to utility conflicts.

Appendix D

1. *(1) Page D-3, ¶ 4 The second sentence of this paragraph states, "The state has classified the water quality of this segment of the Thames River as SC/SB." It should be noted that the CTDEP is currently considering changing this SC/SB water quality classification to SA. For completeness, the Navy should provide an updated water quality discussion pertaining to this potential water quality classification.*

   The text will be revised to note this potential change.

2. *(2) Page D-5 The second sentence of the sixth paragraph pertaining to the applicability of the state Hazardous Waste Management Regulations states, "For all applications to chemical specific ARARs, Connecticut's regulations are identical to EPA's." It should be noted that Section 22a-449(c)-106, "Standards for the management of specific wastes and specific types of hazardous waste management facilities" states that more stringent provisions may need to be addressed pertaining to spent lead-acid batteries. The final disposition of spent lead-acid batteries is currently unknown for the OBDA, therefore, these regulations may be considered potentially an ARAR if these materials ("spent batteries") are transported, stored, or collected for recycling or reclaiming.*

   After a re-analysis of Section 22a-449(c)-106, no chemical-specific standards are evident. These regulations reference the requirements in 40CFR Part 266, Subpart G and contain standards regarding handling, storage, inspection, accumulation, and registration of spent lead acid batteries. No chemical-specific standards are included in this regulatory section.

3. *(3) Page D-12 The seventh paragraph states, "See discussion on federal RCRA standards. There are no significant differences regarding location standards between federal and state regulations." While we agree with this statement, there are more stringent provisions for chemical-specific ARARs provided in Section 22a.-449(c)-106. See previous comment regarding spent lead-acid batteries corresponding to Page D-5.*

   See response to Comment 2 above. Potentially this regulatory section could be an action-specific ARAR if batteries are discovered and if these batteries are to be recycled. To date no batteries have been discovered. This requirement will be classified as a potential action-specific ARAR for the large landfill areas where it is possible that batteries were disposed, i.e., Area A Landfill, DRMO and Goss Cove.

4. *(4) Page D-13 The second paragraph states, "The NSB-NLON property is presently an*

existing well field and to date has not been identified as a potential well field ARAR." The Aquifer Protection Areas (22a-354a through 356 CGS) should remain potentially an ARAR pending the final completion of these requirements.

You misquoted our statement. We stated that the property is <u>not</u> presently an existing well field. Please clarify comment.

5. *<u>(5) Page D-18</u> Subsections 4.1 and 4.2 provide discussions of federal and state requirements that will be considered in selection of a final remedy at NSB-NLON. The Navy should provide a limited discussion for each TBC similar to the discussion for ARARs. Also, two of the three state TBCs under the Department of Health Services and CTDEP should be included in Table 4-1.*

A limited discussion will be provided for all TBCs listed in subsections 4.1 and 4.2.

Table 4-1 does include a listing for Standards for Drinking Water and for Water Pollution Control and the existence of TBC values under these laws is indicated to exist at all sites. Table 4-1 is general in nature. A breakdown into every regulatory section and guidance document will detract from its usefulness and is not warranted at this stage of the RI/FS process. The remedial actions sections of the FS will clearly specify all ARARs on a site basis in light of the general response actions being considered.

<u>Appendix E</u>

A justification should be provided for samples that were analyzed but not included in the risk assessment. For example, in Appendix E, the list of samples used for the scenario involving subase children exploring Area A streambeds and wetland (sediment) has only a partial list of sediment samples collected from Area A. Please justify the exclusion of samples 2WSD3 through 2WSD9. Justifications should be provided for samples excluded from other scenarios, as well.

These comments will be discussed with the USEPA.

<u>Appendix F-1</u>

There is no indication in the species list of any freshwater finfish. This shows inconsistency within the document. If fish were anticipated to inhabit ponds in the downstream areas, as indicated by a proposed fish survey in April 1990, they should be included. If they were omitted due to their absence in the ponds, then the possible reasons should be addressed, i.e., contamination, habitat requirements, etc.

<u>Appendix F-2</u>

Units should be indicated as part of the heading.

This comment will be addressed with the USEPA.

SECTION 1.0 - PRELIMINARY REMEDIAL TECHNOLOGIES

1. *Page 1, ¶ 5, Item 1 Development and Screening of Alternatives lists five (5) steps; however, these steps are not consistent with the CERCLA RI/FS Guidance (EPA, 1988), Section 4.1.2.1 which lists six (6) general steps relative to the development/screening of alternatives. These steps identified in the RI/FS Guidance include:*

   1) development of remedial action objectives
   2) development of general response actions
   3) identify volumes and areas of media
   4) identify and screen technologies
   5) identify and evaluate process options
   6) assemble remedial alternatives

   Note that 3 of the 5 items listed in the FS document [identify treatment technologies..., screen technologies, and identify action-specific ARARs] all fall under Item (4) above. Thus, the list provided above is more comprehensive in outlining the components of the alternative development process.

   The list provided is more comprehensive and will be used, and it will be noted more clearly that the purpose of this Feasibility Study report section is solely to identify and screen technologies to eliminate those that cannot be implemented technically at the site.

2. *Page 1, ¶ 5 The upfront discussions regarding technology screening/alternative development should identify whether an operable unit approach is being utilized by the Navy to address discrete site areas and/or media. Such information needs to be included in the FS because each alternative must be designed such that it addresses all areas or media included within the specific operable unit designation.*

   For instance, if an entire site consisting of soil and ground water contamination is addressed as a single operable unit, then each alternative must incorporate technologies which affect treatment of soils and ground water. If soils and ground water are treated as separate operable units, then separate alternatives would be developed for each media. Thus, alternative development must proceed in concert with the operable unit approach being used (if any) by the Navy.

   Note that the operable unit approach not only applies to site media, but can be used to separate discrete portions of a facility into separate areas (each subject to separate RI/FSs).

   The operable unit approach will be used in the FS for alternative development, screening and detailed analyses. Technology screening and the evaluation of process options will be done on a media basis and will include comments specific to operable units as necessary. This section of the FS will note the approach taken.

3. *Page 2, ¶ 6 Section 1.2, Screening of Technologies is not developed in a manner consistent with the CERCLA RI/FS Guidance, Section 4.2.4 Identify and Screen Remedial*

Technologies and Process Options.

CERCLA Guidance specifies that the technology screening process includes the following two steps: 1) the universe of potential applicable technology types are screened on the basis of technical implementability, and 2) for technology types not screened during the first step, technology process options are evaluated based on effectiveness, implementability, and cost to select a representative process option for each technology. The representative process options are then combined to formulate remedial alternatives.

The Groton FS document presents only a single technology/process option screening step, and the criteria for conducting this initial screening effort are not clearly stated. No representative process option is selected for each technology, thus the Navy's efforts are incomplete.

It is recommended that the Navy adopt the two-step approach recommended in the CERCLA Guidance. The first screening step should evaluate technical implementability (including the ability of the technology to achieve preliminary remediation goals or ARARs).

The second step should evaluate each process option on the 3 criteria stated above.

The sole purpose of this document is to identify and screen the universe of potentially applicable technology types based on technical implementability. As noted in the response to Comment 2 above, this clarification will be made in the introductory text.

4. *Page 4, Table 1-1, Areas of Concern (a) This table does not present information or data which is substantial enough to support the technology screening effort. To properly assess the "implementability" of a technology at the site, it is important that the FS state the volume/areas of media requiring treatment, and a complete list of chemical compounds present in each medium.*

Table 1-1 provides a qualitative discussion of health risks associated with the DRMO, Lowerbase, and Area A. These discussions give little insight into the nature of the contamination problem at each site. To properly support a technology screening effort, this table should present for each media at each site, a complete list of the chemical compounds which pose a carcinogenic risk or non-carcinogenic risk under baseline conditions, the current concentration of the compound, and the risk estimate. Next, the table should present a target risk range [acceptable risk range] and a target or clean-up concentration for each compound.

The above information would inform the FS personnel as to what contaminants need to be treated, and to what level, thus providing them with the information needed to select the appropriate technologies.

Note - the information discussed above (i.e., target clean-up levels) should actually be folded into the Remedial Action Objectives (RAOs) for the site. RAOs should be developed prior to technology screening, and should specify the contaminants of concern, exposure routes

and receptors, and a quantitative target clean-up level or goal based on ARARs and the risk assessment.

We agree with this statement, however, Table 1-1 was intended only to show qualitative risks. Quantitative values will be developed in the remedial action objective section of the FS which is presently being developed.

5. *(b) It is stated that there are no ecological risks at both the DRMO and Lowerbase. Additional sampling and information must be gathered before this conclusion can be drawn.*

This statement will be revised to state that, based on existing information, there are no predicted ecological risks. Additional sampling and assessment was recommended in Section 8.0.

6. *Page 7, Table 1-3 In the Screening Comments relative to the Fencing process option, it appears the last sentence is not complete.*

This sentence will be revised to read as follows: "This process option could be used in conjunction with containment process options to make a more effective alternative."

7. *Page 8, Table 1-3 Screening of Technologies for Soil/Sediment Under the "biological" treatment category, aerobic degradation is cited as a potential technology. The screening comments indicate this technology is not applicable for metals, and may not degrade PCBs. This technology is then cited as a "Potential Option" for all three source areas (Area A, DRMO, LWR Base).*

   1. *Table 1-1 indicates the DRMO is contaminated with PCBs, PAHs and metals, thus, considering the ineffectiveness of aerobic degradation in treating PCBs and metals, the use of this technology at this site is not warranted.*

   2. *Table 1-1 indicates soils in the Lowerbase pose no risk. Thus, according to Table 1-1, remediation of soils is not warranted at this site.*

   3. *Table 1-1 indicates that Area A soils are contaminated with PCBs, thus, the use of aerobic degradation at this is clearly not warranted based on the screening comment.*

   As indicated above, there appears to be no rationale for the selection of aerobic degradation as a process option. The upfront information is inadequate to select a process option, and the screening and process option selections are inappropriate.

It is noted that the above problem is noted in numerous instances in Table 1-3. For instance, on p. 9, soil venting is selected as a process option for treating soils in all three areas. Soil venting is appropriate to the removal of VOCs; however, as indicated above, the

contaminants of concern at the DRMO and Area A are PCBs and metals. Therefore, the use of soil venting at these sites does not appear to be a viable option.

As a final consideration, site-specific conditions must be considered in determining whether a technology is readily implementable at a site. For instance, grain-size distribution of site-soils will affect suitability of solidification/stabilization technologies, BTU content of soils will affect efficiency of incineration technologies, etc. For this reason, a preliminary identification of technologies should be conducted to enable FS personnel to compile a list of site-specific data needed to select appropriate technologies during the screening process. This type of site-specific data should be presented in up-front sections of the FS to support technology screening. If the data needed to support technology selection has not been collected, it may not be appropriate to screen technologies until this type of data is collected.

It is thus recommended that, future sampling programs specify the collection of all data needed to support the technology screening effort. Note that this data collection effort must be suitable to support technology screening and alternative development, but need not be specific to the point where it supports remedial designs.

As stated in the summary of this report (Section 1.3), these tables are informational in nature and serve the sole purpose of ensuring that an appropriate range of technologies and process options are developed. A prudent approach was used in screening technologies, and many were retained for reasons that are not evident at this stage of the RI/FS process. At this time, many issues regarding remedial action objectives have not been resolved and, therefore, these objectives have not been adequately defined. For example, DRMO contains soils with substantial VOC contamination that could be treated by soil venting or aerobically and the Lower Subase contains soils with soil contamination that could be degraded aerobically. Remediation of these areas is only indicated by TBC values and, therefore, were not included in Table 1-1 (areas of concern). Upon establishment of final remedial response objectives, the table will be re-evaluated and modifications made as appropriate.

Work plans for future work at these sites will consider inclusion of relative and applicable feasibility data requirements.

8. *Page 8 The screening comment for in situ anaerobic degradation states that this is a pilot stage technology, therefore, was not considered further. This rationale is also used in the screening of several other technologies in later sections. However, since the NCP indicates a preference for treatments which are innovative, technologies should not be screened exclusively because of their innovative nature.*

We agree that innovative technologies should not be eliminated solely because they are innovative and have included several that are potentially feasible for further evaluation. The comments in this section will be revised to also indicate that this technology has not been demonstrated to be very effective.

9. *Page 10 Anaerobic treatment of sludges has been performed for many years at industrial and municipal waste treatment facilities. It does not appear to warrant consideration as a*

pilot stage technology as stated in the screening comments for this entry.

We are aware of no demonstration projects other than at laboratory scale regarding anaerobic treatment of soils or sediments contaminated with hazardous substances. For these reasons this technology was classified as pilot scale even though many field scale units exist for treatment of POTW sewage sludges.

10. *Page 12 The screening comments for ground water control indicate that feasibility of this technology is questionable in areas adjacent to the Thames River due to large volumes of infiltration. However, infiltration can be minimized by use of sheet pilings, so the implementability of this technology should not be affected by infiltration from the river.*

Infiltration can be minimized but not eliminated by use of a sheetpile. Presently, there is a sheetpile bulkhead in existence at the Lower Subase. This option was retained for further evaluation. To address this comment, the wording will be revised to read as follows: "Implementability will be complicated and effectiveness diminished in areas adjacent to the Thames River...."

ATTACHMENT 1

Soil Gas Sample and Standard Chromatograms
(Not Provided With Phase I Remedial Investigation)

ATTACHMENT 2

Form Ones and Data Validation Checklists
(Not Provided With Phase I Remedial Investigation)

NAVY'S RESPONSE TO EPA'S RISK ASSESSMENT COMMENTS OF NOVEMBER 12, 1991 (MARCH 26, 1992)

NAVY RESPONSES TO EPA'S COMMENTS (November 12, 1991) ON RISK ASSESSMENT FOR THE INSTALLATION RESTORATION STUDY (August 1991) NAVAL SUBMARINE BASE - NEW LONDON

1. *Page 6-1, ¶2: The risk assessment guidance used should have been USEPA, 1989, not USEPA, 1990, as stated.*

   The guidance used was USEPA 1989 and 1991. The text will be corrected.

2. *Page 6-2, ¶7: Which EPAs guidance is the statement in the paragraph referring to?*

   The guidance referenced is USEPA 1989.

3. *Page 6-3, ¶6: Trespassers may need to be considered for future scenarios; fences and guards may not be in place in the future if areas of the base are closed or become inactive.*

   The potential for future use of ground water as a source of drinking water on the base or in neighboring residential areas should be considered. The state classification for ground water at the base is either GA/drinkable or GB/may require treatment before consumption. Some ground water is too saline for human consumption, and may not need to be considered in the future use scenarios. The potential for contaminant plumes reaching residential areas off base and the likelihood of base closure should be evaluated and discussed in the risk assessment.

   For the step II sites, health risks associated with a trespasser scenario under future conditions were not calculated, but considered in our assessment. Exposure scenarios involving children living onsite and adults working onsite were given the highest priority and the onsite risks to these groups of individuals were calculated first. These two groups represent highly exposed and sensitive populations. The exposure scenarios involving these populations would more stringently evaluate the potential health risks associated with a step II site than a future trespasser scenario. For those step II areas which did exhibit potential health risks to these highly exposed populations, remediation alternatives are being evaluated (DRMO, Area A Downstream and Area A Landfill). Therefore, a trespasser scenario under future conditions would not be necessary for those step II sites which are presently scheduled for remediation. For other step II sites which did not demonstrate potential health risks for the highly exposed populations, a trespasser scenario under future conditions is not necessary. A trespasser would visit the area less frequently than the exposure scenario developed for onsite workers and children.

   We feel that comparison of ground water quality to MCLs is adequate to evaluate potential human health risks and that a quantitative risk assessment is not required.

4. *Page 6-6, Section 6.1.3: This section is just a general outline of how to select compounds of concern, and no actual selection process is presented in this document. Table 6-2 does not indicate what compounds are selected for what medium. A contaminant-specific rationale should be provided for each contaminant excluded from further consideration. Exclusion of inorganics based on regional concentrations is inappropriate (see comment for Page 4-2, ¶6). Information on the concentration of chloroform and isophorone should be provided here, as well as information on the toxicity of diethylphthalate. In addition, there is some reservation to the use of natural background as determined in this study to eliminate and choose inorganic COCs.*

The criteria for selecting a compound of concern required that the compound be detected at least once on the site in any medium. Because of the nature of site activities, potentially exposed individuals could visit many areas of the site and participate in several activities thereby receiving multiple exposures. Therefore, the compounds of concern had to represent all areas of the site so that the total risk for a specific exposed population could be calculated. If a compound was not detected in a site area, then the compound was not included in the risk calculations.

Several other stringent criteria related to concentration levels and potential toxicity were also used to exclude some compounds from the risk calculations. Only a few organic compounds were excluded and the reasons for their exclusion are discussed in the report.

A few inorganics were excluded based on frequency of detection and/or detection at levels that are representative of natural background in soils or sediments. To assess whether concentrations of inorganics were compared to published background levels from several sources including USGS data for the Eastern United States and background data for New Jersey and Massachusetts. If an inorganic analyte was within these published background levels or was detected infrequently, it was excluded from further assessment. Carcinogenic inorganic analytes were not excluded from the risk calculations. As a result, only a few inorganics detected in site soils were excluded from the risk calculation. They are: barium, calcium, chromium, cobalt, potassium, silver, sodium, and vanadium. These screening criteria and the reasons each of these metals was excluded from further assessment will be explained in the text.

5. *Page 6-9, ¶2: The arithmetic mean was used to calculate average exposure point concentrations. Information should be provided on the distribution of the data. Contaminant data is frequently distributed log-normally; if this is the case for this data set, the geometric mean would be more appropriate than the arithmetic mean.*

Arithmetic mean is correct for purposes of estimating exposures. Exposure is based on random visits and events and averaged. A geometric mean is only a statistical parameter to describe the distribution.

6. *Page 6-11, ¶1: During our recent site visit in October, the area east of North Lake was in the process of being fenced to prohibit any children from entering the area downstream of Area A. This information should be provided in the report, and any resulting assumptions should be revised.*

Fencing was suggested for the North Lake area because of our evaluation. The effect of the fencing on risk will be discussed as part of the evaluation of alternatives in the feasibility study.

7. *Page 6-14, ¶2: Accessibility of the Overbank Disposal Area from Area A should be addressed. Future exposure scenarios involving trespassers should be developed for this area. It would have been useful to summarize samples taken, and contaminants detected and levels recorded for the CBU Drum Storage Area here.*

   In one of the onsite children scenarios, accessibility to the Overbank Disposal Area from Area A was assessed. From this assessment, Overbank Disposal Area is being evaluated for remediation; therefore, a trespasser scenario under future conditions is not necessary (refer to comment page 6-3 ¶6).

   Refer back to other Section 4 for summary of samples taken in CBU Drum Storage area.

8. *Page 6-14, ¶3: See comment Page 6-14, ¶2. The possibility of future exposures of trespassers at the Rubble Fill site should be considered.*

   The Rubble Fill site is a step I site. Specific scenarios were not developed for the step I sites. A trespasser scenario is not appropriate because Bunker A-86 has limited access as stated in the report. If this area becomes a step II site, other scenarios would be considered and a quantitative risk assessment performed.

9. *Page 6-14, ¶6: Additional exposure scenarios (e.g., exposure of children to surface soils and exposures involving the Thames River) should be considered for the Goss Cove site as appropriate data are collected.*

   We agree; exposure scenarios involving children exposed to surface soil and Thames river exposures will be considered in the Step II evaluation of this site.

10. *Page 6-16: A higher ingestion rate of soil (i.e., 480 mg/day) is appropriate for utility maintenance workers for this and other similar scenarios; such exposure is probably more typical of yard work, for which the higher ingestion rate is derived, than indoor activity, which reflects a lower rate (EPA, 1991).*

    The point is acknowledged. The soil ingestion rate used for a utility worker in this human health assessment was 100 mg/day (USEPA Region I Supplemental Risk Assessment Guidance for the Superfund Program, 1989). Federal EPA has most recently published a new soil ingestion rate of 480 mg/day for landscaping/construction activities. Using the new soil ingestion rate in the applicable exposure scenarios (involving excavation), we re-evaluated the risks for these scenarios. The risks increased, at most, by a factor of 4.8 because soil ingestion rates increase linearly. We will use this information in generating estimates of target levels for the Feasibility Study but do not propose to generate a new set of spreadsheets. The differences in results will be described in narrative fashion in the body of the risk assessment report.

11. *Page 6-16 to 6-81, Tables 6-3 to 6-23: These tables are very tedious and much information has been repeated. The unnecessary data and unexposed pathways were also presented. It is necessary to make the following changes to represent only the information necessary for quantitative risk assessment:*

(a) Omit the data for all the "no potential exposure" pathways in Tables 6-3 to 6-23.

(b) Although the average time is 70 years for carcinogens, the average time for non-carcinogens is the same as years exposed (i.e., exposure duration).

(c) The standard exposure frequency should be 350 days in accordance with the OSWER Directive 9285.6-03 Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors".

(d) Ingestion rate for surface water is incorrect. If a person swims 2.6 hours per day and ingests 50 ml/hr, the ingestion rate should be 0.12 l/day. The 1.2 l/day is based on a 24 hour period, and it is not possible that a person will swim 24 hours per day.

(a) Although this data is not of interest to the EPA, its inclusion in the report is not incorrect and omitting it at this time serves no constructive purpose.

(b) We used actual exposure parameters like 250 days for worker exposures.

(c) The standard exposure frequency of 350 days was used for residential exposures to fugitive dust. For other exposure scenarios, site specific information was used to estimate exposure duration.

(d) The surface water ingestion rate for swimming is correct. The 1.2 l/day is adjusted in the risk calculation according to the amount of time swimming.

12. *Page 6-17: Wherever possible, particulate emission models should be taken from Estimation of Air Emissions from Cleanup Activities at Superfund Sites, Interim Final. EPA 450/1-89-003.*

EPA indicated they would look at this more closely. We explained the methodology that was used and it seemed clear at the meeting.

13. *Page 6-22: See comment for page 6-16 regarding soil ingestion.*

See response to comment for page 6-16 regarding soil ingestion.

14. *Page 6-31: The number of hours given in the notes column here and in Table 6-13 does not add to the number of hours used for the daily exposure period.*

2.5 hr/day is a weighted average per day over the year.

15. *Page 6-34, ¶1: Future use of contaminated ground water (originating from Landfill A) as a drinking water supply should be considered as state classification of the ground water allows for the possibility of future use as drinking water and future base closure may be a possibility.*

Please see response to comment for Page 6-3, ¶6.

16. *Page 6-34, ¶4: Current exposure parameters assume a 6 to 9 year old child will be exploring the area over a six year period. The age group exposed should be redefined to cover a six year period consistent with a reassignment of duty at this base.*

Exposure parameters were based on 6 to 9 year old age group because children of this age group are old enough to participate in unsupervised exploration. However, at the request of EPA, our risk calculations are based on six year exposure period not three years. We could adjust the identified age range to 6 to 12 years to avoid confusion.

17. *Page 6-35: The ingestion rate given (200 mg/day) is for children under six years old. The lower ingestion rate of 100 mg/day should be used for the age group under consideration here.*

The daily exposure period, exposure duration, and exposed body parts given here, and in other tables involving similar scenarios, all seem low for potential exploration during the summer, although probably appropriate for spring and fall exploration. If these levels are low because a zonal approach is being taken, this should be discussed and justified in the text.

We used 200 mg/day for six year old age group (USEPA Region I Supplemental Risk Assessment Guidance for the Superfund Program, 1989). If we apply EPA suggested 100 mg/day for 6 to 12 year old age group, estimated risks are lowered by less than a factor of two. We do not propose to change the spreadsheets, but the effects of alternative assumptions can be discussed in the narrative for this section of the report.

A zonal approach was used. Subase children are assumed to be concurrently exploring many areas of the site all year round. Low exposure frequencies were used in the individual exposure scenarios which described a possible area of the exploration for the children. The rational was to avoid being overly conservative in the individual exposure scenarios. The total frequency of exposure due to exploration by sub-base children is the sum of the individual exposure frequencies provided in each exposure scenario. The fraction of body exposed (dermal exposure) for the sub-base children is relatively conservative and follows federal EPA guidance dictated in Exposure Factor Handbook.

18. *Page 6-40: Dermal absorption of contaminants from surface water may need to be considered for this scenario, especially given the assumption in this table that the child's entire body is being exposed.*

Dermal exposure to surface water is not considered a significant pathway because of the very low levels of contaminants detected in the surface water and the low intermittent flow conditions of the culvert ditches.

19. *Page 6-41: As noted in a previous comment, the daily exposure period for swimming is estimated to be 2.6 hours per day and not 4 hours per day. The ingestion rate on page 6-43 seems incorrect; assuming 50 ml/hr over 2.6 hours = 0.12 l/day, not the 1.2 l/day given. Also, please provide the skin permeability rate assumed here and in other tables.*

Skin permeability rates (cm/hr) were provided by Sara Levinson, EPA Region I (written

correspondence to Dr. Wendy Heiger) to calculate the dermal dose for exposure to surface water during swimming.

Benzene 0.11
Ethylbenzene 1.4
Toluene 1.0
Phenol 1.5E-4
All other compounds of concern were defaulted to 1E-3

20. *Page 6-44: See comment for page 6-16 regarding the soil ingestion rate.*

See response to comment for page 6-16.

21. *Page 6-47, ¶3: A justification should be provided for not considering the following future exposure scenarios for the DRMO site: (1) exposure of child trespassers to surface soils, and (2) effects of contaminated ground water discharge on surface water in the Thames River.*

The DRMO site is presently fenced and risks have been evaluated by exposure scenarios involving frequent exposures to contaminated soils by construction, utility and Department of Defense workers. Risks to children resident on the subase inhaling fugitive dusts from DRMO and the Area A Landfill were also assessed. A child trespasser under future conditions would receive less exposure than any of these groups. Therefore, a child trespasser scenario under future conditions is not needed. The effects of contaminated ground water discharged to the Thames River are discussed in Section 4.0 and Section 7.0.

22. *Page 6-72, ¶2: If further investigations reveal contaminant discharge into the Thames River, additional exposure scenarios may need to be considered.*

The point is acknowledged.

23. *Page 6-72, ¶3: If utilities are buried at 15 feet, contact with soils slightly below this depth should be considered, as well as contact with soils at and above this depth.*

All appropriate soil data were used according to depth where exposure is possible. Appendix E lists all samples used for exposure scenarios.

24. *Page 6-82: The title of Section 6.2.3: "Quantification of Exposure" is not appropriate for Step I sites.*

Since both Step I and II sites fall under this section, alternative section title is Evaluation of Exposure.

25. *Page 6-84, Section 6.2.3.2: In the first paragraph of this section, see comment for page 6-9, ¶2 regarding distribution of data.*

Arithmetic mean is correct for purposes of estimating exposures. Exposure is based on random visits and events and then averaged.

26. *Page 6-85, ¶2: A description of the analytical models used to estimate airborne concentrations of fugitive dust must be clarified/expanded.*

This can be provided.

27. *Page 6-85, ¶3: Wherever possible, particulate emission models should be taken from Estimation of Air Emissions from Cleanup Activities at Superfund Sites Interim Final. EPA 450/1-89-003.*

Particulate emissions modeling and air dispersion modeling should be performed to evaluate airborne particulate concentrations at locations remote from the excavations.

Methodology used was explained at the meeting with EPA on February 13, 1991. EPA said they would consult with personnel in their Air Division and would indicate whether or not this method is appropriate. No EPA feedback has been provided to date.

28. *Page 6-89, Section 6.2.4.2: Terms used should be consistent with EPAs Superfund guidance. "ADD" is not consistent with the term in the guidance.*

ADD will be replaced with average daily intake. However, in the risk assessment we define ADD as exposure dose or intake in Section 6.2.4.2 not absorbed dose.

29. *Page 6-89, ¶6: The averaging period for chronic exposures to non-carcinogens should match the exposure duration. This discussion implies the exposure duration for all chronic doses was assumed to be one year.*

For non-carcinogens, exposure duration (days/year conducting a certain activity) should not match the yearly averaging period (days/year). The exposure durations (days/year conducting a certain activity) and average lifetime exposure (number of years exposed to the site) are based on site specific information. For instance, naval public works worker scenario had exposure duration of 250 days/year and yearly averaging period of 365 days/year. Average lifetime exposure and yearly averaging period varied for several scenarios depending if the exposed population were residents (30 years, 365 days/yr) or workers (maybe several years, 250 days/yr). Non-carcinogenic risks were not calculated over a one year period unless appropriate, but in most cases, the average lifetime exposures for many of the exposure scenarios were several years.

30. *Page 6-91: Medium specific equation with all the parameters should be presented. For non-carcinogens, the average time should be the same as exposure durations. A 30 year exposure duration is recommended if no site-specific data is available in accordance with the "standard exposure factors" of the OSWER Directive 9285.3-03. The statement in the sixth paragraph for long-term concentration and the way to assess non-carcinogens is inappropriate.*

Site-specific exposure data were collected. Therefore, no default values such as "30 year

exposure duration" were needed. Medium specific equations will be provided. Non-carcinogenic risks were calculated according to current federal EPA guidance when guidance was available. When RfDs were not available for compounds with known systemic adverse health effects, surrogate RfDs were estimated for these compounds using structure activity relationships based on comparison to other structurally similar compounds with verified RfD values. We believe this approach reduces some of the uncertainty associated with risk characterization. In other words, we believe it is more important to take the compounds into account in some way as part of the assessment rather than ignoring them. As it turns out, other than for lead, there are no systemic health risks posed by the site. The risks that have been identified are for selected compounds where cancer is the endpoint. By taking full account of all compounds, we feel we are in a more defensible position (i.e., uncertainty has been reduced) in reaching this conclusion.

31. *Page 6-91, ¶2: The text should provide the "standard chemical intake equations" used to calculate average daily doses.*

A general form of the ADD equation was provided on pages 6-91. Media specific equations will be provided if needed.

32. *Page 6-91, ¶8: The uncertainty discussion is extremely weak as written. The probable effect on calculations (i.e., increasing in decreasing exposure estimates) of factors listed should be discussed, as suggested in RAGS.*

The uncertainty discussion will be elaborated on further.

33. *Page 6-93, ¶1: It is incorrect to calculate all the non-carcinogenic effects for all the compounds of interest. In fact, if the compound does not have RfD or other relevant non-carcinogenic toxicity data, it is impossible to assess this compound's non-carcinogenic effect.*

We disagree. Why is it impossible to estimate RfD for a compound with known systemic effects? Usually, these systemic effects have been well documented in primary scientific literature, EPA reports and in other public health publications from various governmental agencies. A verifiable RfD may not be available yet for a particular compound, but is currently under review by EPA headquarters. An acceptable scientific methodology which is used to estimate RfDs and used by EPA scientific community is the use of structure activity relationships. We believe an effort should be made to take account of the potential non-carcinogenic risks associated with these compounds in this assessment we used. Known lowest observable adverse effect levels for structurally similar compounds are used to estimate a LOAEL/NOAEL for compound without a RfD and applied in RfD calculation. The non-carcinogenic risk calculations would be underestimated if compounds of interest were not included in the calculation because they did not have verifiable RfDs, but were known to produce adverse systemic effects. We recognize that uncertainty is a key issue for risk assessment. By taking into account all compounds (those with verified as well as those without verified RfDs) we believe that uncertainty associated with "ignoring chemicals" is reduced. In the present case, other than for lead, there were no systemic (non-carcinogenic) health risks identified. Because we have made the effort to consider all compounds, we feel that we can reach this conclusion with greater certainty

than if we had ignored those compounds for which there are no verified values.

34. *Page 6-95, Table 6-28: The values presented in this table are not updated. The CPF of benzo(a)pyrene should be used as the default value for the CPFs of other carcinogenic PAHs. Benzo(g,h,i)perylene should be deleted from the carcinogenic PAHs category because it is a Group D compound. Also,it is not appropriate to list default RfDs for C-PAHs or include the calculation of C-PAHs for non-carcinogenic effects. For the non-carcinogenic PAHs, if there are no verified RfD available, the interim RfD for naphthalene should be used as the default value.*

The risk assessment was completed prior to EPA publishing its most recent policy on PAH compounds. There are probably hundreds of other risk assessments that are currently going through various levels of review. We propose to use the updated values to derive target levels for the Feasibility Study. In addition, we propose to modify the narrative of the report to discuss the implications of the new policy. We do not propose to generate a new set of spreadsheets and reports. This would take considerable effort for very little benefit. The current risk assessment clearly identifies the compounds, routes of exposure, and receptors that are most important to consider with regard to risk reduction. Carcinogenic risks associated with PAH are important for a number of these. These were calculated in our report by using the "old" CPF values for BaP and applying the EPA/Clement relative potency approach to other carcinogenic PAH. Based on the prevailing scientific understanding of PAHs at the time, this appeared to be the best approach. We have since recalculated the risks for the exposure scenarios where PAHs were of a concern. A cancer potency factor of 5.8 (mg/kg/d)-1 for benzo(a)pyrene was used as a default value for all carcinogenic PAHs for both ingestion and inhalation routes. The carcinogenic risks only changed slightly. If the original calculation did not indicate a carcinogenic risk for a particular exposure scenario than the recalculation also revealed no risk of cancer using both maximum and average concentrations of carcinogenic PAHs. This is due in part to the fact that we used the higher "old" CPF for BaP together with the relative potency approach. We understand that EPA still has not determined how to treat PAH compounds other than BaP. We recommend that until this is settled, the risks be calculated both ways (i.e., with and without the application of relative potency approach). Clearly, by treating all other PAHs as if they were BaP will overestimate the risk and lead to uncertain decisions concerning the need for and efficacy of remediation. With regard to the existing risk assessment, there will be no differences in the conclusions. We propose that this be discussed in the text of the report. The new CPF value for BaP will be used in the Feasibility Study.

We have estimated RfD values for those PAH compounds for which there are no values. We do not agree that naphthalene should be used as a surrogate for other PAH compounds and have gotten concurrence on this from EPA ECAO. The approach we have used is one that was developed as part of work we did in developing the Gas Research Institute (GRI) Guidance Document on PAHs and considers several sources of data. Again, the main objective was to take all PAHs (including those that are B2 carcinogens) into account when estimating the potential for systemic health risks. Simply because a compound is a B2 carcinogen does not mean that it has no systemic health effects. We selected surrogate values which we felt were conservative and generally representative of the PAH group as a whole.

35. *Page 6-99: The following comment is relative to note q to explain why we do not use the proposed MCL for lead to derive an RfD.*

A critical assumption implicit to the RfD is the concept of threshold (i.e., a dose level exists below which adverse health effects will not occur). This assumption precludes developing RfDs based on effects for which thresholds have not been established from experimental or epidemiological data or for chemicals for which theoretical considerations suggest the absence of a threshold. Carcinogens fall into this latter category; for example, theoretical considerations suggest a finite probability that cancer could arise from the interactions of a single molecule of a mutagen with DNA (USEPA 1986a).

Unlike the case for carcinogens, there is no widely accepted theoretical basis for the absence of a threshold for many of the health effects associated with blood lead levels and ALA-D activity, Vitamin D and prymidine metabolism, neuro-behavioral indices, growth and blood pressure indicate that associations may persist through the lowest blood lead levels in the populations tested (≤10-15 ug/dl). Thus, it is possible that if a threshold for the toxic effects of lead exists, it may lie within a range of blood levels < 10-15 ug/dl; however, the data currently available are not sufficient to adequately define the dose-response relationship for may of the toxic effects of lead in populations having blood lead levels, 10 ug/dl. Hence, it is not possible to confidently identify a blood lead level below which no undesirable health effects would occur.

The range of 10-15 ug/dl for blood levels represents a "level of concern". A level of concern is not the same as a threshold. In this case, a level of concern represents a blood lead level associated with health effects that warrant attention from a medical or governmental regulatory standpoint, and does not occur at lower levels of exposure (Davis, 1990).

The complex nature of lead exposure has not prevented advances in our understanding of dose-response relationships for lead in humans because many of the health effects of lead in humans are correlated with blood lead levels. Thus, blood lead (ug/dl) is more an appropriate benchmark for exposure than a level in air (mg/m^3) or an oral exposure level (mg/kg/day). Although it is unclear if health threshold exist for may lead exposure scenarios, significant concern is associated with blood lead levels, one may estimate change in risk of experiencing health effects associated with the blood lead level. By examining changes in blood lead distribution, estimates of population risk may be derived. It is possible to define critical changes of blood lead levels and associated effects. In this way, blood lead levels can be used to define risk in a relative sense.

It is currently feasible to utilize the biokinetic model to provide predictions of blood lead levels that will result from any given range of route-independent lead uptake rates and vice-versa (USEPA, 1989a). These models allow benchmark blood lead levels to be related quantitatively to route-independent uptake rates and can provide estimates of frequency distributions of blood lead levels associate with any given uptake.

In summary, the RfD approach at this time, is inappropriate for lead based on our current understanding of the dose-response relationship and unresolved toxicological issues, for the various effects of lead and multimedia nature of lead exposure. Multimedia exposure analysis couple with predictive biokinetic models, however, provide a powerful tool for developing an

alternative and more useful alternative risk assessment strategy for lead.

We agree, the use of IUBK model is more appropriate. In the Feasibility Study, this model will be used to estimate lead target clean up levels in soil for areas with exposure scenarios where lead is an issue.

36. *Page 6-99: Toxicity data should be based on IRIS. If the compound does not have toxicity value on IRIS, the HEAST should be referenced. A FY-1991 HEAST is now available.*

We may have used HEAST 1990, but for our compounds of interest, none of RfDs or carcinogenic slope factors have changed in most recent HEAST Fy-1991. We will change the reference citation in the table.

37. *Page 6-103, ¶5: The reason for not investigating the possibility of contaminant vapors entering the museum (presumably because the site is paved) should be stated.*

The reason for not investigating the possibility of contaminant vapors entering the museum is because this area is step I site. We acknowledge that vapors could enter the museum; however, this has not been assessed as part of Step I but will be considered under Step II.

38. *Page 6-104, Section 6.4.2.1: It is not appropriate to use the term "ADD(life)", because the dose should be calculated based on site specific duration (less than 30 years) or use the standard duration of 30 years.*

We disagree. The ADD(life) calculation is correct. The exposure durations (days/year conducting a certain activity) and average lifetime exposure (number of years exposed to the site) are based on site-specific information, but average lifetime was kept constant at 70 years following Superfund guidance.

39. *Page 6-105, ¶4: A zonal approach may be appropriate for evaluating risks from some media. For example, several sites may all contribute to risk for residence via inhalation and, therefore, should be combined in final risk estimates.*

We agree. The zonal approach was used throughout the site for all potentially exposed populations. Because of the nature of site activities, potentially exposed individuals could visit many areas of the site and participate in several activities, therefore having multiple site exposures. In preliminary screening, the compounds of concern initially had to represent all areas of the site so that the total site risk for a specific exposed population could be calculated. If a site compound of concern was not detected in a certain site area, then the compound was not included in the risk calculations for those exposure scenarios developed for that particular site area.

40. *Page 6-117, ¶4: See comment for Page 6-91, ¶8 regarding the uncertainty decision.*

See response to comment for page 6-91, ¶8.

41. *Page 7-1, ¶4: The EPA guidance referenced for ecological risk assessment (EPA, 1986) is*

incorrect; EPA, 1989 and EPA, Region I, 1989 are the correct citations.

The correct citations will be added.

42. *Page 7-2, ¶5: The report states: "Compounds of concern were detected in environmental media at the CBU Drum Storage Area and OBDANE sites at very low concentrations and, therefore, these sites were excluded from further assessment. The Rubble Fill at the Bunker A-86 site was only qualitatively evaluated from a human health risk standpoint." A discussion should be provided as to whether or not there are any potential ecological receptors at or near these sites and a table provided showing levels of contamination detected and appropriate benchmarks before stating there are no ecological risks from these sites.*

    Paragraph 5 does not state that there are no ecological risks from these sites. It states that we did not assess risks due to these sites because of the low concentrations of compounds of concern. The text will be expanded to discuss qualitatively the concentrations of compounds detected in these areas and why they are unlikely to pose an ecological risk.

43. *Page 7-3, ¶2: The compounds of interest used for the ecological assessment were identical to those selected for the human health risk assessment. Selection of contaminants of concern for the ecological risk assessment should consider potential to bioaccumulate and any differences in toxicity between humans and other biota. It is of concern that potential effects of pesticides and PCBs were eliminated from consideration in the ecological risk assessment. Is it realistic to expect that they will be confined to the subsurface or is absence from other media a reflection of inadequate sampling?*

    The compounds of concern were the same for both the ecological and human health risk assessments. Because of the stringent criteria for selecting compounds and the desire to work with a master list for the site as a whole, they included almost all compounds detected in any medium. Refer to response to comment 4 for further discussion of selection of compounds of interest. For the ecological risk assessment, compounds were also eliminated from consideration if they were not detected in a medium to which ecological receptors might be exposed. The media that do not represent ecological exposures are subsurface soil below a depth of four feet and ground water outside of areas where ground water is likely to discharge to the ground surface (outside of the Area A Wetlands). The PCBs and pesticides "eliminated from consideration in the ecological risk assessment" were those that were detected only in media to which an ecological receptor would not be exposed. We will clarify this section by adding sentences that explain that certain contaminants in the subsurface are expected to remain in the subsurface and no exposure of ecological receptors to these contaminants is anticipated.

44. *Page 7-3, ¶3: See comment for Page 2-2, ¶5 regarding treatment of non-detects.*

    The treatment of non-detects for the ecological risk assessment was the same as for the human health risk assessment. Compounds that were not detected in any exposure medium were assumed to have a concentration of zero. For compounds that were detected in an exposure medium, but not in an individual sample, the concentration in that sample was assumed to be one half the Contract Required Quantitation Limit as given on Table

2-1. This will be clarified in the text.

45. *Page 7-4, ¶5,7: The Connecticut Natural Heritage Program or a comparable state agency should have been consulted to determine whether or not there are any endangered, threatened, or special concern species on or in the vicinity of the base. U.S. Fish and Wildlife Services should be contact to determine if there are additional trustee resources.*

In preparing a draft environmental impact statement for the Thames River Dredging Project, both the CTDEP and the United States Fish and Wildlife Service were contacted regarding the existence of threatened or endangered species in the vicinity of the proposed dredging project. This area includes all the investigation sites under this study. No known threatened or endangered species are known to exist in the project area. Furthermore, the ecological survey for the risk assessment did not detect the presence of any endangered species at NSB-NLON.

However, the Connecticut Natural Heritage Program and the U.S. Fish and Wildlife Service will be contacted regarding endangered, threatened, or special concern species in the vicinity of the base. This information will be added to this section.

46. *Page 7-4, ¶7: Field forms from the site visits should be provided in Appendix F.*

"Field forms" as such were not used during site visits performed to characterize the ecological receptors at the site. However, a video tape of one of the site visits is available and mention of this will be made in the text. Notes, which consist of a drawing and species list, provided by the ornithologist that performed this site visit, Trevor Lloyd Evans of Manomet Bird Observatory, were included in Appendix F-1. This could be clarified on Page 7-5, Paragraph 5.

47. *Page 7-4, ¶8: The report does not state whether or not a formal wetlands delineation in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands was performed. Wetlands potentially impacted by contamination or remediation should be delineated during the remedial investigation.*

A formal wetlands delineation in accordance with the Federal Manual for Identifying and Delineating Jurisdictional Wetlands was not performed as part of this program.

We are aware that wetlands exist in Area A, and the general boundaries are known. The wetlands regulations will be considered as an ARAR. Following the Feasibility Study, and as part of any remedial design, specific wetlands procedures will be established at that time.

48. *Page 7-5, ¶5: The lists of species observed provided in Appendix F should be supplemented with a literature search to include species expected in the area, especially those that might be difficult to observe in the course of several site visits.*

The species list in the Appendix is fairly inclusive. However, the Connecticut Natural Heritage program, or other sources might be able to provide more information on possible visiting species.

49. *Page 7-5, ¶6: Partially based on the October 8th Site visit in which the downstream ponds and watercourses appeared barren, in order to obtain a baseline on lower food web organisms to evaluate contaminant and potential remediation impact, benthic and invertebrate surveys should be undertaken at the downstream ponds and watercourses.*

A benthic invertebrate survey of the downstream ponds and water courses is being considered for the supplemental sampling work plan.

50. *Page 7-9, ¶1: Amphibians and aquatic birds, mammals, and plants also will be exposed to potentially contaminated ground water discharge, surface water, sediment, and biota at lower trophic levels.*

The statement provided by EPA will be included in this section. Work under consideration for the additional sampling work plan includes an assessment of ecological receptors in the Thames River.

51. *Page 7-9, ¶8: The report states: "Those carnivores whose diets are comprised largely of soil invertebrates will be at greatest risk". Higher order carnivores are likely to be at greater risk if contaminants that bioaccumulate (i.e., DDT) are involved.*

This paragraph should include a sentence referring to potential bioaccumulation and risks to higher trophic level carnivores. However, risks to higher level carnivores may not be greater than risks to consumers of soil invertebrates because the higher trophic level fauna may have a greater feeding area, and therefore, be exposed to less contamination overall.

52. *Page 7-10, ¶2: It would be useful to know whether or not fish are actually present in the ponds in question. If they are not present, then a determination should be made as to whether their absence is a result of pond structure or site-related contamination.*

It is likely that fish are not present in the ponds due to their structure and hydrology. This will be stated in the text. Additional assessment of the presence of fish and other ecological receptors in the Area A Downstream ponds will be considered for the additional sampling work plan.

53. *Page 7-10, ¶5: Please provide a justification for not evaluating the effect of DDT contamination of surface soils/sediments on plants.*

This section will be expanded to explain the reasons why DDT in surface soils and sediments is unlikely to pose a risk to plants.

54. *Page 7-11, ¶3: Extreme caution should be used in interpreting the result of comparing contaminant concentrations in ground water to AWQC to assess the effects of contaminants on soil invertebrates because AWQC were developed for aquatic species and soil invertebrates may have different uptake of an sensitivities to contaminants.*

We discussed this later in the toxicity section. We will add a few sentences about it here.

55. *Page 7-11, ¶5: When reviewing the calculations, the method stated for determination of the*

toxicity quotient is in error. It should be stated that the toxicity quotient is calculated by dividing the soil/sediment concentration by the sediment quality criterion. The associated Appendix results are correct.

The sentence should be changed to read: "The toxicity quotient was then calculated as the measured soil concentration divided by the sediment criterion."

56. *Page 7-12, ¶6: The final equation for concentration in the organism does not follow from the previous equations. For example, there are no exponents in an equations used in the development of this equation.*

If additional samples are taken, organic carbon content should be determined for site soils and sediments, so that actual values can be used in determining contaminant concentrations.

There is a typographical error in the text. The "m" should be an exponent. The relationship between K_{oc} and K_{ow} on page 7-11 should read:

$$K_{oc} = xK_{ow}^{m}.$$

The equation for C_s on page 7-1 should be changed accordingly. We agree that organic carbon content should be measured in additional soil or sediment samples that may be collected.

57. *Page 7-12, last ¶: Potential ecological risk due to sediment/soil contact using the EP approach is based to a large extent on the organic carbon of the media. A 5% carbon content is stated as an assumption with no further explanation. In order to estimate associated risk as accurately as possible, actual organic carbon content must be determined through sampling and analyses along side chemical. These analyses should pertain to both lotic and lentic systems.*

Measurements of organic carbon content should be used, if available, to assess risks as accurately as possible using the EP Method. We will qualify our statement about assuming a 5% organic carbon content and compare it to measurements made elsewhere. We will also add a section discussing the effect the uncertainty in the estimate has on the results.

58. *Page 7-13, ¶3: A habitat description should be provided for the Manomet Bird Observatory in Massachusetts to justify its use as a reference station. It would be preferable to select a reference station closer to the site.*

We could provide more justification for using Manomet Bird Observatory as a reference location.

59. *Page 7-13, ¶3: (a) Is the reason for the lack of fish in the ponds of the downstream area an indication of a stressed system?*

(b) It seems that the sample number totalling six frogs for the Area A Wetlands and Downstream areas shows a lack of representation of biota for the area in question. If possible, the samples should be taken at various locations throughout the area to adequately represent

the area.

(c) There is no indication of bird sample locations on Plate 6-1 as stated in this paragraph.

(a) The assessment of the downstream ponds for fish and other ecological receptors will be considered in the additional sampling work plan.

(b) We do not claim that six frogs are representative of the site. They do give some indication as to conditions in portions of the site. Assessment of ecological receptors in the Area A ponds is being considered for the additional sampling work plan.

(c) Bird sample locations will be added to Plate 6-1.

60. *Page 7-13, ¶4: If the problem of migration was a consideration, why wasn't a more likely non-migratory species chosen?*

The catbird was chosen for analysis because it is abundant at the site, and, therefore is representative of invertebrate-eating birds at the site. Since catbirds nest at the site, the collection of fledglings allowed us to circumvent the "problem" of migration.

61. *Page 7-13, ¶5: Further justification should be provided for not estimating bird and mammal body burdens for metals occurring above background levels. Heavy metals could be persistent in the environment and are toxic to vertebrates.*

We will provide additional explanation regarding metals levels at the site and whether they are likely to pose risks to birds and mammals.

62. *Page 7-13, ¶8: As stated in this report, fledgling catbirds are more likely to have fed in the study area than elsewhere; however, they have had less time to accumulate contaminants than adult birds, and may underestimate the magnitude of the contamination. Also, catbirds feed on low trophic levels, and thus are not the best choice for assessing affects of contaminants that bioaccumulate; predatory birds would be a better choice. Please provide a justification as to why body burdens of contaminants were not estimated for predatory birds.*

We consulted the U.S. Fish and Wildlife Service prior to collecting birds for analysis regarding methods of collection and appropriateness of species. They agreed that contaminants detected in fledgling catbird tissue would be representative of site-related risks. Predatory birds have a large migratory range, and it would be impossible to relate contaminants detected in their tissues to exposures at the site.

The risk assessment did estimate risks to predatory birds due to DDTR in Section 7.5.3.3. These estimates were based on estimated body burdens in small birds and mammals and measured concentrations in fledgling catbirds.

63. *Page 7-17, ¶4: See comment for Page 7-13, ¶3 regarding selection of a reference area.*

We will add a section discussing the selection of a reference area for birds.

64. *Page 7-17, ¶6: The uncertainty discussion as presented is weak. Typically, uncertainties associated with sampling methods and locations, assumptions used in models, selection of benchmarks, etc. should be discussed with respect to whether they are likely to under- or overestimate dose.*

The uncertainty section will be augmented to discuss uncertainties associated with sampling locations, model assumptions, dose estimates, benchmarks used, etc.

65. *Page 7-20, ¶1: Biota (frog) and pond sediment samples were taken from different areas and showed different contaminant levels. Therefore, additional sampling of biota and pond sediments/water may be require to fully characterize and assess the effects of contamination at this site.*

Assessment of ecological receptors in the Area A ponds is being considered for the additional sampling work plan.

66. *Page 7-21, ¶3: The general approach taken for calculating NOAELs from acute/chronic lowest observed effect levels was to multiply by 0.1. It may be appropriate to multiply these values by 0.01 to account for differences in sensitivity among species. While the primary interest is in evaluating population effects rather than individual effects, individual effects can lead to population effects. See comment for Page 7-33, ¶4.*

Wherever possible we took NOAEL and LOAEL data from Ambient Water Quality Criteria documents, where appropriate. NOAELs and LOAELs published in these documents are chosen to represent the most sensitive species tested. Where we referred to the literature for NOAEL and LOAEL data, we chose the most sensitive representative species for which data were available. Since most of the NOAEL data we had represented sensitive species, we used a factor of 0.1 rather than 0.01 to calculate NOAELs from LOAELs. We believe this represents a conservative approach.

67. *Page 7-25: Provide references for EPA, 1987 and USACOE, 1984.*

EPA, 1987 is EPA, 1986 updated May 1, 1987. This will be changed in the table and reference section. The other reference is:

U.S. Army Corps of Engineers, 1984. Review: The Effects and Occurrence of Phthalate Esters in Aquatic Organisms and Sediments, Grays Harbor Navigation Project Operations and Maintenance.

68. *Page 7-27, Table 7-6: Arsenic, cadmium, copper and iron should be shaded as they exceed AWQC chronic values.*

Shading will be added to the table. Maximum concentrations of lead and zinc should also be shaded.

69. *Page 7-29: Provide the units for the concentrations given in this table.*

Units (ug/l) are in Note 1 on the second page of the table (on Page 7-30).

70. *Page 7-33, ¶4: The report states: "We assume that if effects are judged to be insignificant at the average individual level, they are probably insignificant at the population level". This state is not necessarily correct. If a particular sex or age class is more sensitive than the average individual, population effects will occur, even if the hypothetical average individual is unaffected.*

We will clarify our statement. There are insufficient data to characterize risks to all site biota at all life stages. Our assessment used available data to assess ecological risks. We will add EPA's statement to this section, but the data are not available to assess these potential hypothetical effects.

71. *Page 7-40, ¶5: Sediment concentrations of zinc could potentially have effects on organisms consuming contaminated plants. However, absence of zinc contamination in surface water was used to claim the risks from zinc contamination in sediments as low. It is inappropriate to use data from one media to evaluate risk in another media, as was done here and elsewhere in this report.*

We mentioned the zinc surface water concentrations to emphasize the fact that zinc sediment concentrations were not contributing to elevated surface water concentrations. The intention was to put the magnitude or the elevated zinc concentrations into perspective. We will clarify this in the text.

72. *Page 7-47, ¶3: High acetone concentrations are attributed to the possibility of laboratory contamination. It should be stated whether acetone was found in blanks and at what concentration.*

Many samples were blank-corrected for acetone as part of data validation. This could only be done when associated blanks contained acetone. Those samples which were reported as containing acetone did not have contaminated associated blanks. The fact that acetone was found in several field and system blanks coupled with the fact that it is a recognized potential laboratory contaminant, led to the conclusion that acetone detections can be attributable to laboratory contamination.

73. *Page 7-47, ¶4: Further explanation should be provided as to why DDT detection limits were high.*

DDT detection limits were not high relative to Contract Required Detection Limits. Pesticide detection limits were calculated based on the percent moisture of a sample on an individual basis as required. The text refers to the fact that DDT detection limits were high relative to toxicity standards and, therefore, using 1/2 the detection limit as the value for non-detected sample results in a conservative estimate of ecological risk.

74. *Page 7-50, ¶5: It is inappropriate to conclude risks are slight from heavy metals when chronic risk quotients range up to 100.*

The toxicity quotients for risks to soil invertebrates due to metals in ground water were calculated by dividing the ground water concentrations by the chronic Ambient Water Quality Criteria. Paragraph 5 discusses the great uncertainty involved in this method

and, therefore, why these toxicity quotients for metals may not be indicative of great risk. This will be clarified further in the text.

75. *Page 7-53: Although the theoretical presentation of the approach, the Navy used to calculate doses of PAH and DDTR for small mammals and birds is reasonable, insufficient information was presented to allow independent verification of calculations.*

We will add text that will explain the calculations in detail.

76. *Page 7-54, ¶3: It is inappropriate to eliminate the surface soil sample taken just west of the woodland (2WSD9) from consideration because it had higher contaminant levels than other samples; it may represent a local hot spot.*

One surficial soil sample collected from outside the wetland (2WSD9) had PAH concentrations at least two orders of magnitude greater than the remaining samples from within the wetland. We calculated risks to small carnivorous birds and mammals due to ingestion of contaminated soil invertebrates including and excluding this sample from the average soil concentration. We presented risks based on both calculated averages to express the range of risks to these organisms. This will be clarified in the text.

77. *Page 7-54, ¶4: While mammals and birds feeding directly on invertebrates may be maximally exposed to soil contaminants that do not bioaccumulate, they are unlikely to be maximally exposed to contaminants that do bioaccumulate. Potential effects on these organisms cannot be properly evaluated based on risk calculations for other trophic levels. The effects of contaminants on aquatic birds that may be exposed to contaminants in a variety of media (surface water, sediments, and biota) also cannot be evaluated with the risk calculations provided.*

We restricted our calculation of risk to certain trophic levels exposed via certain routes. Risk to small birds and mammals were calculated based on ingestion of contaminants in soil invertebrates. We acknowledge that some birds and mammals will be exposed to site contaminants through different exposure routes. However, we did not calculate risk for every exposure route as there is no method of doing so at this time. Also, our goal was to assess ecological risks, generally, rather than calculate a likelihood of risk for every species and every exposure route.

NAVY'S RESPONSE TO CTDEP'S COMMENTS OF NOVEMBER 25, 1991 (MARCH 26, 1992)

NAVY RESPONSES TO THE CTDEP'S COMMENTS (NOVEMBER 25, 1991) ON DRAFT IR REPORT (AUGUST 1991)

General Comments

1. *Radiation surveys were performed by Radiation Safety Associates, Inc. (RSA) of Hebron, Connecticut for the Area A Landfill, Goss Cove Landfill and DRMO. It is noted that the surveys are contained in a separately bound report. A copy of this report is required by the State for our records.*

   This report has previously been provided.

2. *Please supply the report on the geophysical work performed by Weston Geophysical of Westboro, Massachusetts. The RI report noted that the complete geophysical report is contained in a separately bound report.*

   This report will be provided.

3. *Background concentrations for inorganics at the Groton Subase were based on the data supplied by the US Geological Survey for the Eastern United States. This data was used as the standard in determining whether site-related inorganic sampling results were exceeded. This is not an acceptable practice because of site-specific variations in geology and soil type. Background samples should be obtained for each site in determining whether site-related activities have had an impact on the site.*

   These values were used for illustrative and comparative purposes. Even if we complied with this request, it would not affect the conclusions of the study with respect to human health or environmental impact. Actual metals concentrations were used in these assessments and in the calculation of risk. We would propose to add a discussion to indicate that actual background concentrations at this site are less than the USGS published values.

4. *<u>Section 1.2.3.1, Page 1-5</u>: In 1991, the CTDEP issued a report containing revisions to the 1987 "Connecticut Water Quality Standards and Criteria". This section should be changed to reflect those changes. In addition, the last sentence in the second paragraph noted the following for the ground water classification of GB/GA: "The immediate goal, where appropriate, is to maintain the water at Class GB condition; the long term goal is to restore the water to drinking water quality (GA)". The State's goal is to restore the ground water to drinking water quality for this classification. It is inaccurate to state that there is an immediate goal to maintain the water at a Class GB condition.*

   These requested changes to the text will be made.

5. *Section 3.7.2, Page 3-20: The ground water flow velocity should be 1.4 feet/day, not 1.7 feet/day as stated in the text.*

This change will be made.

6. *Section 3.7.5, Page 3-27: There is a monitoring well identified as 2LMW13D listed in the text of this section. This monitoring well does not appear on Figure 3-16. Please identify where this monitoring well is located.*

Well 2LMW13S on Figure 3-16 is incorrect. It will be relabelled 2LMW13D.

7. *Section 3.7.5, Page 3-35: In constructing the ground water elevation contour map for Area A, offsite wells east of RT12 were pumped for twenty minutes before water level elevations were measured. The rationale for this procedure needs to be explained.*

The residential wells were pumped for twenty minutes to allow any drawdown to occur, thereby, the lowest well elevation was measured. The lowest well measurement (lowest elevation) was used because this represents a worst case condition with respect to ground water gradient from offbase wells to on-base wells (e.g., does well drawdown create a condition where on-base ground water contamination could migrate to offsite wells). This explanation will be added to the text.

8. *Plate 3-3: Ground water contours shown on this plate indicate that some of the water table elevations are plotted higher than the land surface. Please make appropriate corrections.*

This plate will be reviewed.

9. *Section 3.8, Page 3-48: Please indicated what source was used within the Town of New London to establish temperatures, variant ranges in temperatures and precipitation for southeastern Connecticut.*

The source was the Subase Master Plan. The Master Plan did not specify the specific source of the data.

10. *Table 4-1A, Page 4-3: Under the column labeled ARAR for the State of Connecticut, Pesticide Control should be labeled as Pesticide/PCB.*

This change with be made.

11. *Section 1.2.5.1, Page 4-18: It was noted in the 1983 Initial Assessment Study (IAS) that some of the 55-gallon drums were found leaking. Please note if the soil samples acquired during the remedial investigation were taken from where the observed releases occurred.*

There is no specific documentation to indicate exactly where leaking drums were located in this area. However, based on the small size of the area, the three samples provided adequate screening of the site for potential contamination.

12. *Section 4.5, Page 4-25: It is noted that the concentration of delta-BHC and methoxychlor from the surface soil composite sample 4SS3C (Rubble Fill at Bunker A-86) is likely associated with past Area A pesticide applications and not from discrete disposal activities associated with this site. These compounds were not identified in any of the sampling results obtained from the Area A (landfill, wetlands and downstream watercourses) site. Explain the rationale for the conclusion stated.*

The text will be revised to reflect both application or disposal as possibilities. We have recommended that this site proceed to Step II evaluation and in full extent of onsite contamination will be investigated.

13. *Section 4.6.1, Page 4-25: It is noted that the highest concentration of an unknown VOC (possibly toluene) was detected at location SG-21 during the soil gas survey. Future investigations of the northern septic system (which formerly served the Torpedo Shops site) need to identify and quantify what the unknown VOCs are in this area.*

This area could not be sampled because accessibility was difficult with a drill rig. Well 7MW2 was downgradient of this location, and significant concentrations of solvents were not detected in the ground water. A soil sample collected by hand auger will be considered for future investigation.

14. *Section 4.6.2, Page 4-31: An odor was encountered during the drilling of monitor well 7MW1 and was described as that similar to "Simple Green". Identify the components of Simple Green and if the soil sampling results obtained from monitor well 7MW1 correlate with this product.*

Requests to the company which produces "Simple Green" during the preparation of the IR report were unsuccessful in determining the components of this product.

15. *Section 4.8, Page 4-47: It was found that field measured organic vapor readings for surface soil location 14SS1D were detected above background levels for the Obdane site. This surface soil sample came up non-detect under lab analysis for VOCs. Please identify what the background reading was on the PID and what may be the cause or source of the higher background levels.*

The PID reading was 50 ppm at 14SS1D, the background reading was 1 ppm. The cause of the reading is unknown but PIDs do give false positive readings at times.

16. *Section 4.11.1.1, Page 4-58: Identify if any background readings were taken during the performance of the radiation survey at the Area A Landfill. In addition, explain why gamma readings equal to or greater than 20 μR/hr for each surveyed point was used as a benchmark for further investigation as to the origin of the radiation. it is noted that location 8.5E showed 21 μR/hr at waist level and 19 μR/hr in contact with the ground. Explain how the radiation level can be higher at the waist than in contact with the ground.*

In response to this comment, the following paragraphs have been excerpted from the Radiological Assessment Report.

"Location 8.5-E showed 21 μR/hr at waist level and 19 μR/hr in contact with the ground. These levels were traced to a natural rock outcropping in that area. Most rock in New England contain some traces of naturally-occurring uranium, radium, and thorium; finding individual rocks or rock fragments with detectable amounts of radiation is not at all unusual and is not indicative of any radioactive contamination.

Measurements of background radiation were taken outside the perimeter of each area surveyed as well as in several random locations around the base, such as on the golf course (at the corner of Shark Avenue and Wahoo Avenue), at the corner of Thresher Avenue and Corsair Avenue, and at the corner of Crystal Lake Road and the Military highway. Background gamma radiation measured between 12 and 15 μR/hr in all these locations. Background beta radiation in all locations measured 60-80 counts per minute. Background alpha readings were 1-2 counts per minute. These levels are well within what is considered "normal" for this region. Any gamma reading of 20 μR/hr or more in the survey areas was investigated further.

A gamma radiation reading of 20 μR/hr or more was used as a trigger point at which further surveys and evaluations were performed."

17. *Section 4.11.1.4, Page 4-74: It is noted that PCBs were detected in two surface soil samples (2LSS1 & 2LSS2) that are located adjacent to the concrete storage pad where drums, PCB transformers and electric switches were once stored. Figure 4-16 and Plate 4-1 identify where the samples are located, but do not depict where the pad is located. The location of the pad should be depicted in the figure and plate.*

This request will be complied with.

18. *Table 4-32, Page 4-103: This table lists the ground water ARAR for benzene at 5 ppb. Table 4-14 (page 4-45) notes that the To Be Considered (TBC) level for benzene is 1 ppb for ground water at the Goss Cove Landfill. Please explain why a different standard is used at each location for the same constituent in the ground water.*

Table 4-14 will be revised to reflect the benzene ARAR as 5 ppb.

19. *Section 4.11.6, Page 4-118: Information on page 6-82 noted that surface water sampling locations (2DSW12 & 2DSW13) are approximately ten feet away from the outfalls of the Area A Downstream Watercourses. This information should be included on page 4-118 when discussing surface water sampling results.*

This request will be complied with.

20. *Section 4.11.6, Page 4-122: It is unclear where an upgradient sample designated as 2LWSD1 is located.*

This sample was incorrectly referenced in the text as 2LWSD1; it will be changed to 2WSW1. It's location is shown on Figure 4-16 and Plate 4-1.

21. *Plate 4-1, End of Report: Monitoring well 2DMW15S is not displayed on Plate 4-1. However, it is shown on Figure 4-22 on page 4-89. Please revise Plate 4-1 to show the monitoring well location.*

The location of 2DMW15S will be added to Plates 4-1 and 6-1. Please note, as indicated on Figure 4-22, that this was only a boring because ground water was not encountered in the overburden.

22. *Section 6.2.3, Page 6-82: Title of this section should be "Qualification of Exposure" for Step I sites.*

This heading pertains to both Step I and II sites. For the Step I site, the text is clear that the exposure is based on a qualitative basis. Therefore, this change is not believed to be required.

23. *Section 6.2.3.1, Page 6-82: It was noted that the pesticides identified at the Rubble Fill at Bunker A-86 might be indicative of localized contamination because they were different from the pesticides detected at the NSB-NLON. This statement is contrary to the conclusion reached in Section 4.5 on page 4-25. The text on page 4-25 indicates that the pesticides were likely associated with historic Area A applications and not as a result of disposal activities identified with the Rubble Fill at Bunker A-86.*

The text in Section 4.0 will be revised to be consistent with Section 6.0.

24. *Section 8.1.1.2, Page 8-1: Although no further action was recommended for the CBU Drum Storage Area, further investigation is warranted for the following reasons: 1) total petroleum hydrocarbons (TPH) were found at each surface soil sample location at concentrations ranging up to 9800 ppm; 2) except for sample 1SS1, TPH concentrations at the other two sample locations (1SS2 & 1SS3 increased with depth); and 3) the composite sample (1SS4C) indicated the presence of two PAHs. Further sampling of soils is required to characterize the depth and lateral extent of contamination. The potential exists that ground water in this area may have been impacted from the documented leakage of drums which contained waste oil, lube oil, and paint materials.*

We feel the site has been adequately investigated and assessed to support the no further action recommendation. We will discuss it further with the CTDEP and the USEPA.

25. *Section 8.1.3.2, Page 8-3: The report has recommended that the Torpedo Shops proceed to the Step II phase of the Installation Restoration (IR) program. It is recommended that an inventory of compounds that are or have been used at the Torpedo Shops be compile to assist in a review of this site.*

Comment is so noted.

26. *Section 8.1.4.2, Page 8-5: Any future subgrade construction projects planned for the Goss Cove Landfill, on which the Nautilus Museum is located, should be noted in this section or that the information exists in Appendix E. In addition, it is noted that worker health and safety will be assessed for any future construction activities proposed at this site. Potential*

public exposure to VOCs and/or fugitive dust should also be addressed in this assessment.

The text will be revised to note that some utility reconstruction is being designed. We concur that exposure to VOCs and\or fugitive dust should be addressed in the construction plans/specifications.

27. *Section 8.1.6.2, Page 8-7: If any future construction activity is required at the Spent Acid Storage and Disposal Area, health and safety considerations should include the public.*

We concur.

28. *Section 8.2.1.2, Landfill Soils, Page 8-18: It was recommended that further soil sampling should be accomplished around the Area A concrete pad to define the full extent of contamination. In addition, a sampling plan to address PCB contamination of the concrete pad should be conducted. this plan should include areal wipe samples and chip and/or core samples to determine the depth of potential contamination. This action appears appropriate due to the storage of drums and transformers on the pad and the subsequent discovery of PCBs in the soils adjacent to the pad.*

This request will be considered in the development of the supplemental field investigation work plan for this site.

29. *Area A Downstream, Page 8-11: Further characterization of the area around sample location 2DMW15S may be necessary due to an unconfirmed report stating that past disposal may have occurred in this general vicinity. It is possible that the TCE and PCE detected in the subsurface soils may be related to this activity.*

Further review of this claim with Subase personnel and an examination of aerial photographs did not substantiate this claim.

NAVY'S RESPONSE TO TOWN OF WATERFORD COMMENTS OF OCTOBER 16, 1991 (MARCH 26, 1992)

NAVY RESPONSES TO TRC COMMENTS ON DRAFT IR REPORT (AUGUST 1991)

Town of Waterford (October 16, 1991)

1. *The recommendations contained in Section 8 summary and conclusions relative to moving forward with Step II investigations and feasibility studies for remediation are supported. We are particularly interested and supportive of the additional testing to be conducted in the Thames River. These investigations should include ground and surface water quality monitoring on a regular interval.*

   Additional ground water and surface water sampling and analysis will be conducted in future investigations.

2. *Sediment testing and sampling of fish and shellfish adjacent to the base should be done. I have attached a report from John Volk, Director of the Agriculture Division of the State Department of Agriculture. This report on the status of shellfishing in the Thames River indicates that due to chemical and sewage discharges from the base (page 3) a prohibited area was established 1000' into the River.*

   The provided information will be considered in designing future field investigations.

3. *In your consideration of ARAR, the degree of remediation to be undertaken, particularly as it relates to compliance with state surface and ground water quality classification goals, it is recommended that all reasonable efforts be taken to identify and control discharges to the river. It is recommended that you contact Mr. Volk for any guidance he may be able to provide to you in studying the shellfish resources adjacent to the base. I have also attached the maps showing the location of shellfish beds leased by the Town of Waterford in the Thames River.*

   Comment so noted.

4. *In reviewing the information for the Goss Cove Landfill, there appears to be some uncertainty regarding levels of radioactivity in samples taken. I raised the question at the last TRC meeting, whether or not the Navy had verified the disposal of all low level radwaste generated on the site. The answer is no. Will the Navy be reviewing its records of disposal of low level and other nuclear wastes generated onsite?*

   In 1966, 1972, and again in 1989, the EPA conducted independent environmental monitoring for radioactivity associated with nuclear powered warships at SUBASE NLON. EPA monitoring included analysis of samples taken from SUBASE NLON and direct radiation level measurements using sensitive detection equipment. The results of

the EPA monitoring confirm the absence of a threat to human health or the environment from radionuclides associated with the operation and maintenance of naval nuclear propulsion plant, and confirm those of separate Navy monitoring, reported annually. (See Naval Nuclear Propulsion Program Report NT-91-1). The EPA Results also verify that the Naval Nuclear Propulsion Program's practices (e.g., prohibiting intentional discharge of liquids containing low-level radioactivity to the harbor environment, reuse of radioactive liquids to the maximum practical extent and solidification of those liquids that cannot be reused), and disposal facilities (radioactive waste associated with naval nuclear propulsion plants has never been buried at SUBASE NLON) have been successful in ensuring that there is no radioactivity associated with the Naval Nuclear Propulsion Program at or near SUBASE NLON that requires remediation.

5. *Sewage discharge was assumed to have been resolved with the connection of the base to public sewers. Mr. Volks letter indicates that sewage discharges are one of the reasons for the prohibited shellfish designation. Have all buildings been connected and are there any tests of surface and ground waters for fecal chloroform that have been conducted to determine if in fact sewage discharges are still occurring?*

Testing done for our National Pollution Discharge Elimination System permit application did indicate the presence of fecal coliform in some storm sewer discharges. We have requested funding to do a survey of the lower base storm and sanitary sewer systems to determine sources of any cross-connections. We intend to proceed as soon as funding is available.

6. *In my review of the study, there was not any discussion of efforts to institute a set of best management practices to insure that spills and discharges of chemicals are prevented in the future. What actions have been taken to comprehensively address the handling of materials and should these efforts be documented in this study.*

The intent of the remedial investigation was to characterize contamination that exists from past releases. Information on current management practices are not included in the report as they are not part of the focus of the study. The Submarine Base controls petroleum and hazardous materials through a number of structural and operational practices. We have recently completed a tank replacement program, where we replaced, abandoned or removed from service and emptied all oil storage tanks over 20 years old. Above ground tanks storing oil and chemical products have secondary containment systems. Our Spill Prevention, Control and Counter Measure Plan is currently being updated and all improvements recommended will be instituted. Hazardous material storage, use, and disposal are controlled by the SUBASE NLON Hazardous Material Management and Hazardous Waste Management Plans. Additionally, we have a Spill Contingency Plan with highly trained and well equipped personnel ready to response to any release.

NAVY'S RESPONSE TO NOAA'S COMMENTS OF SEPTEMBER 22, 1991 (MARCH 26, 1992)

NAVY RESPONSES TO NOAA'S LETTER (SEPTEMBER 27, 1991) ON DRAFT IR REPORT (AUGUST 1991)

The comments from the National Oceanic and Atmospheric Administration (NOAA) were reviewed. They principally included a summarization of the information included in the report. Most comments regarding additional investigation are already included in the site specific recommendations in Section 8.0. Therefore, no specific response to NOAA's letter is provided.

NAVY'S RESPONSES TO THE FISH AND WILDLIFE SERVICE COMMENTS (DECEMBER 6, 1991) ON THE DRAFT IR REPORT (AUGUST, 1991)

1. General

Several of the "To Be Considered" (TBC) values and background concentrations used for the NSB-NLON investigation appear high. The soil or sediment TBC values for PCB (10 ppm), DDT (500 ppb) and the background concentrations for several inorganics exceed the tenth percentile effect range (ER-L) concentrations presented by Long and Morgan (1990). The effect ranges, ER-L for the tenth percentile and ER-M for the 50th percentile, suggest the potential for adverse biological effects. Though the effect ranges have varying degrees of confidence for different contaminants, and were developed primarily for marine sediments, the concentrations provide some guidelines for assessing freshwater sediments.

Many of the inorganic contaminant concentrations detected at the site may fall within the 95% background range of variation developed from Shacklette and Boerngen (1984), but it should be made clear that some of these levels may be potentially hazardous to biota. My concern is that soil or sediment samples with concentrations at or slightly above these upper-range background levels would be considered "safe". It may be prudent to collect soil samples in undisturbed areas of the site or in the general area to determine if the values derived from the U.S. Geological Survey paper are similar to site-specific background levels.

These values were used for illustrative comparative purposes. Even if we complied with this request, it would not affect the conclusions of the study with respect to human health or environmental impact. Actual metals concentrations were used in these assessments and in the calculation of risk. We would propose to add a discussion to indicate that actual background concentrations at this site are less than the USGS published values.

2. Rubble Fill Site Near Bunker A-86

At the site, an elevated concentration of arsenic (127 ppm) was detected in surface soil sample 4SS3C. I could not locate this sampling station on Figure 4-2 (pg. 4-22); only 4SS1

and 4SS2 are marked. This concentration suggests a need for additional soil sampling to fully delineate the area requiring remediation.

As indicated in the text on pages 4-18, sample 4SS3C is a composite sample from location 4SS1 and 4SS2. Additional sampling has been recommended in Section 8.0.

3. <u>Torpedo Shop</u>

There is a small drainage ditch along the west site of Building 450, the Torpedo Shop. A small pipe under the building's asphalt apron connects the ditch to the catch basin that empties down to SW/SD-1. A soil/sediment sample should be considered for the small ditch beside the building. During the site visit, the cover for this ditch's catch basin appeared to be stained with paint residue. It should be noted for this site that since the swale at SW/SD 1 has been recently disturbed by land-moving activities, new sampling at this station may reveal lower contaminant levels.

Although there is considerable human activity at the Torpedo Shop and much of the area is built-up land, exposure to ecological receptors remains a possibility. The small grassy bank between Buildings 450 and 325, the drainage swale, and the nearby leach field/lagoon are areas likely to be utilized by several species of birds along with species of amphibians and reptiles.

These comments will be considered in the development of Step II work plan.

4. <u>Goss Cove Landfill</u>

The field investigation for the Goss Cove Landfill did not include sediment sampling in the adjacent Thames River. Elevated levels of several inorganics were detected in soils at the site and sampling of nearby river sediments appears appropriate. During the landfill operations, site contaminants may have entered the river through runoff or erosion. On the site visit, the oil containment booms below the large outfalls at the USS Nautilus, beside the former landfill, were noteworthy. The sewer drainage of the tank farm may not be part of the CERCLA investigation, but has there been any sampling in the sediments below the outfalls to determine SVOC levels or the impacts of oil discharges to benthic organisms? If small discharges occur on a regular basis, this area should be investigated.

Investigation of surface water and sediment quality within the adjacent Thames River has been recommended in Section 8.0 of the IR report.

5. <u>Area A Wetland</u>

It appears in Figure 4-16 (page 4-66) that SW-1 exists in a drainage between the Perimeter Security Road and Route 12. Plate 4-1 does not show the Perimeter Road, so the station may be within the wetland boundaries. Is SW-1 the upgradient location? If SW-1 exists in an upgradient drainage, a description of the drainage within the NSB-NLON boundaries and east of Route 12 would be useful. We did not visit this station during the site visit. It would be useful to know if this drainage contains the same heavy iron floc or orange precipitate found downstream of the Area A wetland in the adjacent OBDA drainage. A comparison with

upgradient sites may indicate that the wetland or Area A landfill are the sources of the floc.

In previous sediment sampling, DDT was detected in the range of 17 ppm within and upgradient from the Area A wetland. These levels are potentially harmful to fish and wildlife. Cadmium, chromium, copper, lead, mercury, and zinc were also detected above the ER-L concentration. A more comprehensive sampling plan, particularly to determine the extent of DDT contamination, appears warranted to identify portions of the wetland and Area A for remediation.

Sample 2WSW1 is located east of Perimeter Road and is an upgradient location with respect to the wetland and landfill. These sample points did not contain the "iron floc". The watershed is residential/undeveloped and wooded.

Regarding DDT contamination in the wetland, Section 8.0, page 8-18 includes a recommendation for additional sampling in the wetland.

6. **Area A Wetland**

A more intensive effort should be made to identify the fish species in the open water areas of the wetland. The habitat of the area and the reported sighting of otter further down the drainage suggests that semi-aquatic species may be exposed to site contaminants. Due to the presence of piscivorous birds and mammals in the area, this potential exposure route should be investigated more thoroughly.

Catbird fledglings were used to quantify exposure in the terrestrial food web near the Area A wetland and Downstream watercourses. I have not obtained the paper by Menzie et al. (1991), but I would echo the comment by the oversight contractor that the habitats and prey items at the NSB-NLON and the Manomet Bird Observatory may not be similar. I have requested a copy of the paper from Atlantic; perhaps Menzie describes the differences in the two sites in his paper. I do not view this issue as a problem, only as a point requiring clarification.

These comments will be discussed with the USEPA relative to the ecological assessments.

7. **Downstream Watercourses and OBDA**

In the drainage between the upper pond and the Area A wetland, SW/WD samples were not collected. This drainage contains the same iron floc or orange precipitate described above. SW/SD samples should be collected from this drainage, and an assessment of the fisheries or benthic fauna, if any, in the drainage should be provided. If a depauperate macroinvertabrete community is found, toxicity testing may be the next step for these drainages. Even is laboratory bioassays indicate that the waters or sediment are not toxic to the test organisms, the impact of the floc or precipitate on the quality of the habitat for fish and macroinvertabretes in the stream should be discussed. During our visits, the depth

of the floc layer on the bottom substrate and on the rocks and woody debris in the streams was striking.

Fish species in the two small ponds below Area A should be identified for the exposure assessment. The report states that fish were not observed in these ponds, but it is unclear if any fish collection was attempted. The upper pond appears more suitable fish than the lower pond. If fish are not present in the lower pond, I would expect a variety of amphibians to utilize the area. During the site visit, this pond looked like a good mole salamander breeding pool.

These comments will be discussed with the USEPA relative to the ecological assessments.

8. **DRMO**

As discussed during the October 8th visit, the Thames River sediments directly adjacent to the DRMO should be samples due to the likelihood of transformer oil and other contaminants entering the river through erosion, surface water runoff and periodic flooding. Station SW/SD-12 may not detect PCBs from the DRMO and higher concentrations may be found in sediments closer to the site.

Refer to Section 8.0, page 8-25, which provided recommendations for Thames River sediment sampling.

9. **Miscellaneous**

Since it is likely the wetlands at the site will require remediation, a wetlands delineation along with a function and value analysis should be conducted.

We are aware that wetlands exist in Area A, and the general boundaries are known. The wetlands regulations will be considered as an ARAR. Following the Feasibility Study, and as part of any remedial design, specific wetlands boundaries will be established at that time.

NAVY'S RESPONSE TO MR. FROMER'S COMMENTS OF OCTOBER 13, 1991 (MARCH 26, 1992)

ROBERT FROMER LETTER (October 13, 1991)

1. *Section 8.1.4.1, Health and Ecological Risk Assessment, ¶ 3, page 8-5: The report claims that contaminant concentrations in the ground water at Goss Cover are expected to be below water quality criteria after further dilution in ground water, attenuation due to adsorption to soils, and dilution in the Thames River estuary. Further study is essential to determine the leachate rate as a function of time. Experience in Connecticut with the pesticide EDB indicates that the porosity of sand particles serves as a reservoir for long-term leaching. The previous philosophy that, "dilution is the solution to pollution" seems still prevalent in this report. Consideration should be given to removal of contaminated soils as a remediation method. While the contaminants discharged into the Thames River may be relatively small, the Navy must take into consideration the cumulative pollution in the river. This is especially important considering the State of Connecticut, Department of Environmental Protection's policy of "no net loss of attainment in water classification".*

   Recommendation 4 on page 8-6 states that a quantitative health and environmental risk assessment of the potential impacts of the site on the Thames River should be conducted to verify the quantitative assessment. The Navy intends to proceed with this assessment.

2. *Section 8.2, Area A Downstream Watercourses, ¶ 2, page 8-9: Since the stream flows under the golf course, consideration should be given to any correlations between pollutant levels and any pesticide applications on the course.*

   The source areas of pesticides have been determined to be upgradient of the golf course based on the analytical data.

3. *Section 8.2, Ecological Risk Assessment, pages 8-17 to 8-18: The study investigated the impact on terrestrial and aquatic species; however, since there is ground water contamination, an expansion of the study is essential to include subterranean species to a specified depth. Ground water is not so pure as to be devoid of fauna and flora.*

   The assessment in inadequate, speculative and inconclusive. There is no correlation that the wildlife sampled in the study are representative of the ecological impacts. For example, to deduce that based on a few samples of catbirds, the risks to birds feeding on soil invertebrates appears to be low is preposterous. This presumes that all birds in the area feeding on the same menu have and identical biochemistry. In the absence of hard evidence to the contrary, I claim that the presumption is mythical and mystical.

   Further, the assessments are not statistically based creating serious questions as to their conclusive legitimacy. There is too much presumption in the analysis. For example, because the shrew is maximally exposed by diet, the investigators conclude that it would have the greatest exposure to DDTR. There is no objective study clearly demonstrating the level of exposure by shrews in the area. Even if the exposure is greatest, the shrews body chemistry may metabolize the DDTR without harmful effects.

   The methods employed in the ecological risk assessment were either developed by the

EPA for use in similar situations such as the equilibrium partitioning (EP) method or are currently widely used for the same purpose as they were used in this assessment such as the simple bioaccumulation models. They are, therefore, appropriate for use in ecological risk assessment.

Because of the large number of species present at the site and the complexity of the their interrelationships (which is true of many sites), certain species were selected for assessment based on their feeding and migratory patterns and their abundance on the site. The intent of the assessment was not to assess risks to all species. The EPA and U.S. Fish and Wildlife Service were consulted as to the appropriateness of species selected for assessment.

There is additional sampling planned for the site with regard to ecological receptors. This plan will be reviewed by the TRC and EPA. This will provide further opportunity to have direct input.

4. *Section 8.2.3, Lower Subase, pages 8-23 to 8-25: Because of nuclear activities at the lower base, this area requires study and monitoring of radioactivity. Such expansion of the study would secure the public's confidence in its integrity. In fact, all Step I and II areas should be monitored for radioactivity.*

In 1966, 1972, and again in 1989, the EPA conducted independent environmental monitoring for radioactivity associated with nuclear powered warships at SUBASE NLON. EPA monitoring included analysis of samples taken from SUBASE NLON and direct radiation level measurements using sensitive detection equipment. The results of the EPA monitoring confirm the absence of a threat to human health or the environment from radionuclides associated with the operation and maintenance of naval nuclear propulsion plants, and confirm those of separate Navy monitoring, reported annually. (See Naval Nuclear Propulsion Program Report NT-91-1). The EPA Results also verify that the Naval Nuclear Propulsion Program's practices (e.g., prohibiting intentional discharge of liquids containing low-level radioactivity to the harbor environment, reuse of radioactive liquids to the maximum practical extent and solidification of those liquids that cannot be reused), and disposal facilities (radioactive waste associated with naval nuclear propulsion plants has never been buried at SUBASE NLON) have been successful in ensuring that there is no radioactivity associated with the Naval Nuclear Propulsion Program at or near SUBASE NLON that requires remediation.

1.0 INTRODUCTION

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

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

During the course of this study, NSB-NLON was placed on the National Priorities List (NPL) by the U.S. Environmental Protection Agency (USEPA), pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. **NSB-NLON was proposed for listing on the NPL on October 26, 1989 and was listed on August 30, 1991.** The NPL, or Superfund list, is USEPA's data base of uncontrolled or abandoned hazardous waste sites identified for priority remedial actions which meet or surpass a predetermined hazardous ranking system score.

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

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

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

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

Mr. W. Haas, Town Planner Town of Ledyard	Mr. Robert Fromer LEAF

Mr. Thomas Wagner
Town of Waterford

Mr. Ronald Ochsner
Citizen

Mr. Eugene A. Cioffi
Citizen

Mr. Remy H. Davis
City of New London

Mr. Chuck McGuire
CINCLANTFLT (N4423A)

Ms. Adrienne Townsel
NORTHNAVFACENGCOM (Code 14)

Ms. Deborah Jones
Wetlands Planner
Town of Groton

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

Dr. Clifford Striba
Director of Health
Uncas Health District

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

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

Mr. Richard Massad
Environmental Engineer
Naval Submarine Base New London

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

Mr. Paul Burgess
Atlantic Environmental Services, Inc.

1.1 Purpose of Report

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

This report has been revised to incorporate comments from TRC members as explained in the preface. All revisions to the text are shown in bold print. The more significant changes include the following:

- **revisions to incorporate changes in USEPA MCLs;**
- **revisions to incorporate the adoption of numerical water quality standards by the CTDEP; and**
- **the changing of final recommendations at three Step I sites (CBU, OBDANE, and Former Gasoline Station) from no further action to recommending supplemental Step I investigations.**

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

1.2 Site Background

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

1.2.1 Site Location

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

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

1.2.2 Site and Area Land Use

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

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

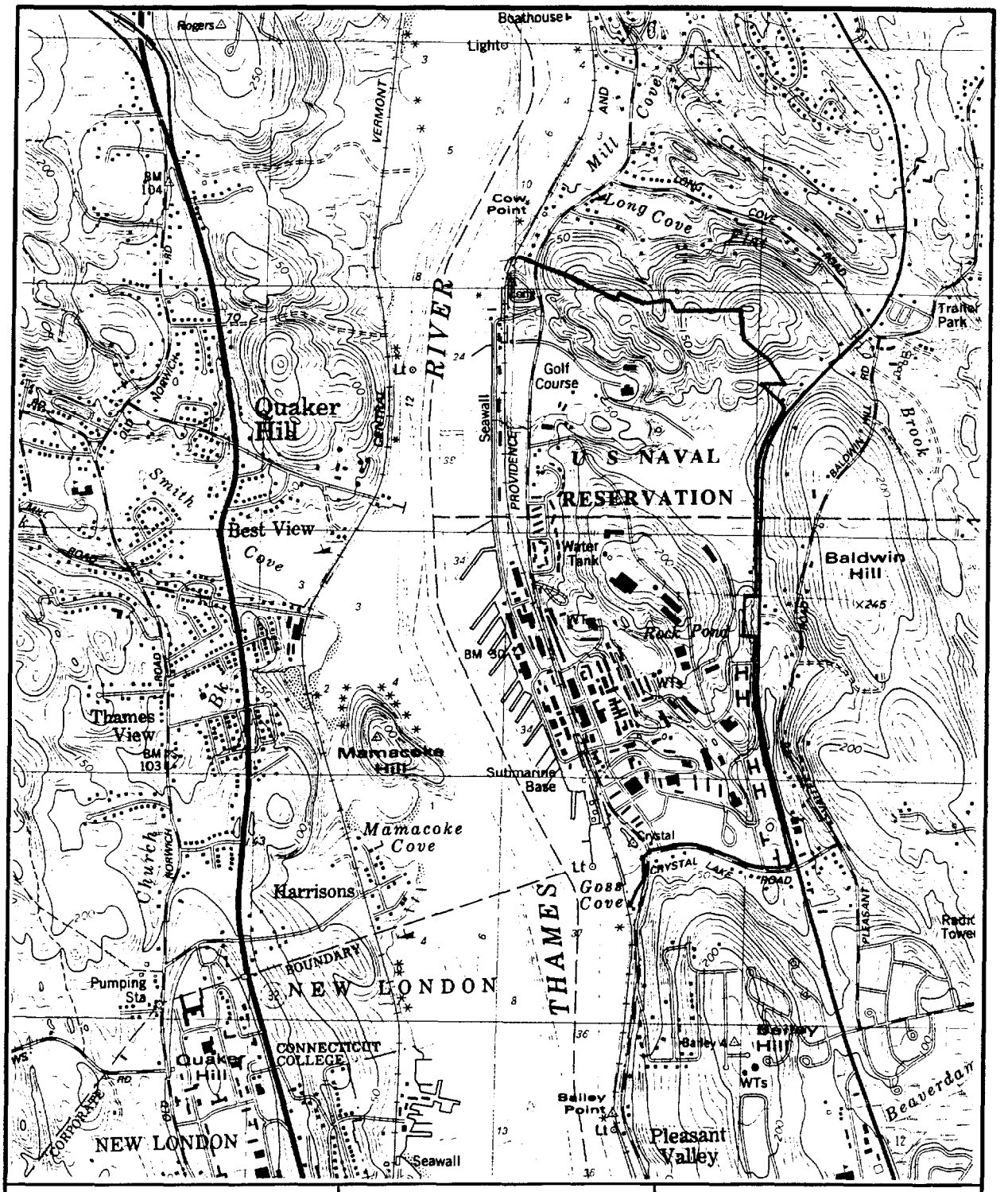
1.2.3 Water Quality Classifications and Water Supply

1.2.3.1 Water Quality Classifications

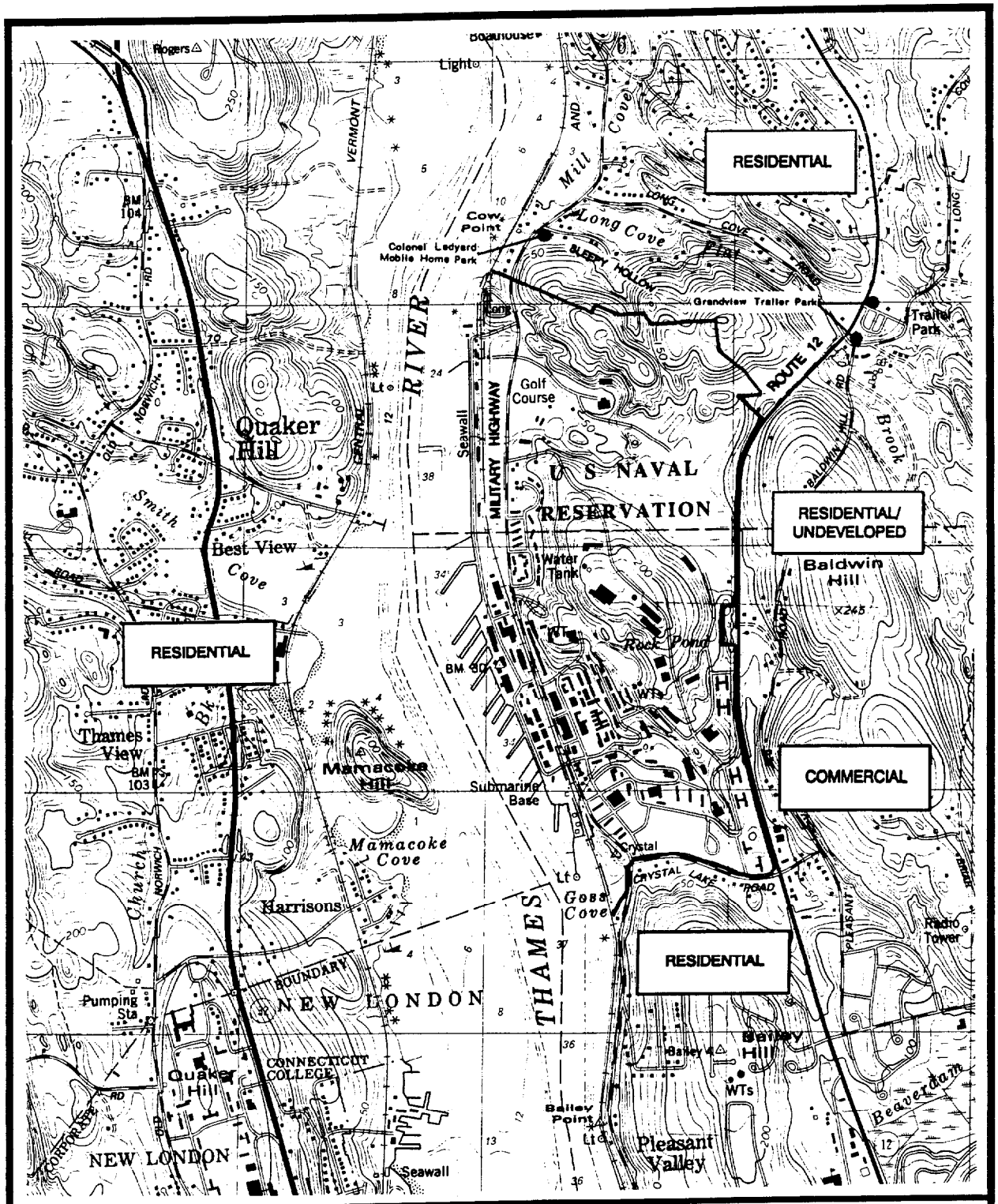
The State of Connecticut Department of Environmental Protection (CTDEP) has classified the Thames River quality as SC/SB. **This classification designates the water for marine fish, shellfish, and wildlife habitat, certain aquaculture operations, recreational uses, industrial and other legitimate use,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

The CTDEP has classified the ground waters beneath the central and southern portions of the site as GB/GA. A classification of GB/GA indicates that the ground water may not be

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	SOURCE: Marshall Penn-York Co. Inc. 0 1 2 SCALE OF MILES	FIGURE 1-1 SITE VICINITY ATLANTIC ENVIRONMENTAL SERVICES, INC.



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



INSTALLATION RESTORATION STUDY

NAVAL SUBMARINE BASE - NEW LONDON

GROTON, CT

SOURCE: Uncasville, Ct.
U.S.G.S. Topographic Map 1984

● Active Water Supply Well

N

0 1000 2000'

SCALE

FIGURE 1-3

AREA LAND USE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

suitable for direct human consumption without treatment due to waste discharges, spills, chemical leaks, or land use impacts. GB/GA waters may be useful for industrial process waters or cooling waters. **The State's** goal is to restore the water to drinking water quality (GA).

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

1.2.3.2 Water Supply

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

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

1.2.4 General Site History

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

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

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

The growth of NSB-NLON continued after World War II. The Medical Research Laboratory was established in 1946. In 1968 the status of the Submarine School was changed from an activity to a command and became the largest tenant on the base. The Naval Submarine Support Facility was established in 1974 and the Naval Undersea Medical Institute was

established the following year. At present, NSB-NLON consists of over 300 buildings on 547 acres of land (U.S. Navy, 1988).

1.2.5 Site Descriptions

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

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

Step I Sites

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

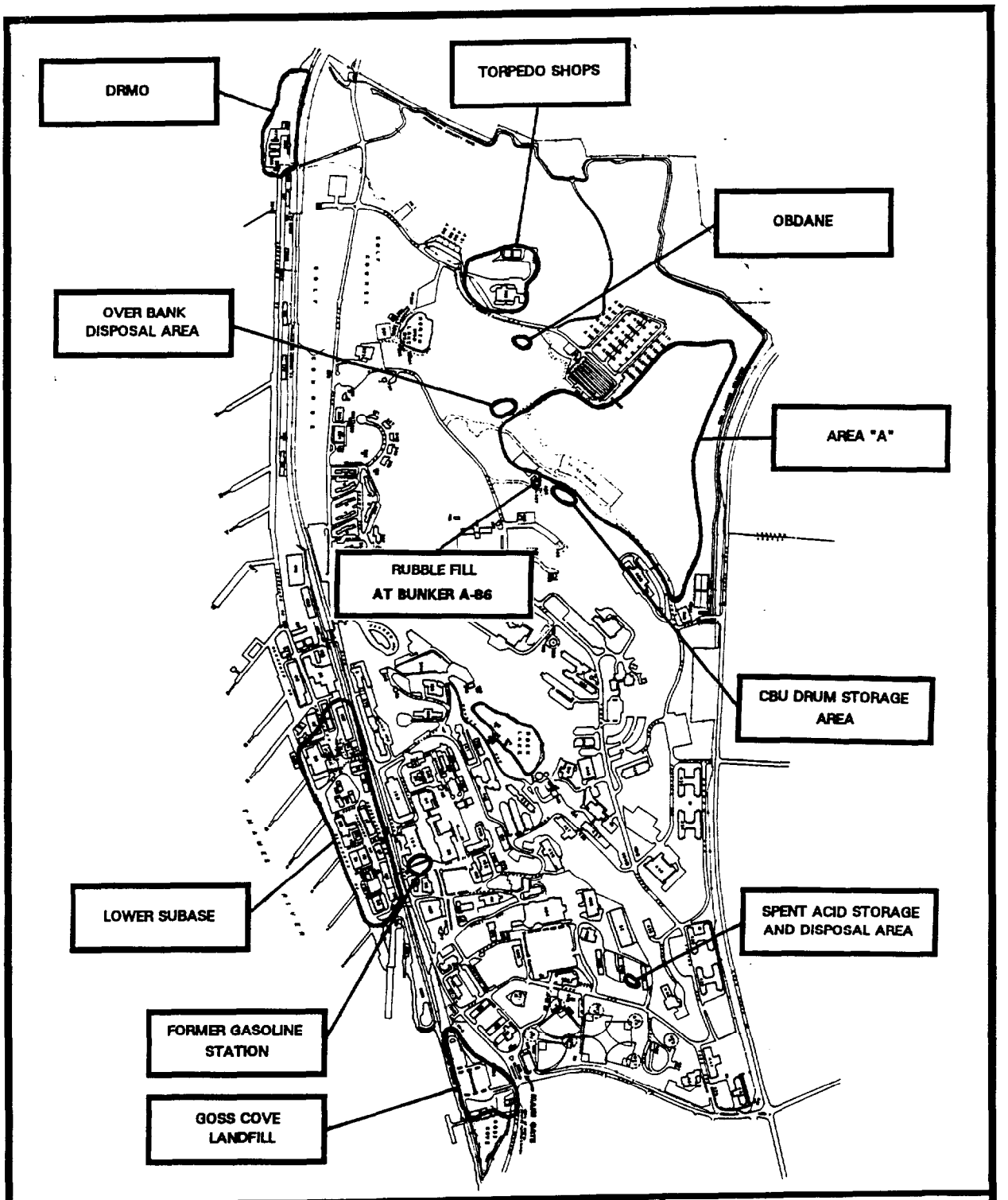
Step II Sites

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

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

1.2.5.1 CBU Drum Storage Area

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



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

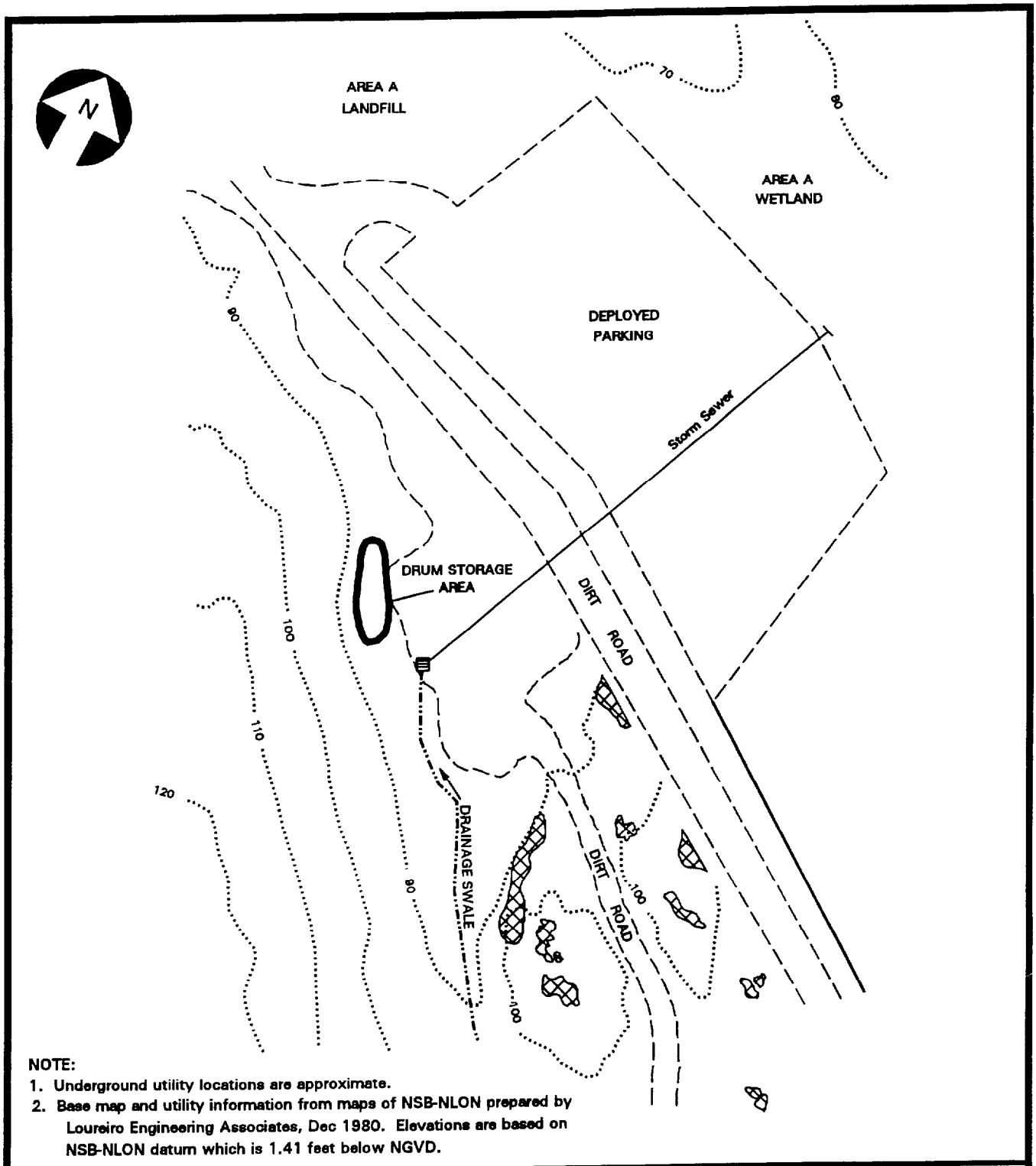
SOURCE: Naval Submarine Base
Existing Conditions
April 1985
Loureiro Engineering Associates

N

0 800'
SCALE

FIGURE 1-4
INSTALLATION RESTORATION
SITES INVESTIGATED

ATLANTIC ENVIRONMENTAL SERVICES, INC.



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

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

site at a 25 to 30 percent grade. **The size of the site is approximately 15 feet in width by 30 feet in length.** The site is unpaved. Surface drainage from the site flows northeast across the unpaved deployed parking lot and into the Area A Wetland.

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

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

1.2.5.2 Rubble Fill at Bunker A-86

Bunker A-86 is located on a dirt road off Wahoo Avenue in the north central section of NSB-NLON. Area A landfill is adjacent to the north, and the Subase hazardous waste storage facility is adjacent to this site to the south. A site plan showing topography, drainage features, and utility information is shown as Figure 1-6. The rubble fill area is located to the north of the dirt road and to the west of the bunker. **The size of the site is approximately 25 feet in width by 60 feet in length.** The site is on a wooded hillside that slopes down to the north-northeast at an approximately 30 percent grade. Surface drainage from this site also flows north-northeast toward the Area A landfill and wetland.

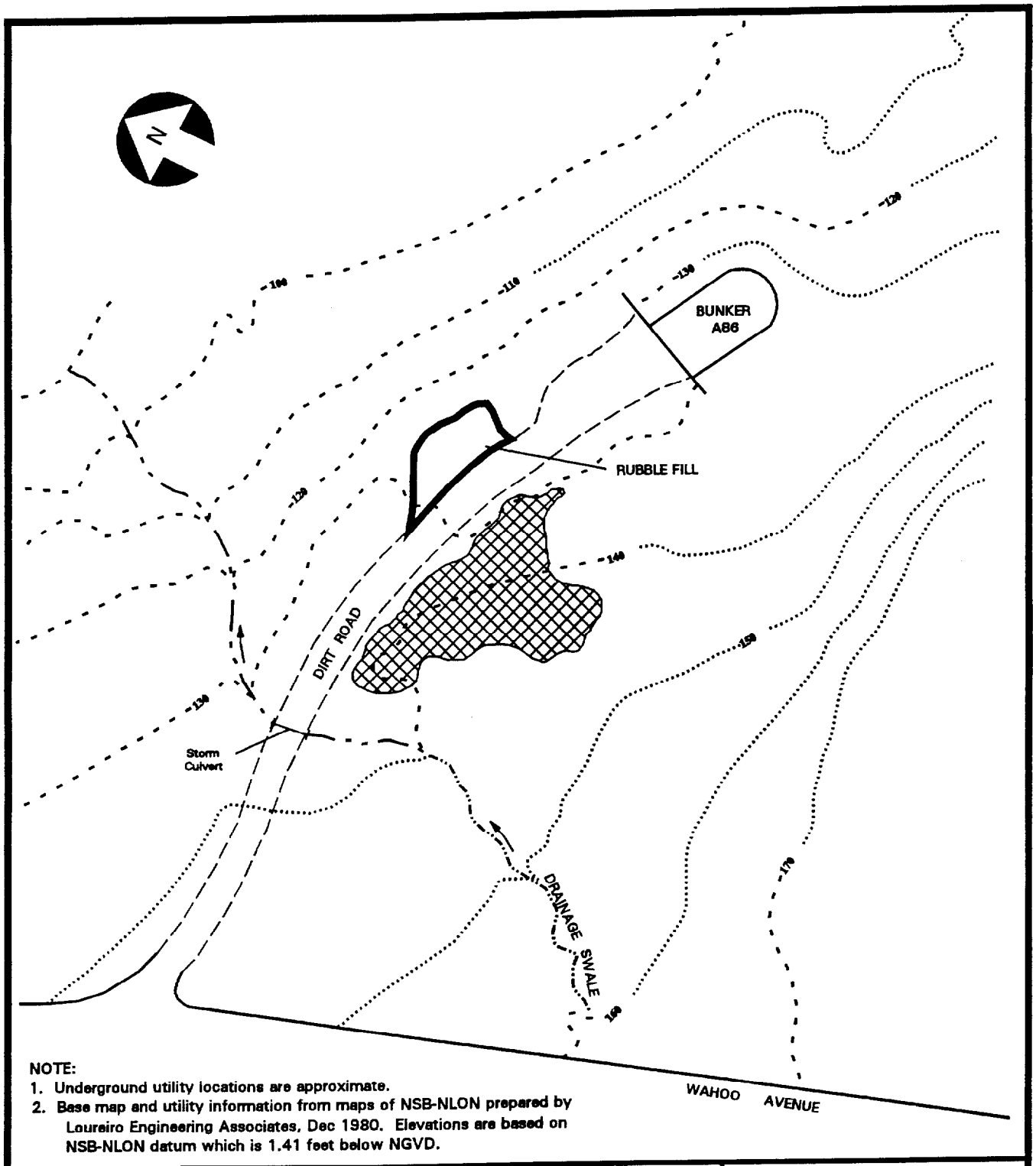
The IAS report identified discarded construction materials including concrete, asphalt, an electric motor, tar buckets, wood, and gravel. The report concluded that material had not been disposed at this site for more than ten years before the date of the IAS inspection (1982).

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

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

1.2.5.3 Torpedo Shops

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



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

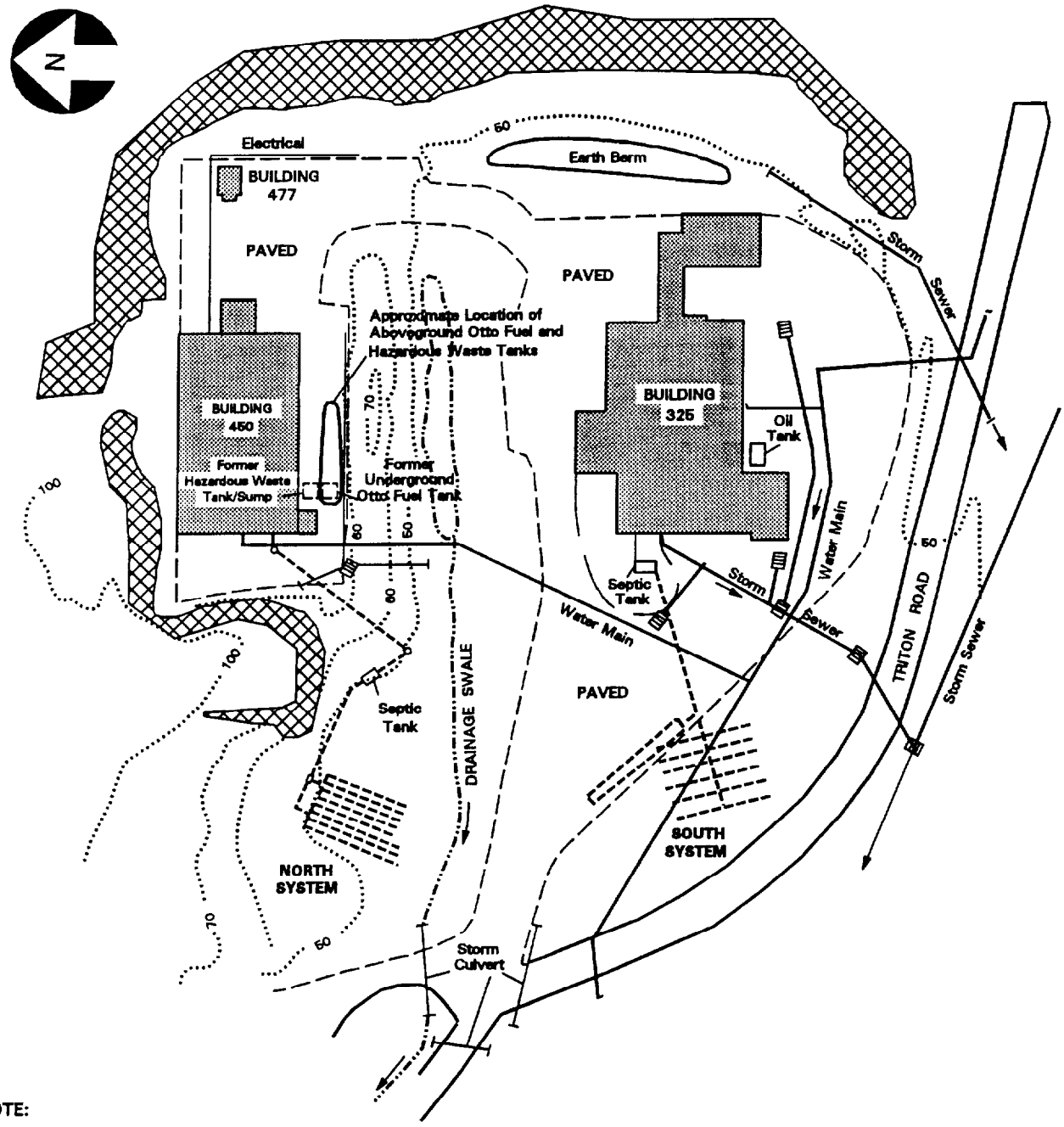
LEGEND

- 95 - Existing Grade
- Exposed Bedrock
- Building
- Watercourse

Approximate Scale
0 20 40'

FIGURE 1-6
SITE PLAN
RUBBLE FILL AT BUNKER A86

ATLANTIC ENVIRONMENTAL SERVICES, INC.



NOTE:

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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ··· 96 ··· - Existing Grade - Exposed Bedrock - Watercourse - Catch Basin	- Former Septic System - Building Approximate Scale 0 40 80'	FIGURE 1-7 SITE PLAN TORPEDO SHOPS ATLANTIC ENVIRONMENTAL SERVICES, INC.

by the berm, as well as the storm sewer system, drains through culverts under Triton Avenue into the Area A down-stream watercourses and eventually into the Thames River.

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

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

A smaller attached building to the east was inspected. It had been used previously as an assembly shop for torpedoes and was a paint shop at the time of inspection. A storage closet in this building included containers of 1,1,1-trichloroethane and methyl ethyl ketone (MEK). Hazardous waste drums were stored outside on the east side of this building. The drums were labeled as containing propane, isobutane, MEK, xylot, methylene chloride, propellant, and zinc chromate.

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

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

In the past, only domestic wastewater from toilets, lavatories, and showers in Building 450 was directed to the septic field **(north system)**.

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

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

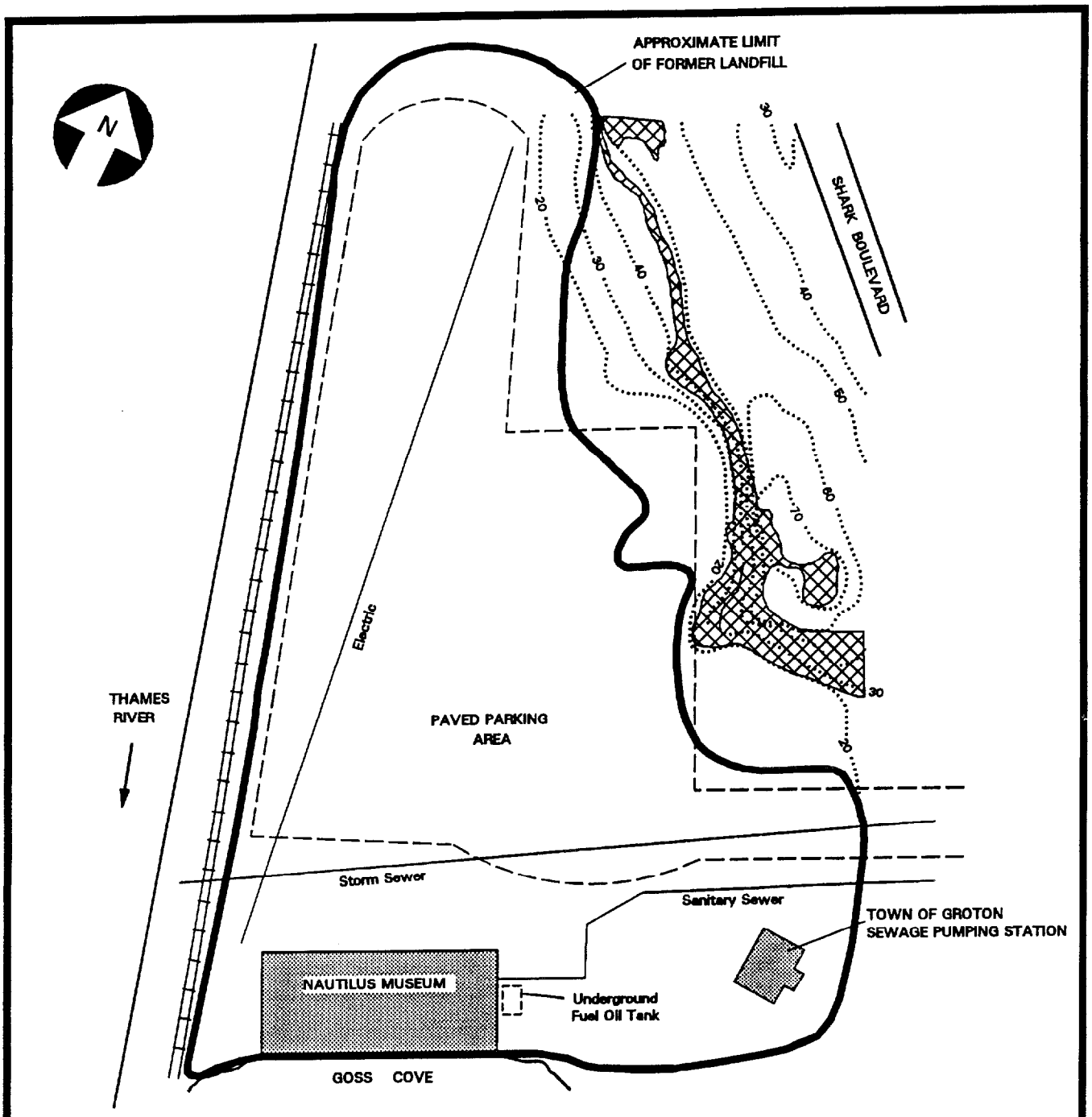
1.2.5.4 Goss Cove Landfill

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

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

Atlantic personnel reviewed archive photographs for the Goss Cove area available at the Connecticut State Library. In the 1934 aerial photograph, the original limits of Goss Cove appear to be open water with no evidence of fill. The railroad tracks are shown at their present position between the cove and the Thames River. In 1951 aerial photographs, the fill extends south approximately to the location of the current access driveway to the museum. The 1965 aerial photographs show the landfill extending to the present limit of encroachment on Goss Cove. Aerial photographs from 1965, 1970, 1975, and 1980 show cars parked on the landfill surface. In the 1986 photographs, the Nautilus Museum is present on the southern limits of the landfill and a paved parking area extends over the remaining limit of the landfill to the north. **Construction of the Nautilus Museum was completed in 1985.**

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



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

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

1.2.5.5 Over Bank Disposal Area Northeast (OBDANE)

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

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

No development of this area is planned at this time.

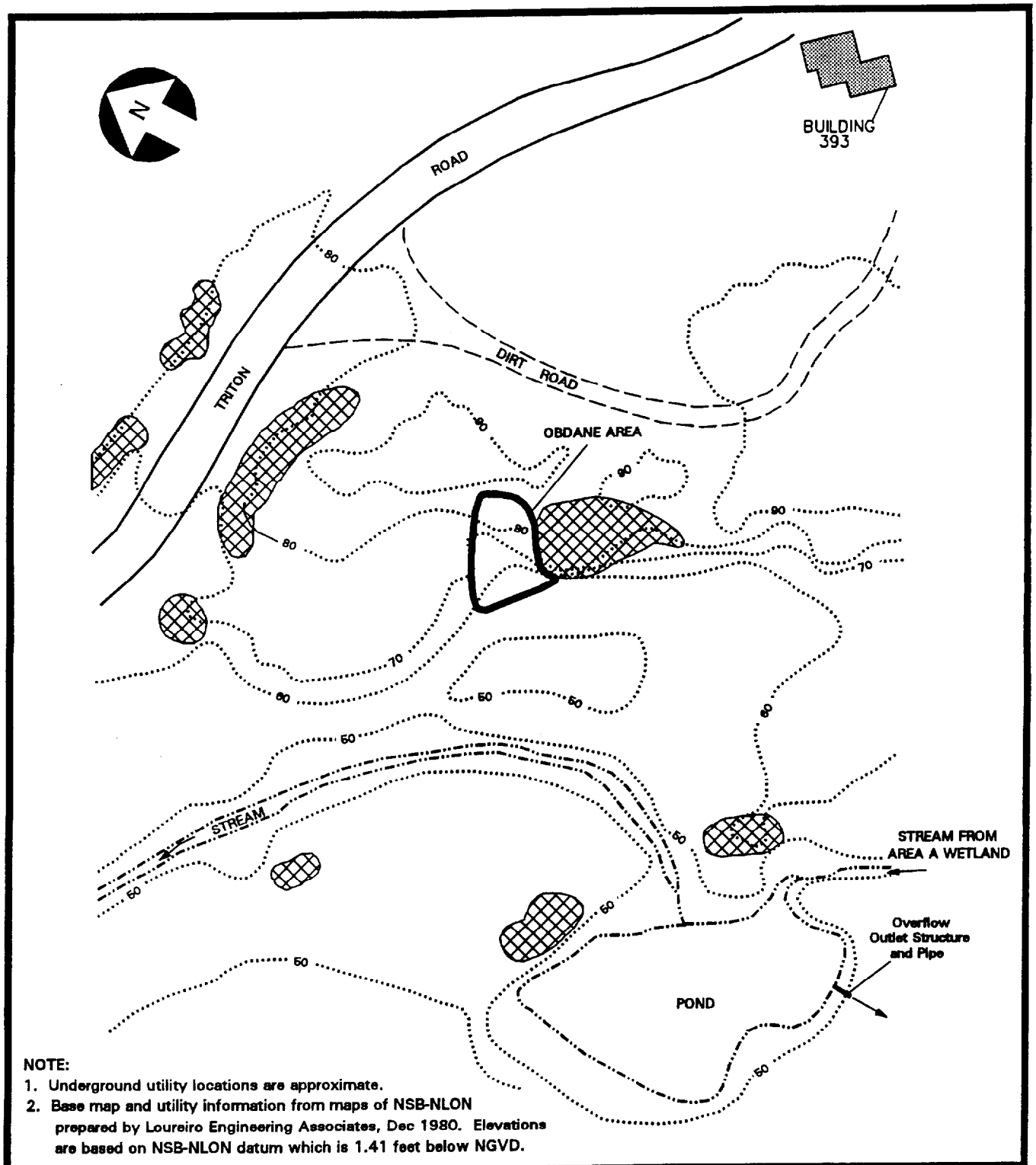
1.2.5.6 Spent Acid Storage and Disposal Area

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

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

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

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



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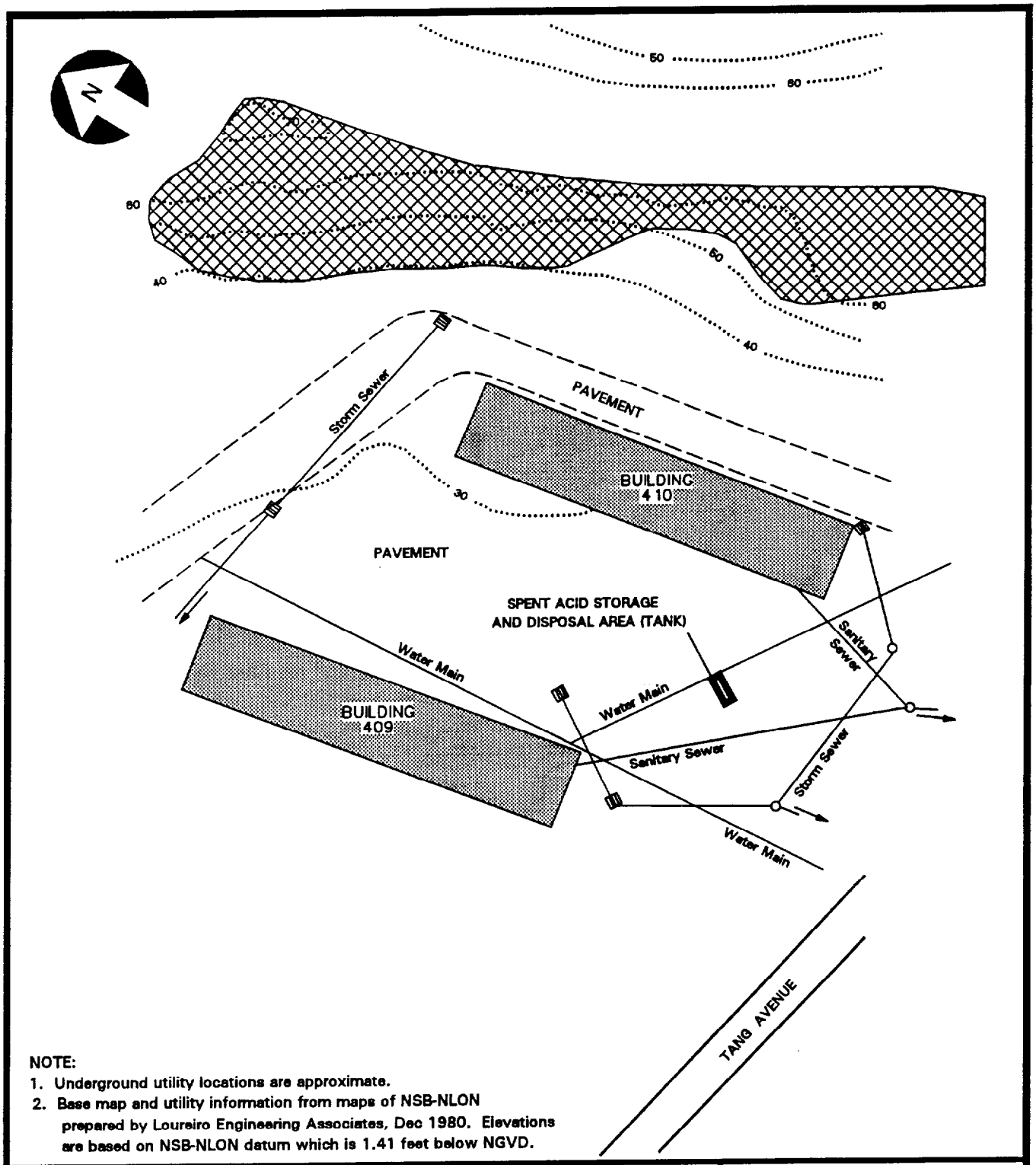
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ··· 95 ··· - Existing Grade - Exposed Bedrock	- Building - Watercourse Approximate Scale 0 20 40'	FIGURE 1-9 SITE PLAN OBDANE ATLANTIC ENVIRONMENTAL SERVICES, INC.



NOTE:
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INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock - Catch Basin - Manhole	- Building 95 - Existing Grade Approximate Scale 0 20 40'	FIGURE 1-10 SITE PLAN SPENT ACID STORAGE AND DISPOSAL AREA ATLANTIC ENVIRONMENTAL SERVICES, INC.

1.2.5.7 Former Gasoline Station

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

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

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

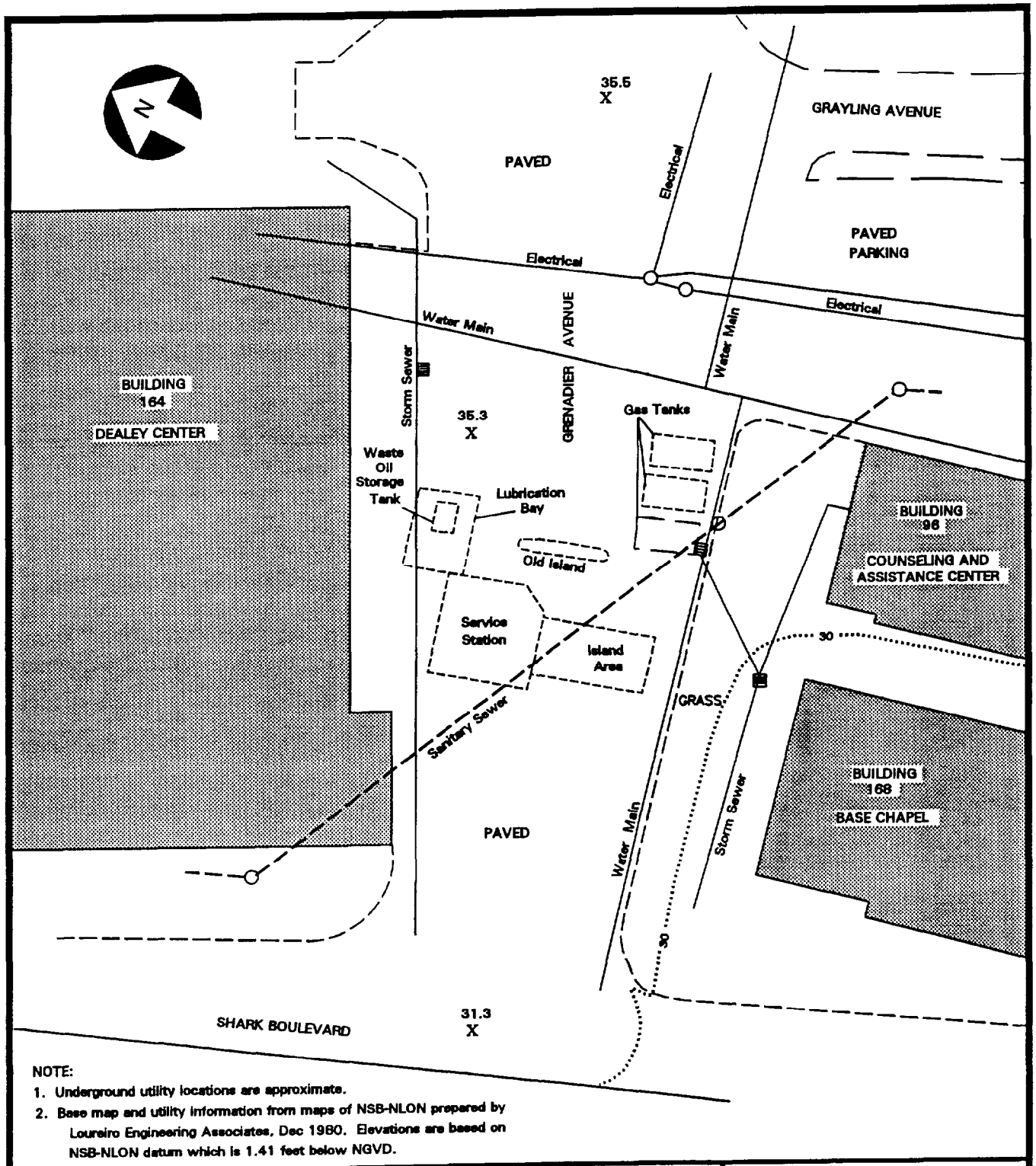
Atlantic personnel inspected this site on March 20, 1989. No evidence remained of the gasoline station or the underground tanks.

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

1.2.5.8 Area A

The discussion of this site is divided into three areas: Area A Landfill; Area A Wetland; and Area A Downstream Watercourses. Figure 1-12 is a site plan showing site development and drainage features. A figure showing topography of Area A is provided in Section 4.10.

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



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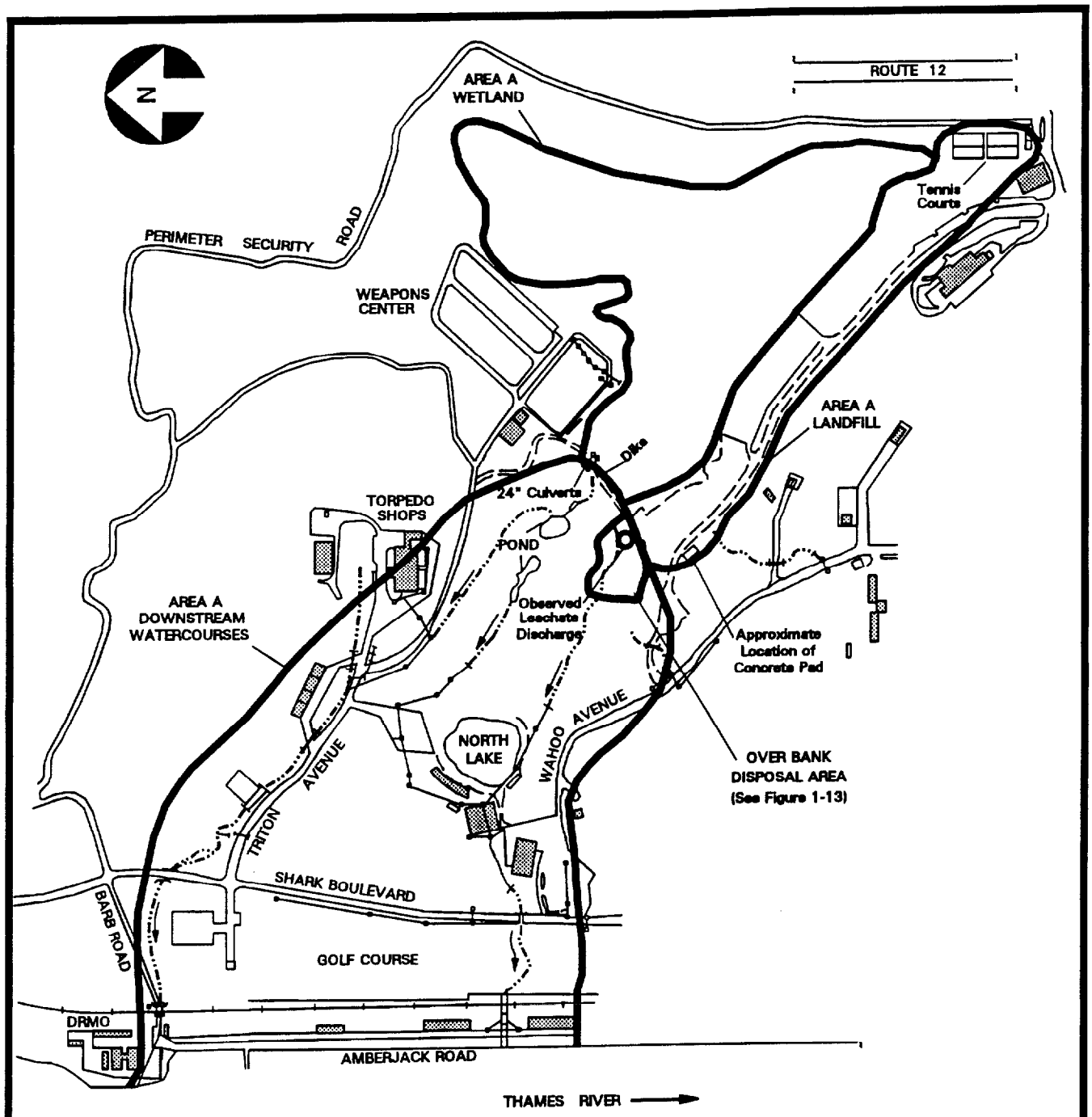
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ···95··· - Existing Grade - - - - - Former Structure ▤ - Catch Basin ○ - Manhole	▩ - Building 78.2 X - Spot Grade Approximate Scale 0 20 40'	FIGURE 1-11 SITE PLAN FORMER GASOLINE STATION ATLANTIC ENVIRONMENTAL SERVICES,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



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

According to the IAS report, the landfill opened sometime before 1957, **however, a 1957 aerial photograph shows no apparent landfilling, indicating a somewhat later startup date. All materials generated by base operations that were not salvageable were incinerated, and the residues were disposed in the Goss Cove and Area A Landfills.** The base incinerator ceased operating in 1963, and from 1963 to 1973 all wastes were disposed in the landfill unburned. During this time, all non-salvageable materials generated by the submarines and base operations were disposed in the Area A Landfill. **The former incinerator was located north of the Lower Subase along the waterfront at the present location of Building 478.**

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

Landfilling operations ceased in 1973. After closure, a concrete pad was constructed in the southwest portion of the landfill for above ground storage of industrial wastes. **The pad is still in existence and is located adjacent and to the northeast of Building 373, and south of the dirt road that extends through this area.** At the time of the IAS survey, 42 steel drums, 87 transformers (mineral and PCB), and 60 to 80 electric switches were stored on the pad. Two transformers and several electrical switches were leaking. Past leakage of oil was also evident. Most drums were stacked on wooden pallets and those having PCB labels were covered and bound with plastic sheeting. All of these materials have since been properly disposed offsite.

The IAS report also noted that refuse, including steel drums, oxygen candles, wood scrap, metal scrap, concrete, and tires, was exposed at the edge of the landfill adjacent to the wetland. The IAS reported that petroleum compounds had recently been poured from containers and had flowed into the wetland at two locations (northwestern portions of landfill). **The IAS report also stated that when batteries were overhauled, spent sulfuric acid solution was transferred to barrels and transported to Area A for disposal. The acid was poured into trenches dug with a bulldozer and subsequently covered with soil.**

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

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

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

<u>Area A Wetland:</u> The Area A Wetland abuts the north side of the landfill and is approximately 30 acres in size. The maximum wetland sediment thickness is approximately 35 feet, based on boring information. **Based on the boring logs, the total volume of dredged material in the wetlands is approximately 1,170,000 cubic yards.** Until **the late 1950s**, this

portion of the site was undeveloped, wooded land. In **the late 1950s**, dredge spoils from the Thames River were pumped to this area and contained within an earthen dike that extends from the Area A Landfill to the south side of the Weapons Storage Area. The dredged sediments, in combination with the elevated water table due to the damming of the stream, appear to have created this large wetland. There is a small pond located at the southeast end of the wetland and between one and three feet of standing water is present during all seasons. *Phragmites* is the predominant type of vegetation. Atlantic learned during the course of this study that, previously, pesticide "bricks" were placed on the wetland ice during winter and allowed to melt and discharge into the wetland for mosquito control.

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

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

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

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

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

1.2.5.9 Over Bank Disposal Area (OBDA)

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

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

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

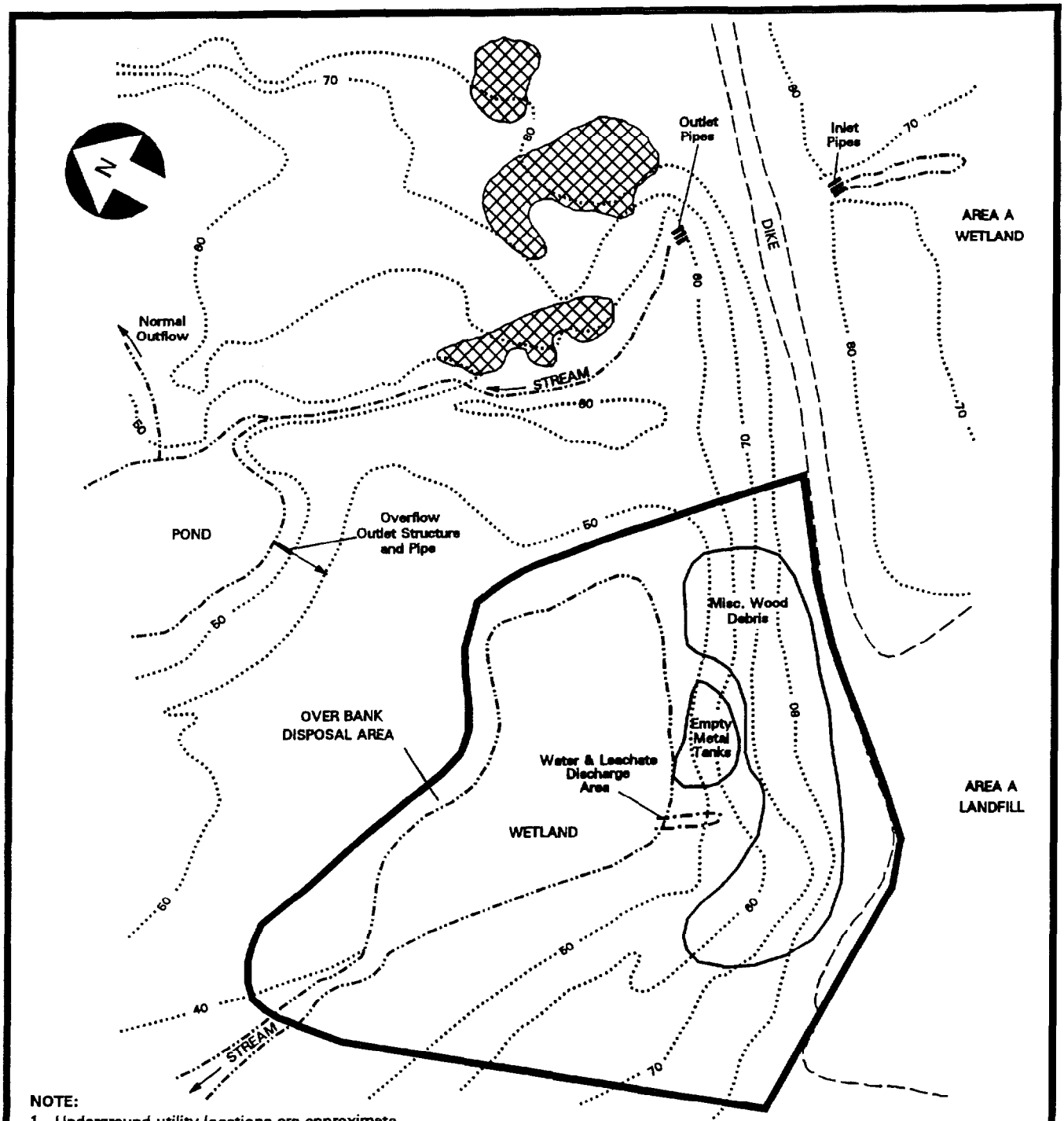
Background data and the topographic/hydrologic setting indicates that the OBDA and the Area A Landfill, Wetland, and Downstream Watercourses are closely related. Therefore, in subsequent sections of the report, data from and discussions of the OBDA are grouped with those of Area A.

1.2.5.10 Defense Reutilization and Marketing Office (DRMO)

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

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

Atlantic personnel reviewed archive aerial photographs for the DRMO area. The 1934 photographs show fill in the southern portion of the existing site. Fill for the bulkheads and the



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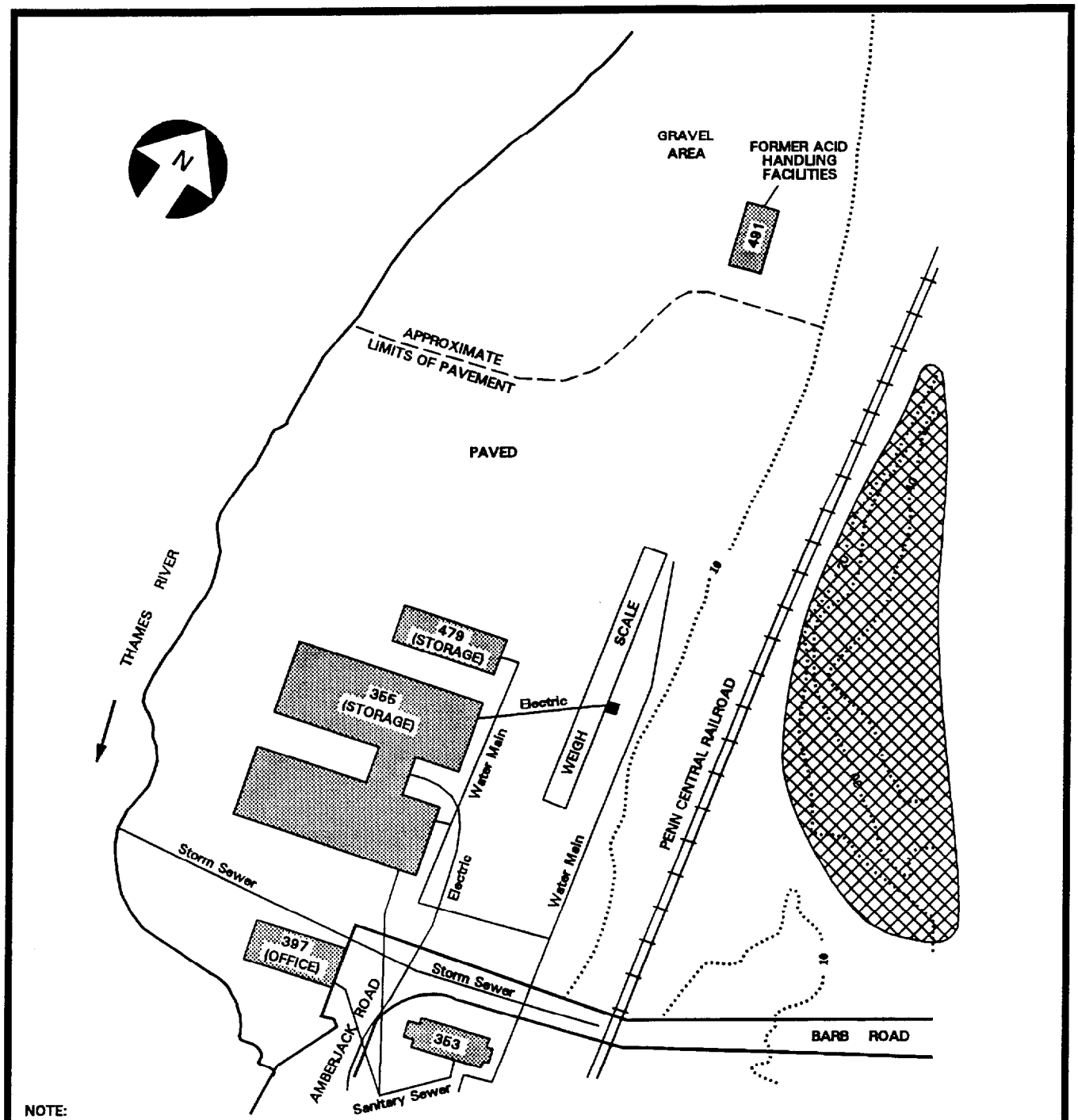
	LEGEND		
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	··· 95 ··· - Existing Grade - Exposed Bedrock	- Building - Watercourse Approximate Scale 0 20 40'	FIGURE 1-13 SITE PLAN OVER BANK DISPOSAL AREA ATLANTIC ENVIRONMENTAL SERVICES, INC.



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

docks south of the DRMO did not exist at this time. Aerial photographs from 1951 show the land in its present configuration, except for the northwest portion, which was not filled at that time.

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

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

1.2.5.11 Lower Subase

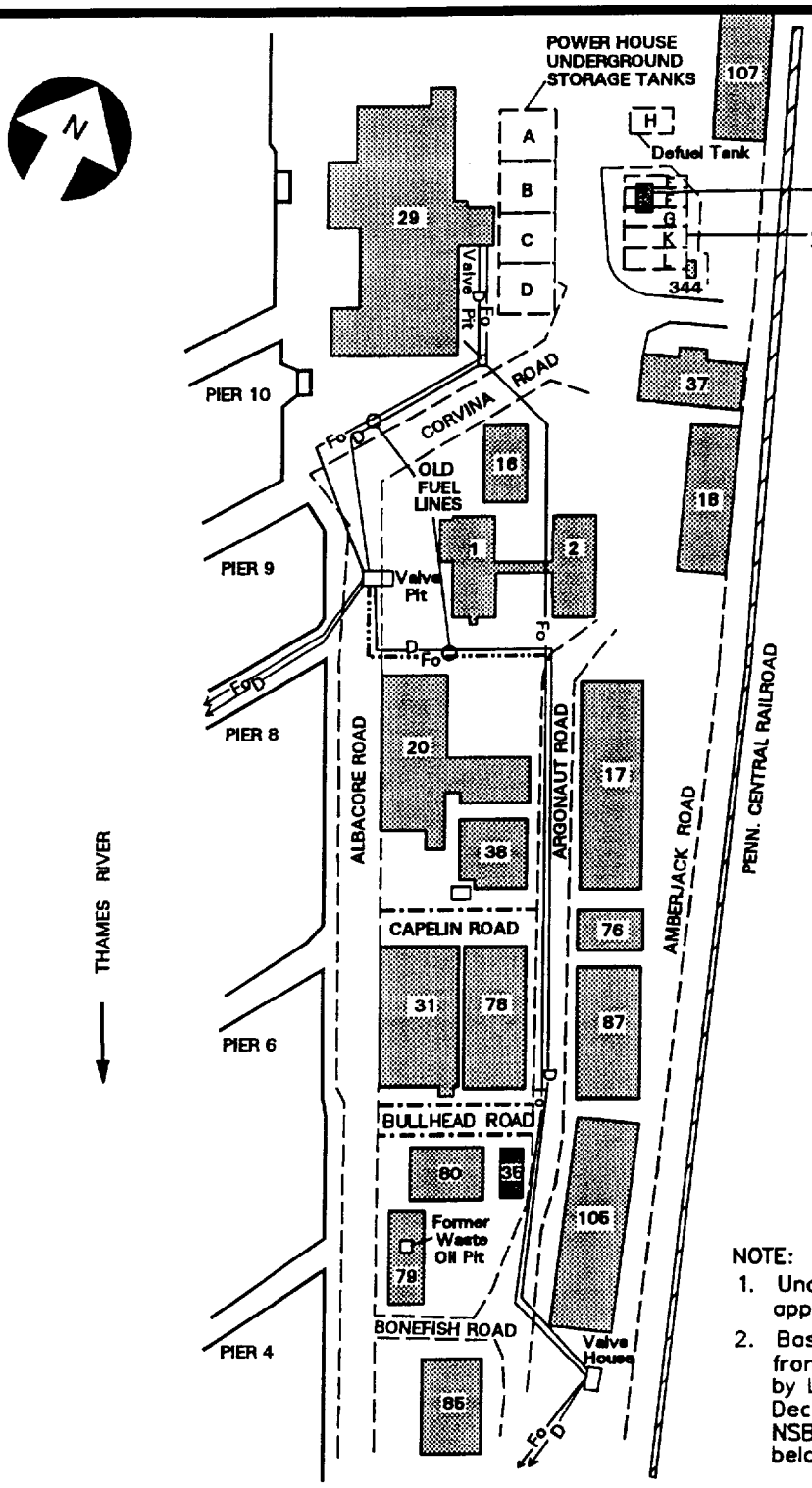
The extent of the Lower Subase site under investigation is shown on Figure 1-15. The site is bounded on the west by the Thames River and to the east by the Penn Central Railroad. This investigation extends to and includes Building 29 (Power Plant) to the north and Building 85 to the south.

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

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

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

Power Plant Oil Tanks: These four underground tanks (A, B, C, D) were located adjacent to and east of the power house (Building 29). Tanks A and B contained No. 6 grade fuel oil which was pumped to them from the tank farms on the south end of NSB-NLON. Tank C contained diesel oil and Tank D contained waste oil from the bilge water oil recovery system



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

LEGEND

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

FIGURE 1-15
SITE PLAN
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

at the power plant. The tanks have been in place since World War II. Mr. Mansfield reported that past oil leakage was apparent when the old tanks were cleaned, however, the old tanks were repaired and are now used as containment structures for three new tanks. The new tanks have a capacity of 150,000 gallons each and are constructed of steel.

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

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

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

1.2.6 Previous Investigations

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

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

1.2.6.1 NESO Report of Lower Base (1979)

In 1979 the Navy Environmental Support Office (NESO) conducted a study to determine the source and extent of oil contamination at the Lower Subase. The study was initiated to

investigate oil found in soils along the riverfront and oil slicks reported in the pier area. NESO drilled a total of twelve soil borings and installed piezometers in each borehole to determine the amount of oil floating on the water table. Figure 1-16 shows the locations of borings installed in this investigation except for NESO-1, which is north of this investigation area near Pier 12. Soil samples from each boring were analyzed for oil content. A ground water sample was collected from each piezometer to check for the presence of oil and, where present, to check product thickness.

The study identified contamination near the powerhouse tanks extending toward the Thames River, to a lesser degree around the tanks south of Building 107, and northwest of Building 79. The oil found in the vicinity of Building 79 was identified as a lubricating oil. The NESO report recommended the abandonment of the building waste oil pit (it was filled with concrete) and the installation of a recovery well system near Building 79. A recovery well system was installed near Building 79 in 1985 (approximate) and operated for a period of several months. It was determined to be ineffective and was abandoned.

1.2.6.2 Initial Assessment Study Report (1982)

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

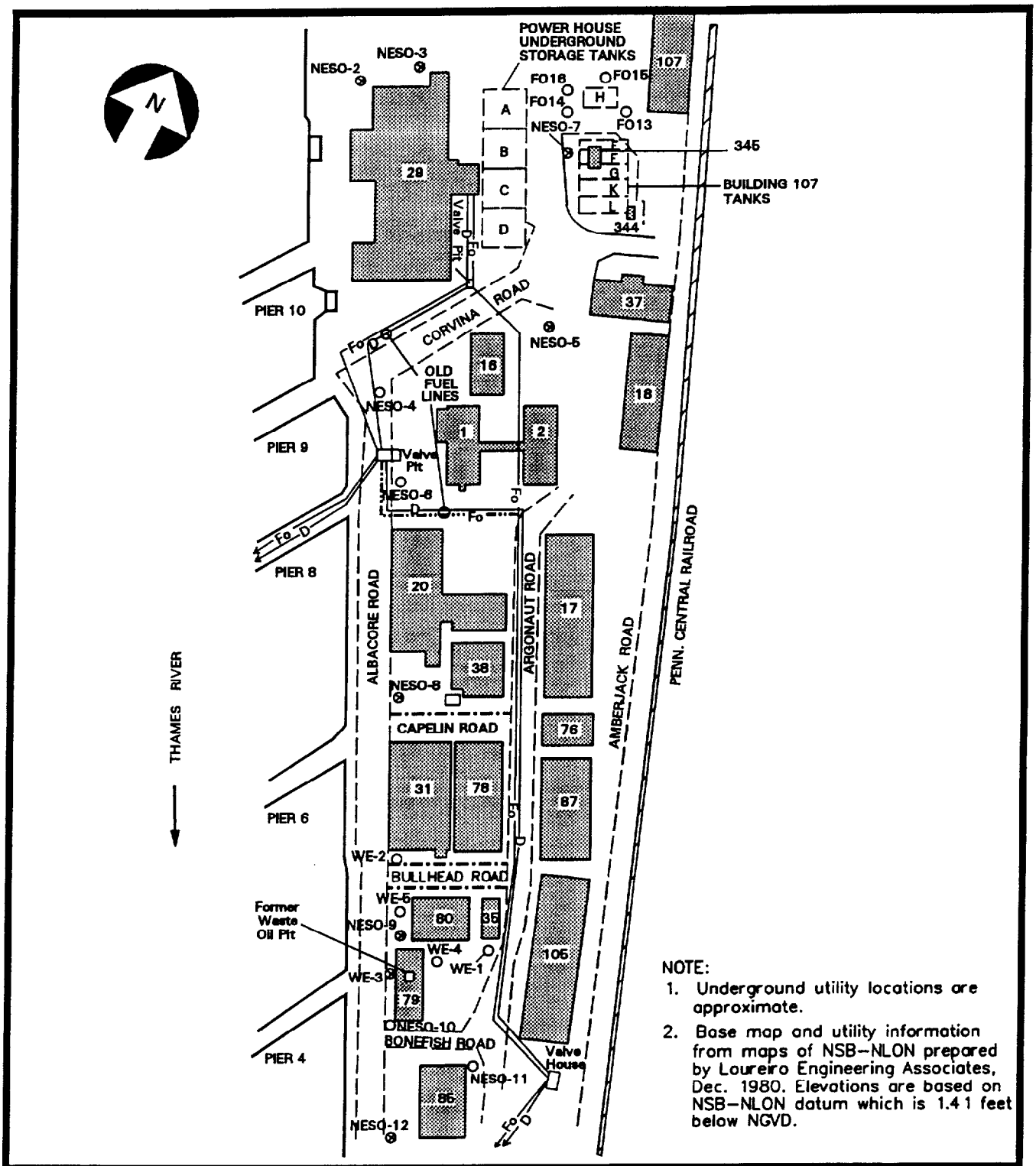
1.2.6.3 Site Investigation Report - Subsurface Oil Contamination - Lower Subase (1987)

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

Three separate oil contaminated areas seem to be present.

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

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



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

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

Recommendations for these three sites include:

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

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

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

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

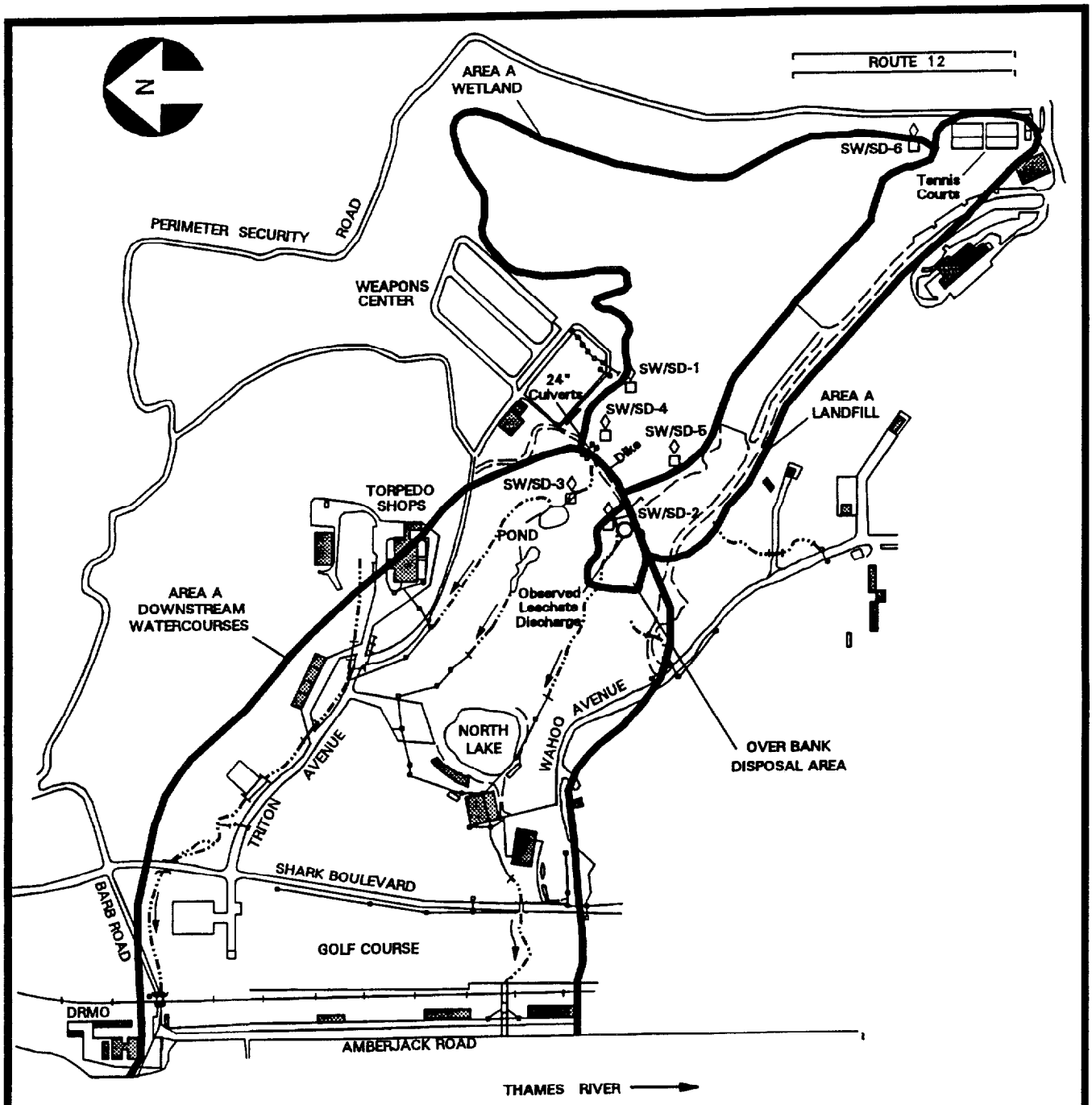
1.2.6.4 Verification Study - Area A, OBDA and DRMO (1988)

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

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

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

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



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

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

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

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

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

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

Parameter	Sample I.D.					
	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6
Volatile Organics (ppm)						
Benzene	ND	0.24	ND	ND	ND	ND
Chloroform	ND	ND	ND	0.01	ND	ND
Methylene chloride	0.29	0.15	0.018	0.016	0.031	0.027
Toluene	0.016	0.016	0.1	0.092	0.058	0.036
Semi-Volatile Organics (ppm)						
Benzo(a)anthracene	1.2	ND	ND	ND	ND	ND
Benzo(b)fluoranthene	0.95	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	0.95	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	0.55	ND	ND	ND	ND	ND
Benzo(a)pyrene	0.75	ND	ND	ND	ND	ND
Chrysene	0.55	ND	ND	ND	ND	ND
Fluoranthene	1.85	ND	ND	ND	ND	ND
Phenanthrene	0.75	ND	ND	ND	ND	ND
Pyrene	1.35	ND	ND	ND	ND	ND
Pesticides/PCBs (ppm)						
4,4 DDD	ND	79	91	17	0.01	12
4,4 DDE	0.0048	7.4	2.5	1.3	0.093	0.82
4,4 DDT	0.022	59	4.8	17.6	ND	17
Inorganics (ppm)						
Antimony	18.3	36.2	18.4	12	10.4	12.7
Arsenic	3.21	1.96	3.68	2.94	2.92	1.33
Beryllium	0.44	0.68	2.62	0.48	0.31	0.51
Cadmium	0.8	1.81	2.5	0.64	0.49	0.49
Chromium	20.4	7.5	12	9.84	9.37	6.6
Copper	30.8	11.3	33.2	20	26.3	13.9
Lead	104	38.7	5960	1486	39.2	24.6
Mercury	ND	ND	0.28	ND	ND	0.06
Nickel	18.32	32.14	22.5	13.2	15	13.5
Selenium	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND
Thallium	5.86	2.35	4.47	3.24	2.48	3.25
Zinc	57.2	90.5	169	53.8	56.5	30.4
Cyanide (total)	2.53	0.36	0.79	0.63	1.52	0.11
Phenols (total)	ND	ND	ND	ND	ND	ND

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

contaminants. Samples SW-2 and SW-3, located in the downstream area below the dike, contained the highest concentrations of pesticides.

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

DRMO: The Verification Study at the DRMO was conducted in December 1984. Sample locations are shown on Figure 1-18. Three soil borings were drilled in the landfill material. Soil samples were collected continuously to a depth of ten feet. The samples were composited (0 to 10 feet) from each boring and analyzed for VOCs, SVOs, pesticides/PCBs, and inorganics. The results are presented in Table 1-3.

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

1.2.6.5 Conforming Storage Facility Report - DRMO (1988)

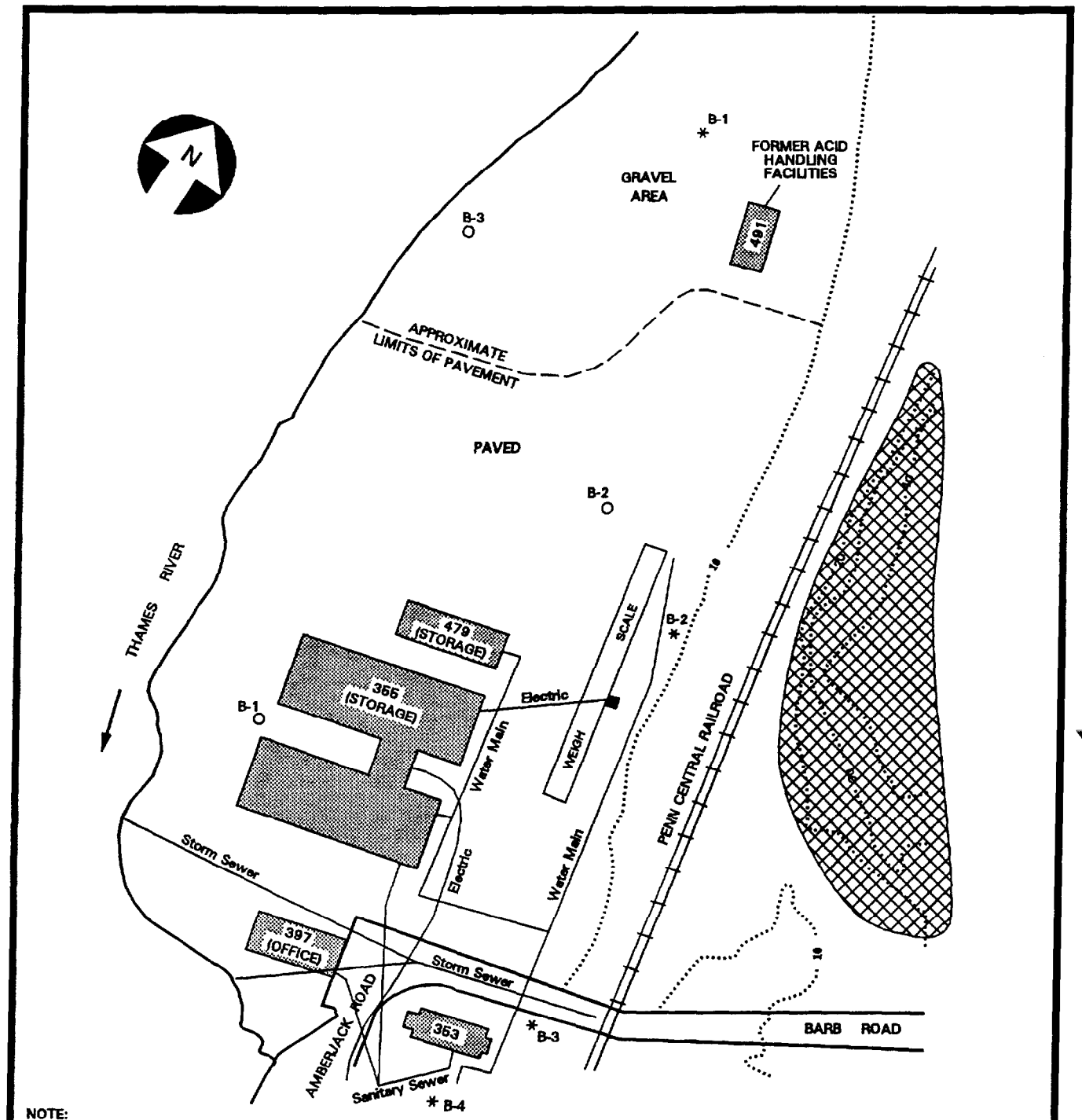
In November of 1988, Goldberg-Zoino & Associates, Inc. (GZA) conducted a study at the DRMO site in preparation for the siting of a Conforming Storage Facility (hazardous waste storage) at the northern portion of the DRMO site. GZA installed four test borings and collected four composite samples for analysis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

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

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

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

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



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock O B-1 - Test Boring 1984, Wehran * B-1 - Test Boring 1988, GZA ··· 95 ··· - Existing Grade - Building Approximate Scale 0 20 40'	FIGURE 1-18 PREVIOUS SAMPLING LOCATIONS DRMO ATLANTIC ENVIRONMENTAL SERVICES, INC.

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

Parameter	Sample I.D./Depth (ft.)		
	B-1/(0-10)	B-2/(0-10)	B-3/(0-10)
Volatile Organics (ppm)			
Chloroform	ND	ND	0.016
1,1-Dichloroethene	0.03	ND	0.026
1,2-Dichloroethene	0.011	ND	0.039
Methylene chloride	0.036	ND	0.057
Toluene	0.096	0.041	0.076
1,1,1-Trichloroethane	0.013	ND	ND
Trichloroethylene	ND	0.03	0.011
Semi-Volatile Organics (ppm)			
Acenaphthene	1.85	ND	ND
Anthracene	5	ND	1.6
Benzo(a)anthracene	5.35	ND	5.6
Benzo(b)fluoranthene	2.35	ND	3.55
Benzo(k)fluoranthene	3.3	ND	1.95
Benzo(g,h,i)perylene	1.3	ND	1.65
Benzo(a)pyrene	2.65	ND	2.35
Chrysene	4.85	ND	4.65
Fluoranthene	11	ND	12.3
Fluorene	8.8	ND	ND
Indeno(1,2,3-cd)pyrene	0.7	ND	1.25
Naphthalene	ND	ND	1.05
Phenanthrene	18.2	ND	7.25
Pyrene	9.3	ND	9.2
Inorganics (ppm)			
Antimony	12.8	7.5	13
Arsenic	1.73	1.5	1.87
Beryllium	0.25	0.3	0.5
Cadmium	0.49	0.45	4.4
Chromium	10.7	9.44	26.4
Copper	43.4	38.9	1000
Lead	30.6	45.8	750
Nickel	9.87	10.2	130
Silver	ND	0.35	2.1
Thallium	4.44	2.99	4
Zinc	103	8.19	1050
Cyanide (total)	0.07	0.07	0.1

1. Source of analytical data (Wehran, 1988).

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

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

1. Source of analytical data (Wehran, 1988).

Soil samples collected from 10 to 12 foot depths as FO-13, FO-14, FO-15 and FO-16 had organic vapor readings of 22, 800, 40, and 410 ppm (methane equivalence), respectively. Ground water analytical results are summarized in Table 1-5. No floating petroleum product was identified in the wells.

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

Parameter	FO-13	FO-14	FO-15	FO-16
Fuel Oil (ppm)	97	1100	750	21
Toluene (ppb)	11	ND	ND	ND
Xylenes (ppb)	9.6	ND	ND	ND

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

1.2.6.7 North Lake Analytical Data

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

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

1.3 Report Organization

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

1.3.1 Site Investigation

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

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

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

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

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

SOURCE: Analytical Data provided by U.S. Navy

NOTES

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

included. Tables are provided listing samples collected and analyses performed for all samples by site and media.

1.3.2 Physical Characteristics of the Study Area

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

1.3.3 Nature and Extent of Contamination

Section 4.0 presents the radiation, geophysics, and soil gas survey results for applicable sites. Laboratory analytical data is also presented in tabular and graphical form for surface soils, subsurface soils, sediment, ground water, and surface water. Biota sampling results are presented and discussed in Section 6.0. Results are compared with site specific applicable or relevant and appropriate requirements (ARARs), and to be considered (TBC) values, which are also discussed in this section of the report.

1.3.4 Contaminant Fate and Transport

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

1.3.5 Health and Ecological Risk Assessment

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

1.3.6 Summary and Conclusions

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

2.0 SITE INVESTIGATION

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

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

2.1 General Discussion

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

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

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

- Sample Description: Denoted by the following abbreviations:

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

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

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

- **Other Abbreviations Used**:

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

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

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

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

2.2 Laboratory Analysis Program

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

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

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

Actual laboratory detection limits are in some cases lower than the CRQLs listed in Table 2-1 due to instrument capabilities. Values reported between this level and the CRQL are estimated by the laboratory.

TABLE 2-1
TARGET COMPOUND LIST VOLATILE ORGANICS

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

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

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

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

Compound	CAS Number	Contract Required Quantitation Limits (CRQL)	
		Water (ppb)	Soil/Sediment (ppb)
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330
4-Chlorophenyl-phenylether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-10-6	50	1,600
4,6-Dinitro-2-methylphenol	534-52-1	50	1,600
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenylether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1,600
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Di-n-butylphthalate	86-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	660
Benzo(a)anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis(2-Ethylhexyl)phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo(b)fluoranthene	205-99-2	10	330
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(a)pyrene	50-32-8	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenzo(a,h)anthracene	53-70-3	10	330
Benzo(g,h,i)perylene	191-24-2	10	330

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

TABLE 2-3
TARGET COMPOUND LIST PESTICIDES/PCBs

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

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

TABLE 2-4 TARGET ANALYTE LIST - INORGANICS	
Compound	**Contract Required Detection Limit (CRDL) Water (ppb)**
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5,000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5,000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5,000
Selenium	5
Silver	10
Sodium	5,000
Thallium	10
Vanadium	50
Zinc	20
Boron	200
Cyanide	10

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

2.3 Surveying and Mapping

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

2.3.1 Surveying

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

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

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

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

2.3.2 Mapping

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

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

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

2.4 Radiation Survey

Radiation Safety Associates, Inc. (RSA) of Hebron, Connecticut performed a radiological survey of three areas at NSB-NLON. The three sites surveyed were the Area A Landfill, Goss Cove Landfill, and DRMO. The purpose of these surveys was to determine if any radioactive

material had been disposed of at the former landfills, or if any radioactive contamination now exists at any of these locations. Surveys were carried out on June 27, July 10, and August 8, 9, and 17, 1990. The complete radiation survey report is provided as a separate bound report.

2.4.1 Instrumentation

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

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

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

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

2.4.2 Methodology

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

Survey results are discussed in Section 4.0.

2.5 Geophysical Investigation

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

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

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

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

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

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

Survey results are discussed in Section 4.0.

2.6 Soil Gas Survey

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

2.6.1 Sample Collection and Analysis

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

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

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

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

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

- Duplicates - one per day minimum;
- Background Samples - system blanks which were run at the beginning and end of each day;
- Calibration Standards - beginning and end of each day, and whenever a question of shifting retention times arose; and
- Calibration Blanks - one in ten samples and whenever a question of possible cross-contamination arose.

Background and calibration blank samples were considered acceptable if no peaks were generated. Duplicate samples were evaluated qualitatively. Results were considered acceptable if, in comparison of duplicate analyses, there was a general match of identified compounds (presence of or absence of the same compound), and if there was no significant difference in concentration, generally around an order of magnitude.

2.6.2 Data Utilization

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

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

QUANTITATION OF SOIL GAS DATA	
Assigned Sample Concentration	**Range of Concentrations/ Peak Areas (volt-seconds)**
None Detected	< 0.3
Trace	0.3 - 2.0
Low	2.1 - 50
Moderate	51 - 300
High	< 300

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

2.7 Soils Investigation

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

2.7.1 Test Borings

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

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

At most sites, soil borings were extended to auger refusal or a maximum depth of twenty feet. Exceptions to this procedure included locations in Area A and the DRMO where nested monitoring wells (overburden/bedrock) were to be installed and borings were extended to bedrock at the nested well locations; the Area A Wetland and Goss Cove Landfill where borings extended to the underlying native material; and the Lower Subase where borings were extended approximately ten feet below the ground water table. **Auger refusal does not necessarily confirm the top of bedrock elevation for the shallow monitoring wells or borings.**

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

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

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

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

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

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

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

NOTES

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

TABLE 2–6
AREA A
SUMMARY OF SOIL SAMPLING PROGRAM

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

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

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

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

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

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

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

NOTES

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

TABLE 2-7
DRMO
SUMMARY OF SOIL SAMPLING PROGRAM

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

NOTES

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

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

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

4) Sample submitted for VOC analysis was not composited.

TABLE 2–8
LOWER SUBASE
SUMMARY OF SOIL SAMPLING PROGRAM

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

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

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

NOTES

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

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

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

4) Test boring installed, organic vapor measurements and visual contamination documented; not sampled for laboratory analysis.

5) Twelve test borings were proposed in the Work Plan, however, only five borings were installed due to proximity of proposed locations to underground utilities. Soil samples from these borings were evaluated for visual contamination and screened for organic vapors to assist in delineation of extent of contamination.

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

2.7.2 Surface Soils

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

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

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

2.7.3 Sediments

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

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

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

TABLE 2–9
AREA A
SUMMARY OF SEDIMENT SAMPLING PROGRAM

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

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

			LABORATORY ANALYSES[1]										
SAMPLE ID[2]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INOR-GANICS	PESTI-CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE-SCENCE	pH
OFFSITE STREAM													
020791–OSSD1	0 – 0.5		●	●	●	●	●						
020791–OSSD2	0 – 0.5		●	●	●	●	●						
020791–OSSD3	0 – 0.5	Sheen on Water	●	●	●	●	●						

NOTES

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

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

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

2.8 Ground Water Investigation

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

2.8.1 Monitoring Well Installation

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

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

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

TABLE 2–10
SUMMARY OF MONITORING WELL INFORMATION

WELL ID	WELL TYPE	SCREEN LENGTH	GROUND SURFACE ELEV.	BEDROCK ELEV.	ELEV. OF WELL BOTTOM	TOP OF WELL CASING ELEV	DEPTH/ELEV. OF WATER[3]		ELEV. OF SCREENED INTERVAL BOTTOM	ELEV. OF SCREENED INTERVAL TOP	
CBU DRUM STORAGE											
None											
RUBBLE FILL BUNKER A–86											
None											
TORPEDO SHOPS											
7MW1D	Bedrock	11[1]	54.67		29.47	54.08	9.93	44.15	29.47	40.47	25.0'
7MW2	Overburden	7	48.6		37.6	50.41	5.43	44.98	37.6	44.6	11.0
7MW3	Overburden	10	45.98		29.06	45.71	6.2	39.51	29.09	39.09	16.9
GOSS COVE LANDFILL											
8MW1	Overburden	10	10.48		−6.25	10.15	8.68	1.47	−5.92	4.08	
8MW2	Overburden	10	9.91		−6.02	9.43	6.98	2.45	−6.02	3.98	
8MW3	Overburden	10	9.25		−6.54	8.96	6.23	2.73	−6.54	3.46	
8MW4	Overburden	10	9.62		−5.76	9.34	6.29	3.05	−5.76	4.24	
OVER BANK DISPOSAL AREA, NORTHEAST											
None											
FORMER ACID STORAGE AND DISPOSAL AREA											
None											
FORMER GASOLINE STATION											
None											
AREA A LANDFILL											
2LMW7S	Overburden	10	82.8	52.6	61.15	84.37	9.9	74.47	61.15	71.15	
							11.4[4]	72.97			
2LMW7D	Bedrock	10.09[1]	83.1	54.6	39.51	85.16	5.4	79.76	39.51	49.6	
							7.6[4]	77.56			
2LMW8S	Overburden	10	86.4		70.9	87.45	0.71	86.74	70.9	80.9	
							3.84[4]	83.61			
2LMW8D	Bedrock	77.87[1]	87.1	45.6	−37.27	89.33	0[6]	>89.33	−37.27	40.6	
							1.42[4]	87.91			
2LMW9S	Overburden	10	85.3		67.06	86.96	9	77.96	67.06	77.06	
							12.65[4]	74.31			
2LMW9D	Bedrock	12.74[1]	85.4	43.4	25.66	87.11	26.87	60.24	25.66	38.4	
							28.91[4]	58.2			
2LMW13S	Overburden	10	86.9	70.44	70.44	88.53	13.44	75.09	70.44	80.44	
							16.31[4]	72.22			
2LMW13D	Bedrock	35.53	86.8	67.3	26.77	88.2	5.4	82.8	26.77	62.3	
							10.38[4]	77.82			
2LMW14S[2]											
2LMW14D	Bedrock	8.5[1]	91.9	78.4	64.9	93.9	5.23	88.67	64.9	73.4	
2LMW17S	Overburden	10	82.48		64.73	82.12	5.89	76.23	64.73	74.73	
2LMW17D	Bedrock	15.9[1]	82.62	64.62	43.62	82.37	0[6]	>82.37	43.62	54.52	
2LMW18S	Overburden	10	77.94		62.2	77.6	6.05	71.55	62.2	72.2	
							7.0[4]	70.6			

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

WELL ID	WELL TYPE	SCREEN LENGTH	GROUND SURFACE ELEV.	BEDROCK ELEV.	ELEV. OF WELL BOTTOM	TOP OF WELL CASING ELEV	DEPTH/ELEV. OF WATER[3]		ELEV. OF SCREENED INTERVAL	
									BOTTOM	TOP
2LMW18D	Bedrock	8.03[1]	77.67	41.67	28.64	77.34	8.55	68.79	28.64	36.67
							7.51[4]	67.83		
AREA A WETLAND										
2WMW1S[2]										
2WMW1D	Bedrock	90.55[1]	128.05	125.05	29.5	127.58	10.88	116.7	29.5	120.05
2WMW2S[2]										
2WMW2D	Bedrock	40.93[1]	110.45	106.45	60.52	110.22	22.85	87.37	60.52	101.45
2WMW3S	Overburden	15	81.43		58.64	81.04	7.26	73.78	58.64	73.64
							4.90[4]	76.14		
2WMW3D	Bedrock	49.24[1]	81.68	8.68	−45.44	81.36	5.73	75.63	−45.44	3.68
							7.31[4]	74.05		
2WMW4S[2]										
2WMW4D	Bedrock	106.38[1]	93.07	84.07	−26.31	92.69	7.43	85.26	−26.31	80.07
2WMW5S	Overburden	10	73.5		58.25	76.48	2.68	73.8	60.96	70.96
2WMW6S	Overburden	10	83.4		74.12	84.67	7.63	77.04	74.12	79.12
2WMW6D	Bedrock	30.53[1]	83.2	72.7	37.17	84.87	9.93	74.94	37.17	67.7
AREA A DOWNSTREAM										
2DMW10S[2]										
2DMW10D	Bedrock	16.09[1]	52.8	49.3	26.71	54.52	10.25	44.27	26.71	42.8
2DMW11S	Overburden	10	45.4		32.95	46.85	2.1	44.75	32.95	42.95
2DMW11D	Bedrock	3.55[1]	51.5	34.5	25.95	53.2	7.97	45.23	25.95	32.0
2DMW15S[2]										
2DMW15D	Bedrock	9.51[1]	42.2	38.2	22.69	44.09	5.46	38.63	22.69	32.2
2DMW16S	Overburden	10	35.6		23.91	37.85	3.55	34.3	23.91	33.91
2DMW16D	Bedrock	41.91[1]	35.9	23.4	−24.01	37.69	3.74	33.95	−24.01	17.9
OVER BANK DISPOSAL AREA										
3MW12S	Overburden	10	41		28.66	43.51	2.67	40.84	28.66	38.66
3MW12D	Bedrock	6.1[1]	41.1	26.1	15	42.2	0.5	41.7	15	21.1
DRMO										
6MW1S	Overburden	10	7		−7.02	8.63	7.35	1.28	−7.02	2.98
6MS2S	Overburden	10	5.4		−7.8	7.3	6.18	1.12	−7.8	2.2
6MW3S	Overburden	10	4.3		−9.5	6.1	4.87	1.23	−9.5	0.5
6MW4S	Overburden	10	5.18		−7.6	4.9	3.71	1.19	−7.6	2.4
6MW5S	Overburden	10	14.05		−3.12	13.88	10.75	3.13	−3.12	6.88
6MW5D	Bedrock	4.8[1]	14.23	−10.77	−20.57	13.93	10.75	3.18	−20.57	−15.77

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

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

NOTES

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

outwashed Ottawa sand up to two feet above the top of the screen. A two-foot bentonite seal was placed above the sand. The remainder of the annular space was tremie backfilled with cement-bentonite grout.

Nineteen bedrock monitoring wells were drilled. The wells were cased through the overburden and sealed at the bedrock interface to avoid possible contamination of the bedrock aquifer by the material above. The depth to bedrock was determined during the installation of the shallow monitoring well or boring. Using either air rotary or mud rotary methods, an eight or ten inch bit was used to drill through the overburden and the first five feet of bedrock. **The mud rotary technique was used to maintain the opening in the overburden to allow the placement of the bedrock casing. The mud did not come in contact with the open hole within the bedrock and will not have any impact on the water quality. The shallow wells were not installed directly adjacent to the bedrock wells and, therefore, the mud should not affect the water quality.** Six inch diameter casing was installed five feet into the bedrock. The casing was grouted in place with a bentonite-cement slurry and allowed to set for 24 hours. A six inch roller bit or air hammer bit was used to drill through the casing to the bedrock aquifer. **Bedrock drilling continued until a sufficient water bearing fracture was encountered. A flow rate of approximately one-gallon per minute or greater was considered adequate flow.** The bedrock was cored in selected wells as specified in Atlantic Procedure 1030.

Construction details for each well are included in Appendix B.

2.8.2 Monitoring Well Development

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

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

The bedrock wells were developed by Empire under Atlantic supervision. Bedrock wells were developed with compressed air supplied from an oil free compressor. Development was performed immediately after drilling while the drill rods were still in the hole. Development continued until the clarity of the water was comparable to that of a jar of distilled water. **Due to low flow rates realized during drilling, a submersible pump was used to develop two of the bedrock wells. Compressed air development of these wells would not have been a cost efficient use of the drill rig as water clarity was not readily achieved. The wells were developed until the clarity of the water was comparable to that of a jar of distilled water.**

2.8.3 Hydraulic Conductivity Tests

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

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

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

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

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

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

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

2.8.4 Ground Water Sampling

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

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

Prior to the extraction of any ground water, the depth to water was measured to the nearest 0.01 feet, using a Solinst electronic water level indicator. If the depth of the well was unknown the bottom was also sounded. The well volume was then calculated using this data. The device was properly decontaminated between wells. A minimum of four well volumes were purged while measuring pH, temperature and conductivity at regular intervals. After the evacuation of the four well volumes, the sample was collected when these three parameters stabilized to within five percent fluctuation. In wells where a peristaltic pump was used for purging, the pump and tubing were used to collect non-volatile samples. Following the collection of the last non-volatile sample, the peristaltic pump tubing was removed from the well and the VOC sample was collected with a single-use teflon bailer. When a bailer was used to collect all samples, VOCs were collected first to avoid the loss of volatiles that could be caused by the constant agitation of a bailer. All samples for metals analysis were field filtered with an in-line 0.45 micron filter.

2.8.5 Residential Well Sampling

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

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

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

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

NOTES

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

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

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

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

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

NOTES

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

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

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

NOTES

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

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

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

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

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

NOTES

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

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

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

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

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

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

2.9 Surface Water Investigation

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

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

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

2.10 Ecological Investigation

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

TABLE 2–15
SUMMARY OF OFFSITE RESIDENTIAL WELL SAMPLING PROGRAM

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

NOTES

1) VOC – Volatile Organic Compounds
SVO – Semi–Volatile Organic Compounds
2) MW – Ground Water Sample
SW – Surface Water Sample
3) Original Sample Data rejected during validation; location resampled at a later date for parameters indicated. Inorganic rejections pertained only to cyanide.

Inorganics – Metals and Cyanide
PCBs – Polychlorinated Biphenyls
S – Overburden Monitoring Well
D– Bedrock Monitoring Well

2.11 Quality Assurance/Quality Control (QA/QC)

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

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

2.11.1 Field Quality Control (QC) Samples

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

TABLE 2-16
SUMMARY OF QA/QC SAMPLES

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

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

The referee duplicates were collected by Alliance Technologies, an EPA oversight contractor. To date final results of the referee duplicate analyses have not been received,

however, the USEPA has indicated that preliminary results are acceptable. The trip blanks contained deionized laboratory water. The equipment rinsates consisted of distilled water utilized as a final rinse during decon procedures. The field blanks were samples of driller's water, and water used during equipment decon.

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

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

2.11.2 Field Audits

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

Date	Type of Sampling Observed
August 30, 1990	Subsurface Soils
November 13, 1990	Subsurface Soils
January 15, 1991	Ground Water

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

USEPA oversight was provided by Alliance Technologies, Inc.

2.11.3 Data Validation

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

is included in Appendix C.

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

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

TABLE 2-17
LABORATORY ANALYTICAL DATA QUALIFIERS

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

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

2.11.4 Data Quality Objectives

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

detail, including calculations, in Appendix C.

Precision is a test of the repeatability of a measurement and is based upon the results of field or laboratory duplicates. Precision is considered acceptable if the relative percent difference (RPD) between two duplicate samples is within ±30 percent **(aqueous samples) or ±50 percent (soil samples)**. RPDs were calculated as part of the data validation process and **two** percent of the analytical results were estimated due to duplicates having RPDs greater than **30** percent.

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

Accuracy calculations, prepared by the laboratory, are provided in the laboratory analytical package. Analytes exhibiting values lower or higher than this were estimated in associated samples. Samples for inorganic analysis which were not detected and had associated spike recoveries <30% were rejected as part of data validation. Samples for organic analysis which were not detected and had spike recoveries <10% were rejected as part of data validation. Less than one percent of all analytical data was rejected based on accuracy considerations.

Completeness is a measurement of valid data obtained relative to the total amount of data generated. This project's QC objective for data completeness, as a percentage of valid data reported, was ≥90%. **As shown in Appendix C, 1.4% of all data was rejected corresponding to a completeness of 98.6%. Completeness is discussed in further detail in Appendix C.**

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

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

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

3.1 Topography

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

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

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

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

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

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

Cove were once part of the Thames River, it is evident that the topography of both sites has been altered significantly.

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

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

3.2 Soils

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

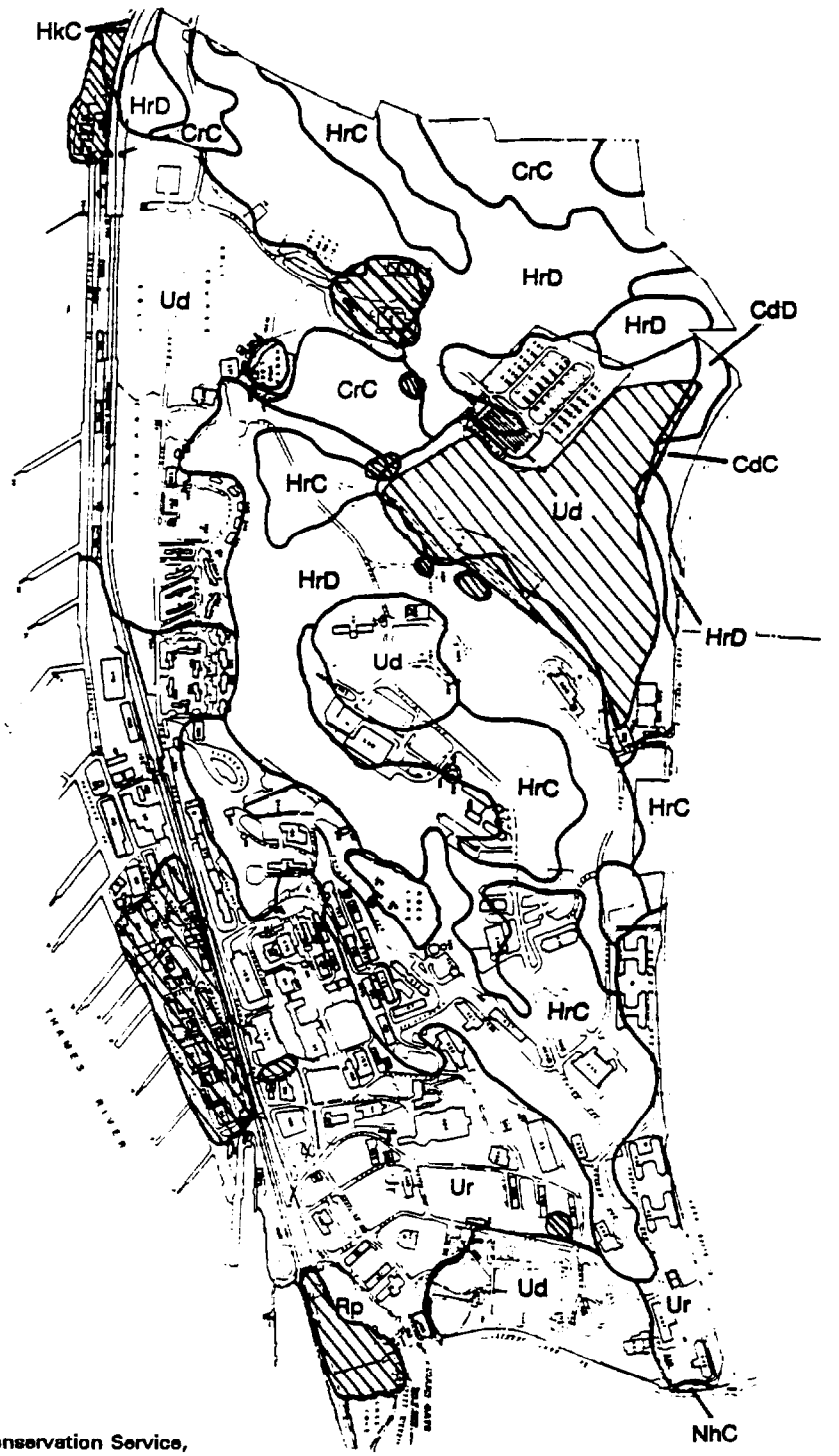
Regarding SCS soil descriptions, the following is noted: 1) SCS soil grain size ranges are different from those used in geological and engineering practice; 2) SCS descriptions are only based upon the first five feet of soil from the surface; and 3) descriptive permeability ranges for a given soil type correspond to specific numerical values.

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

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

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

The Charlton soil typically has a very dark grayish brown, fine sandy loam surface layer three inches thick. The subsoil is dark yellowish brown, yellowish brown and light olive brown fine sandy loam 26 inches thick. The substratum is grayish brown fine sandy loam to a depth of 60 inches or more. Permeability of the Charlton soil is moderate or moderately rapid.



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

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NAVAL SUBMARINE BASE - NEW LONDON
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LEGEND

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

FIGURE 3-1
SOILS MAP

ATLANTIC ENVIRONMENTAL SERVICES, INC.

Available water capacity is moderate. Charlton soil warms up and dries out rapidly in the spring. It is strongly acidic to medium acidic. The hazard of erosion is moderate or severe.

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

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

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

Characteristics of the Charlton Soils are described above.

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

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

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

Typically, the Hinckley soil has a dark brown, gravelly sandy loam surface layer seven inches thick. The subsoil is yellowish-brown gravelly loamy sand 15 inches thick. The substratum is brownish-yellow very gravelly coarse sand to a depth of 60 inches or more.

Permeability is rapid in the surface layer and subsoil and very rapid in the substratum. Available water capacity is low, and runoff is medium or rapid. Hinckley soil warms up and dries out rapidly in the spring. It is strongly acidic or medium acidic.

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

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

Rp - Rock Outcrop-Hollis, 3-45 % Slopes - This gently sloping to very steep complex consists of rock outcrop and a somewhat excessively drained soil on glacial till uplands. Stones and boulders cover one to eight percent of the surface. Mapped areas are irregular in shape and mostly 2 to 15 acres in size. This complex is about 50 percent rock outcrop, 30 percent Hollis soil, and 20 percent other soils. The hazard of erosion is severe. Rock outcrop is hard, unweathered, exposed bedrock.

The characteristics of the Hollis soil are described above.

Ud - Udorthents-Urban Land, 0-15 % Slopes - This complex consists of excessively drained to moderately well drained soils that have been disturbed by cutting and filling, and areas that are covered by buildings or pavement. Mapped acres are mostly 5 to 40 acres in size. About 60 percent of the complex is Udorthents, 25 percent is urban land, and 15 percent is other soils.

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

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

Ur - Urban Land - This group consists of land where more than 85 percent of the surface is covered by streets, parking lots, buildings and other structures. Most urban land is in densely populated areas and units are 5 to 30 acres in size.

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

3.3 Bedrock Geology

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

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

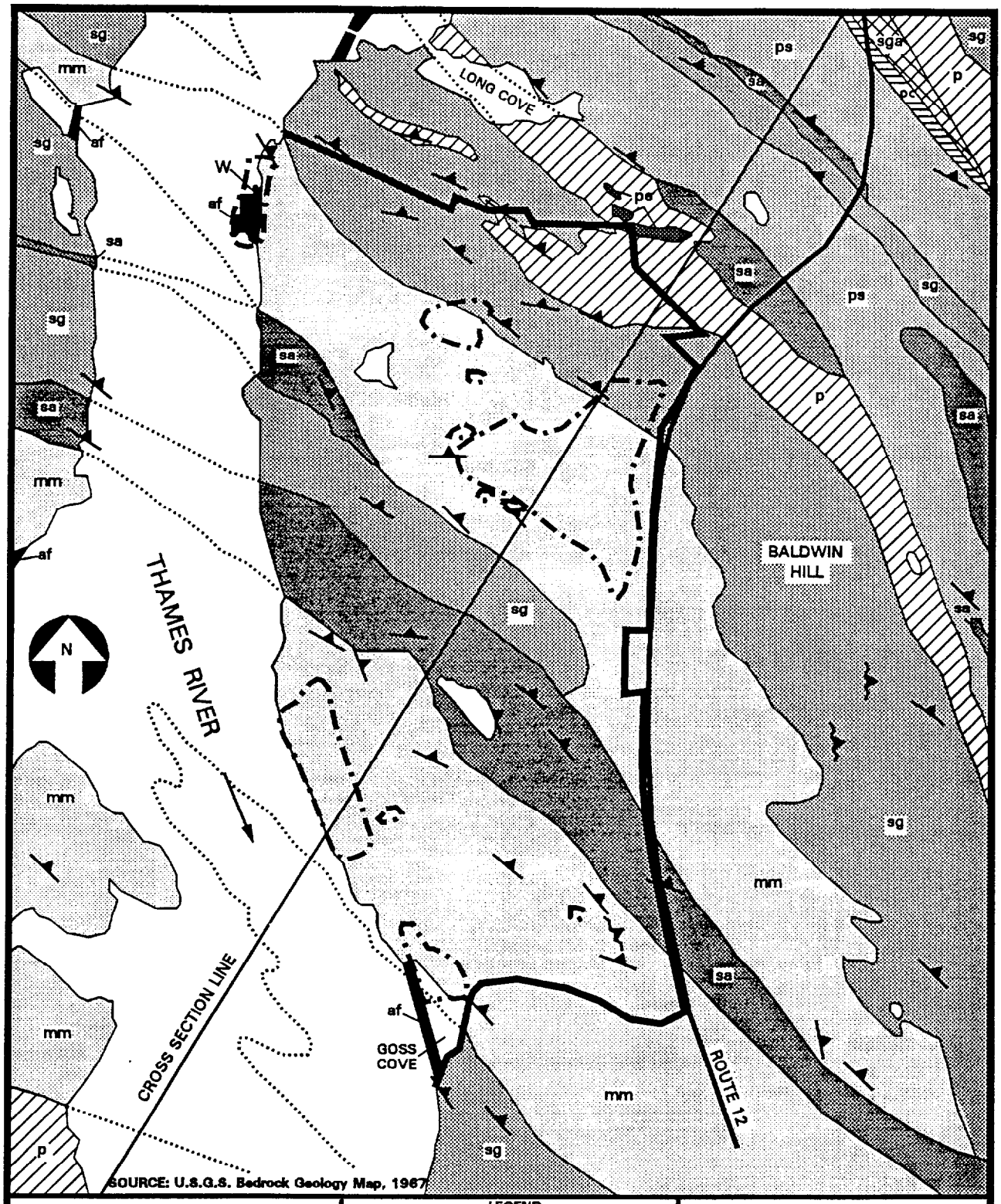
According to the USGS Bedrock Geologic Map (USGS, 1967), the bedrock at NSB-NLON can be divided into three age groups, Pre-Silurian, Pre-Pennsylvanian, and Pennsylvanian or younger. The local bedrock contains a complex series of folds, faults, anticlines and synclines. Figure 3-2 shows the bedrock geology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

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

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

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

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



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LEGEND

Refer to Figure 3-3 for formation descriptions.

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

w - Westerly Granite — - Sites Investigated

Strike & Dip of Mineral Foliation

- Inclined
- Gently Folded

FIGURE 3-2

BEDROCK GEOLOGY MAP

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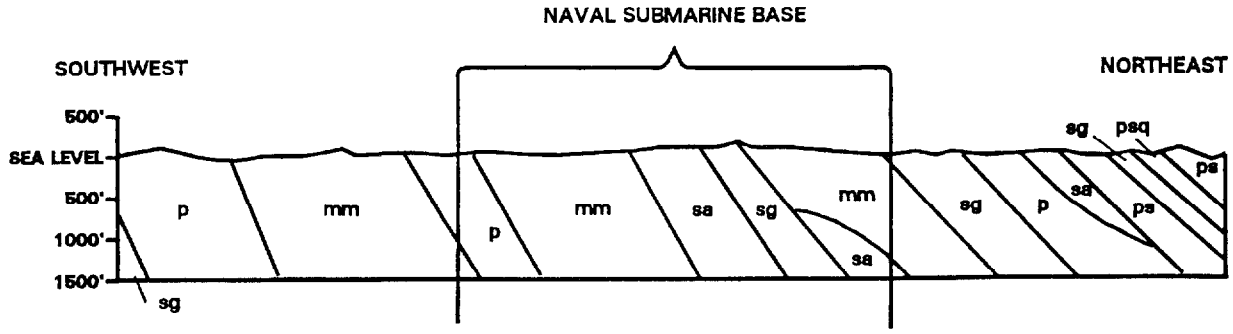


Cross-section location shown on Figure 3-2

Legend

Alaskite gneiss

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

Granite gneiss

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

Mamacoke Formation

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

Plainfield Formation

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

pc - calc-silicate quartzite and gneiss.

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

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

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

biotite tends to be concentrated on the boundaries of lenses.

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

3.4 Surficial Geology

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

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

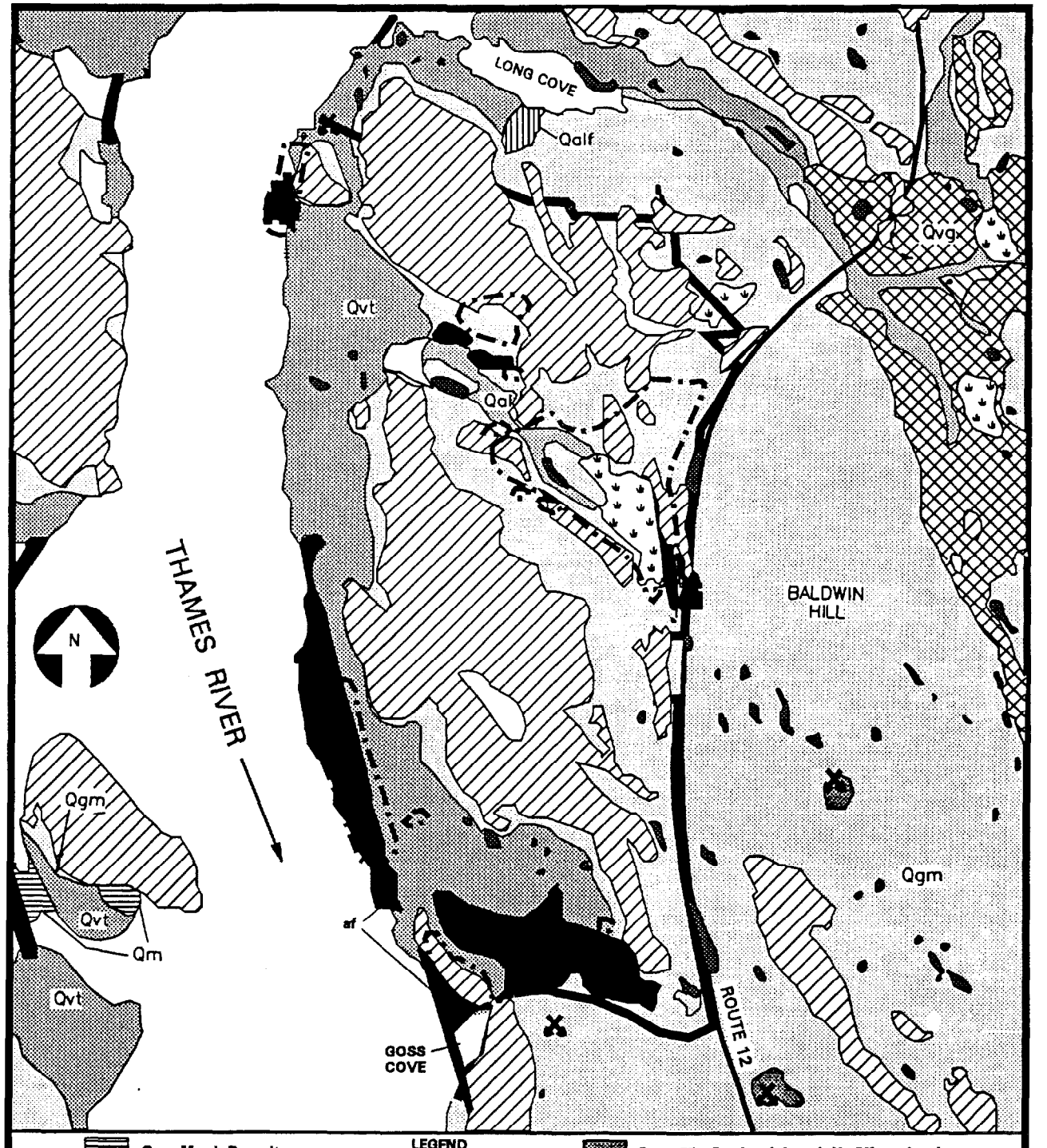
The glacial deposits are divided into two types: nonstratified drift (also known as till or ground moraine) and stratified drift (also known as outwash). Nonstratified drift was deposited in direct contact with the glaciers. Stratified drift was deposited by meltwater streams from a near or distant ice mass.

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

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

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

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



LEGEND

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

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- Bedrock Exposures
- Artificial Fill
- Borrow Pit, Active
- Sites Investigated

Refer to Figure 3-4A for sediment descriptions.
SOURCE: U.S.G.S. Surficial Geology Map, 1960

FIGURE 3-4

SURFICIAL GEOLOGY MAP

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Artificial fill is mapped in the areas of Goss Cove Landfill, DRMO, the majority of the Lower Subase, and the southernmost portion of NSB-NLON (former location of Crystal Lake).

Extensive bedrock outcrops are mapped and were observed throughout NSB-NLON at or adjacent to all sites except the Lower Subase.

3.5 Surface Water Hydrology

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

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

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

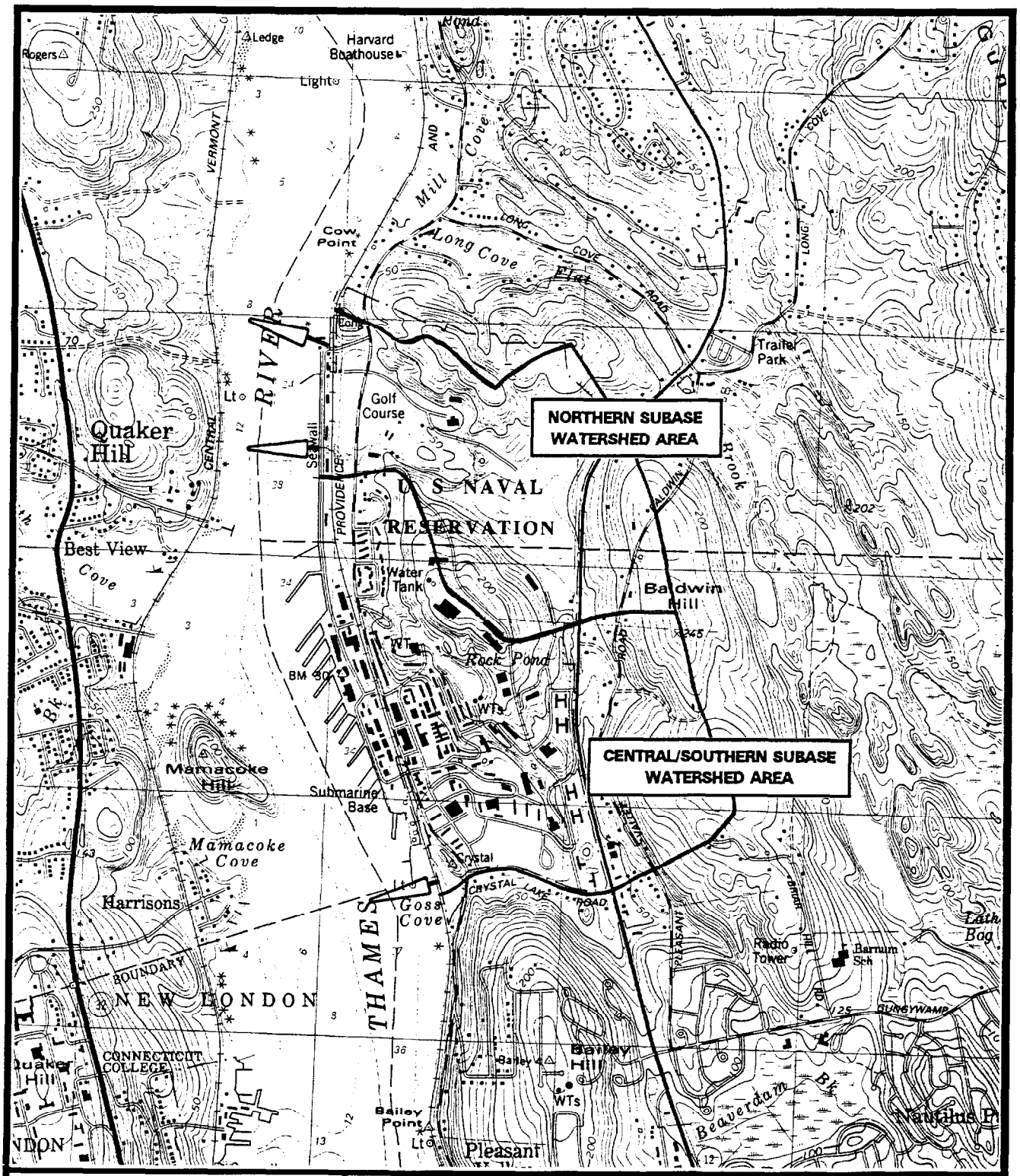
3.6 Ground Water Hydrology

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

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

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

The bedrock in the site area consists of fractured metamorphic rock covered by glacial material that is thick in the lowlands and thinner in the uplands. In bedrock aquifers, ground water movement is along joint planes rather than through intergranular openings. Well records indicate that bedrock wells in the site vicinity yield from between one and 65 gpm. Potential



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
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LEGEND

SOURCE: U.S.G.S. Topographic Map, 1984
Uncasville, Ct.

N

Major Surface Water Discharge Points

FIGURE 3-5
WATERSHED AREAS IN THE VICINITY OF NSB-NLON

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well yields in bedrock wells are dependent on degree of fracturing, topography, and type and thickness of overburden. In general, the greatest well yields occur in valleys where bedrock is highly fractured and is overlain by over 50 feet of stratified drift.

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

3.7 Site Specific Geology and Hydrogeology

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

3.7.1 Torpedo Shops

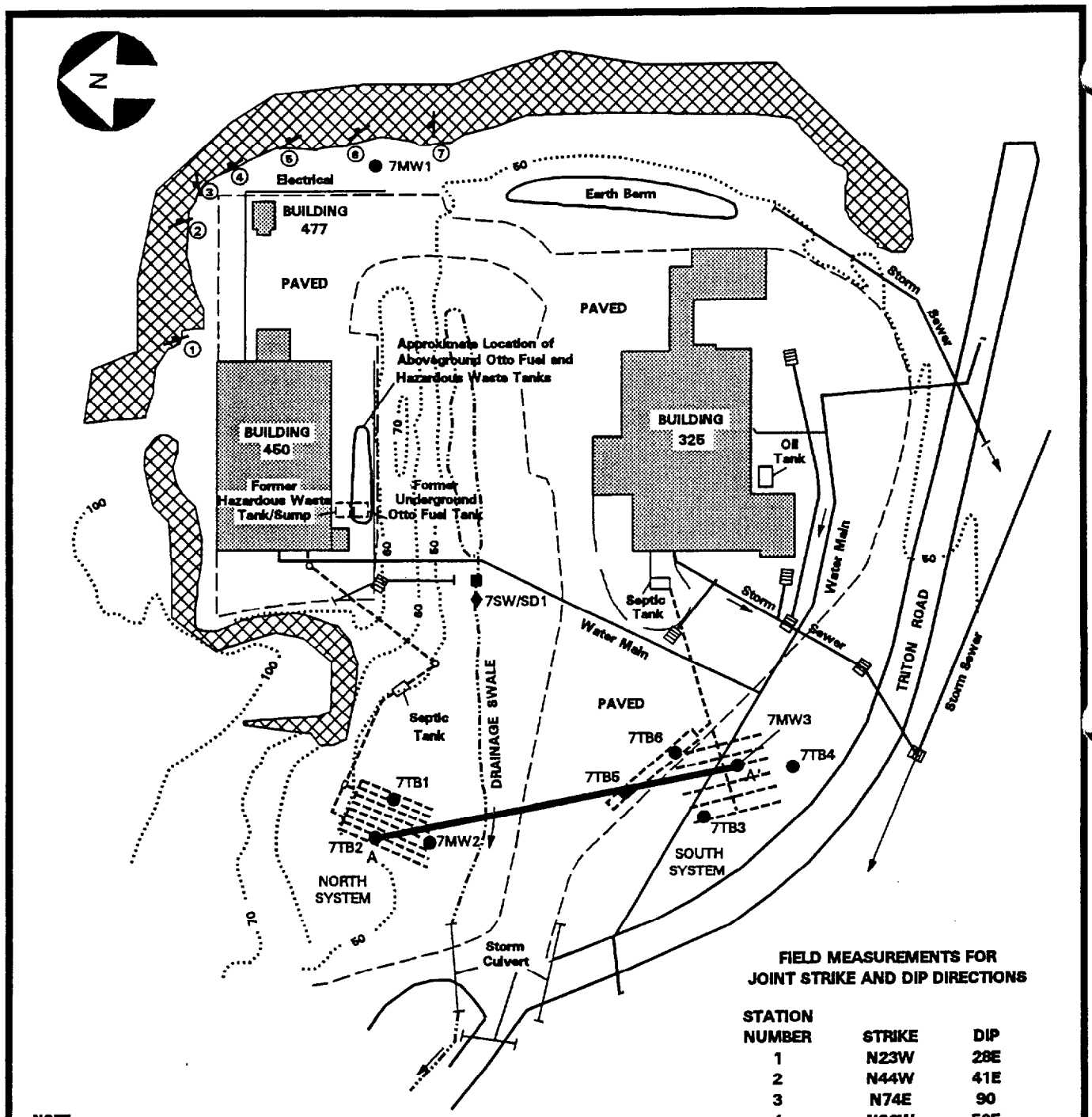
The subsurface at the Torpedo Shops was characterized with nine soil borings. Eight of the soil borings were located in the western portion of the site and the remaining one was located on the east side of the site. The borings were extended to auger refusal or a maximum depth of 20 feet. Figure 3-6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

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

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

Atlantic personnel measured the orientation of joints in the bedrock outcrops onsite and observed that the major joint set strikes east-southeast to west-northwest. Vertical fractures were also observed striking north-south. **These measurements are shown on Figure 3-6.**

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



FIELD MEASUREMENTS FOR JOINT STRIKE AND DIP DIRECTIONS

STATION NUMBER	STRIKE	DIP
1	N23W	28E
2	N44W	41E
3	N74E	90
4	N36W	50E
5	N43W	29E
6	N47W	51E
7	N83W	90

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

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
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LEGEND
- Exposed Bedrock
- Catch Basin
- TB1 - Test Boring
- MW1 - Monitoring Well
- SD1 - Sediment Sample
- SW1 - Surface Water Sample
- Strike and Dip
- 95 - Existing Grade
- Former Septic System
- Building
- Watercourse

Approximate Scale
0 40 80'

FIGURE 3-6
GEOLOGIC CROSS-SECTION LOCATION
TORPEDO SHOPS

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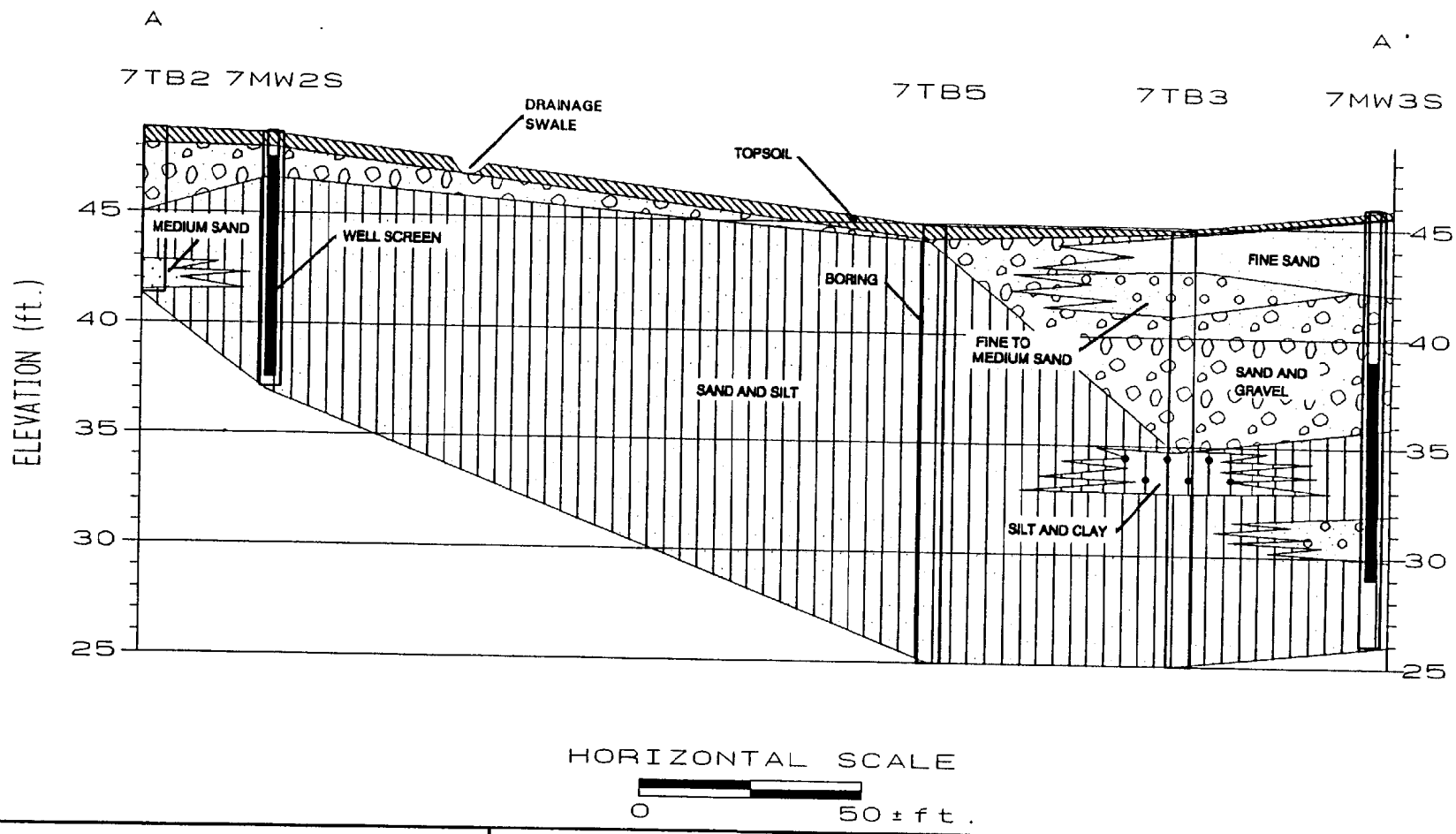

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

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

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record the lithology of fill material rather than native material.

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

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

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

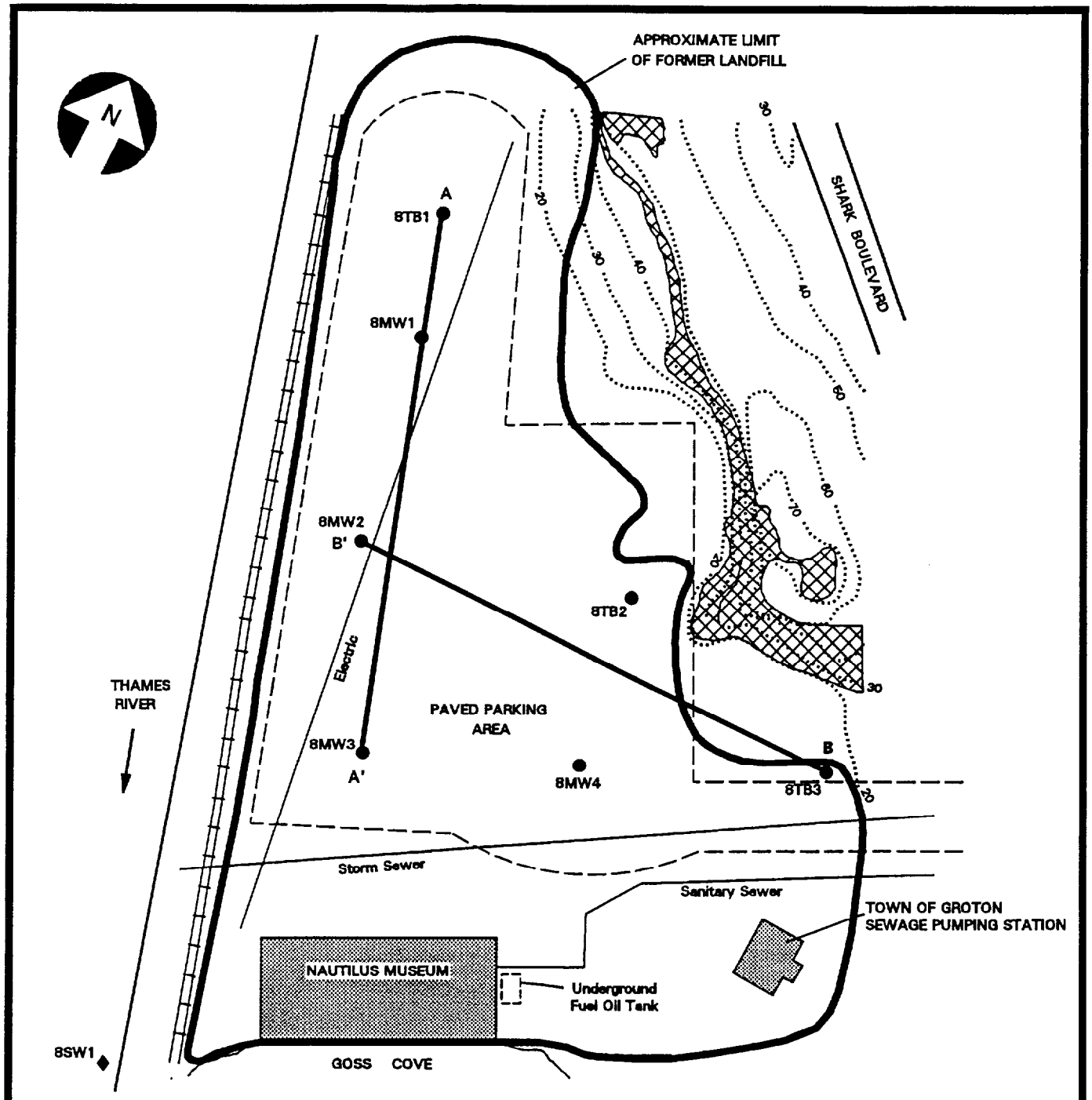
Slug displacement tests were performed in overburden well 7MW2 and bedrock well 7MW1 in the Torpedo Shops area. Well 7MW2 is screened ten feet in fine-grained sand and silt in the northwestern part of the site. The hydraulic conductivity of the fine-grained sand and silt was calculated to be **10.7** feet per day (feet/day) from slug test data. The ground water velocity was not calculated for this site due to limited information on the ground water table gradient.

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

3.7.2 Goss Cove Landfill

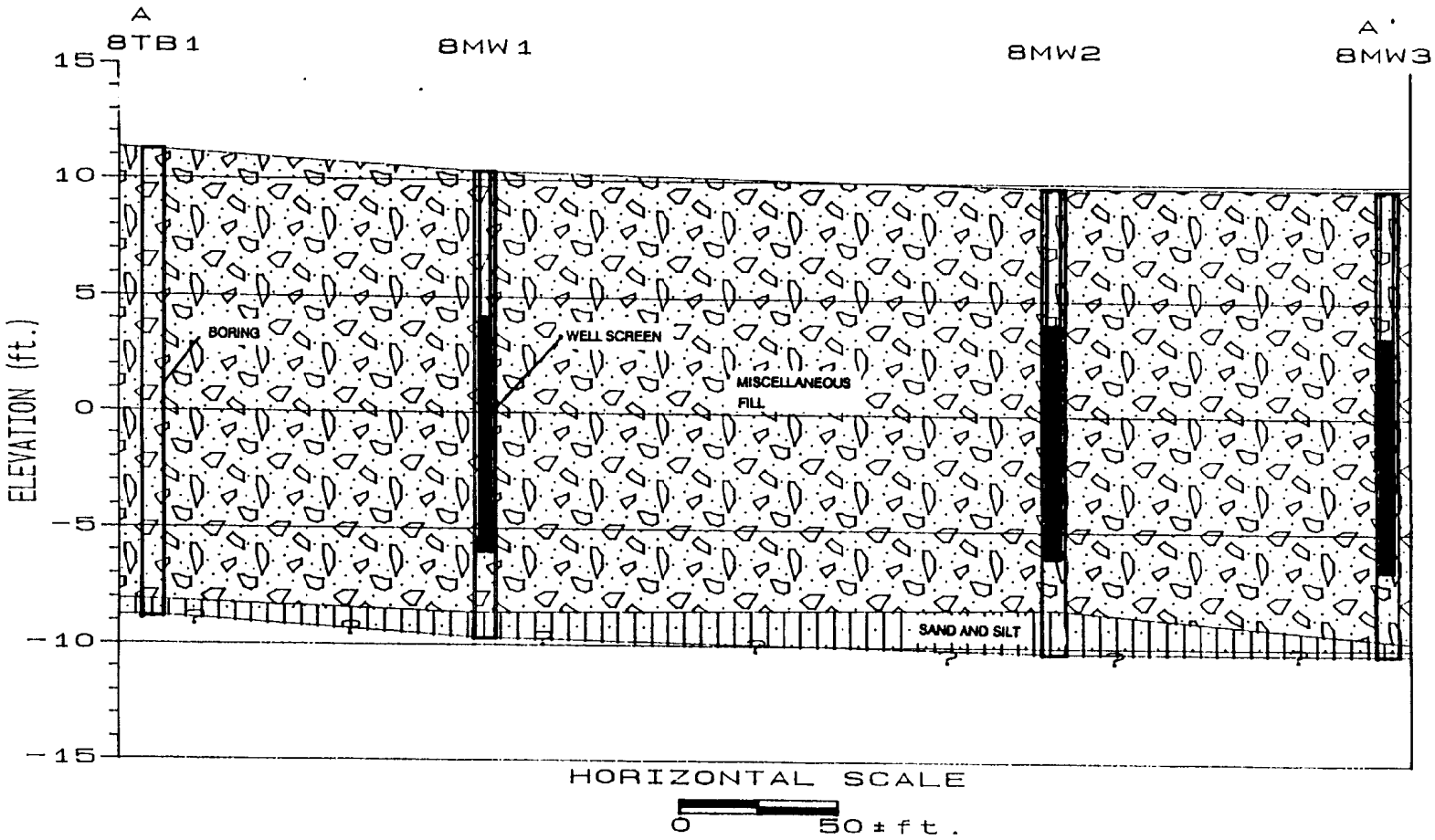
The subsurface at Goss Cove Landfill was characterized with seven test borings, four of which were finished as monitoring wells. The borings were drilled under or adjacent to the Nautilus Museum parking lot and were extended to auger refusal or a maximum depth of 20 feet. Geologic cross-sections were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

The 1967 USGS Bedrock Geology Map (Figure 3-2) shows the Goss Cove Landfill site as an open cove flanked on the west by the artificial fill of the railroad bed. Figure 3-1 shows that the southwestern portion of the site is underlain by a gneissic biotite granite known as the



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

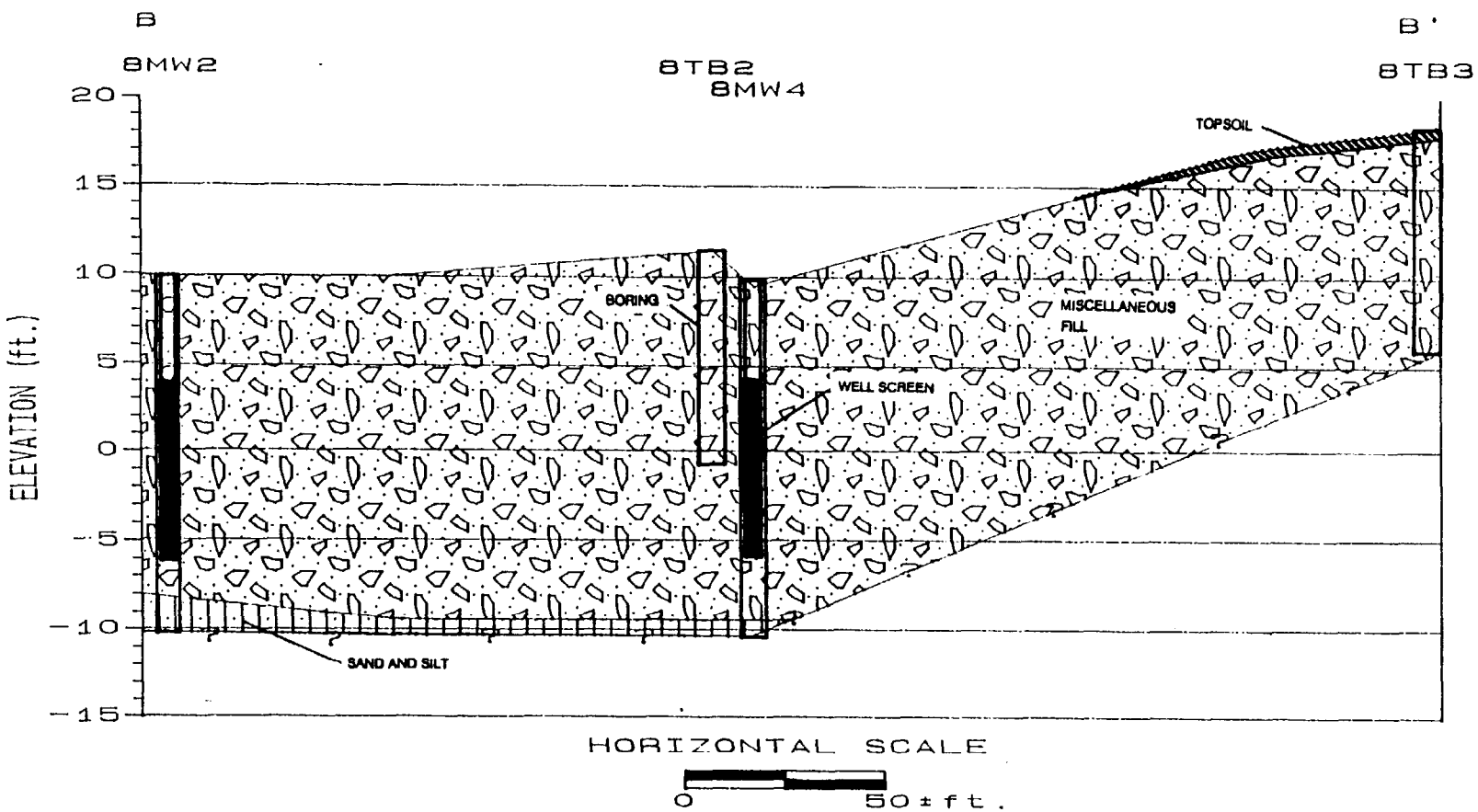
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock TB1 - Test Boring MW1 - Monitoring Well SW1 - Surface Water Sample •••95••• - Existing Grade - Building Approximate Scale 0 20 40'	FIGURE 3-8 GEOLOGIC CROSS-SECTION LOCATIONS GOSS COVE LANDFILL ATLANTIC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



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

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

ATLANTIC ENVIRONMENTAL SERVICES, INC.



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

FIGURE 3-10
GEOLOGIC CROSS-SECTION B - B'
GOSS COVE LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC.

Granite Gneiss Member of the Sterling Plutonic Group. The bedrock in the northeastern corner of the site, which includes the bedrock outcrops present onsite, consists of a biotite-quartz-feldspar-gneiss that is a member of the Mamacoke Formation.

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

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

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

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

Slug displacement tests were performed in the four overburden wells installed in the Goss Cove Landfill. These wells are screened predominantly in fill material comprised of fine- to coarse-grained sand and gravel with ash, metal fragments, glass, brick and other refuse. Review of the slug test data indicates that the slug displacement test was an ineffective method for determining the hydraulic conductivity of the fill material due to its high permeability. The hydraulic conductivity of this material was estimated to be 280 feet per day based on published values for clean sand and gravel from Freeze and Cherry (1979). The ground water flow

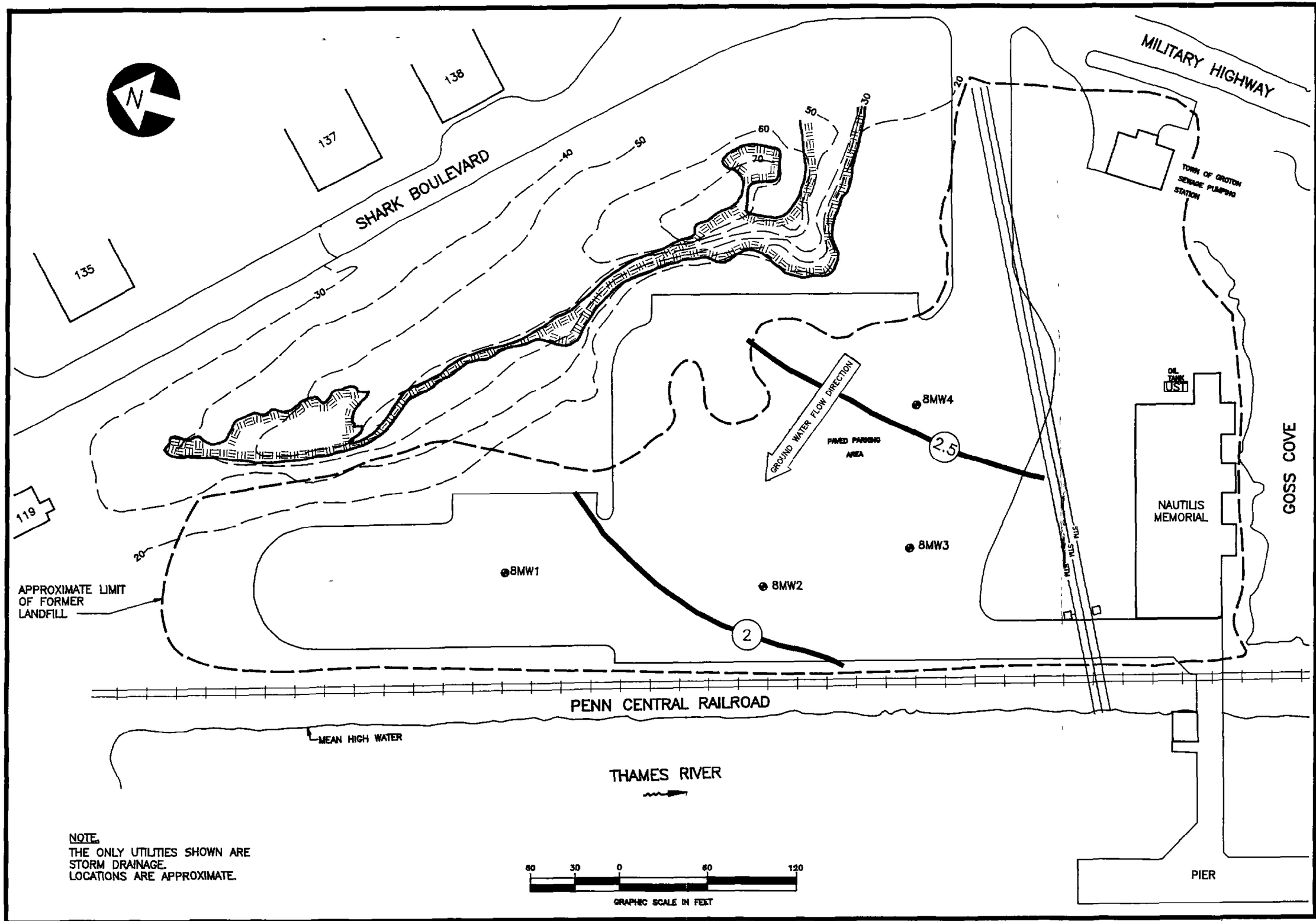


FIGURE 3-11
GROUND WATER CONTOUR MAP
GOSS COVE LANDFILL

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

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velocity through the fill material was estimated to be **1.4** feet per day, assuming a hydraulic conductivity of 280 feet per day, a porosity of 0.40 (Freeze and Cherry, 1979), and a hydraulic gradient of 0.002, based on Figure 3-11. The fill material was determined to have a maximum thickness of 20 feet. The thickness of unconsolidated sediments in the Goss Cove Landfill is between 25 and 100 feet. For purposes of estimating the volume of ground water discharging to the Thames River from the Goss Cove Landfill, the thickness of sediments is assumed to be 50 feet. Based on the calculated flow velocity, the length of the area perpendicular to the flow path, and an estimated thickness of 50 feet, the volume of water discharging to the Thames River is estimated to be 20,400 cubic feet per day (152,600 gpd). The majority of this discharge probably is derived from the fill material which is assumed to be more permeable than the underlying fine-grained sand and silt.

3.7.3 Spent Acid Storage and Disposal Area

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

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

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

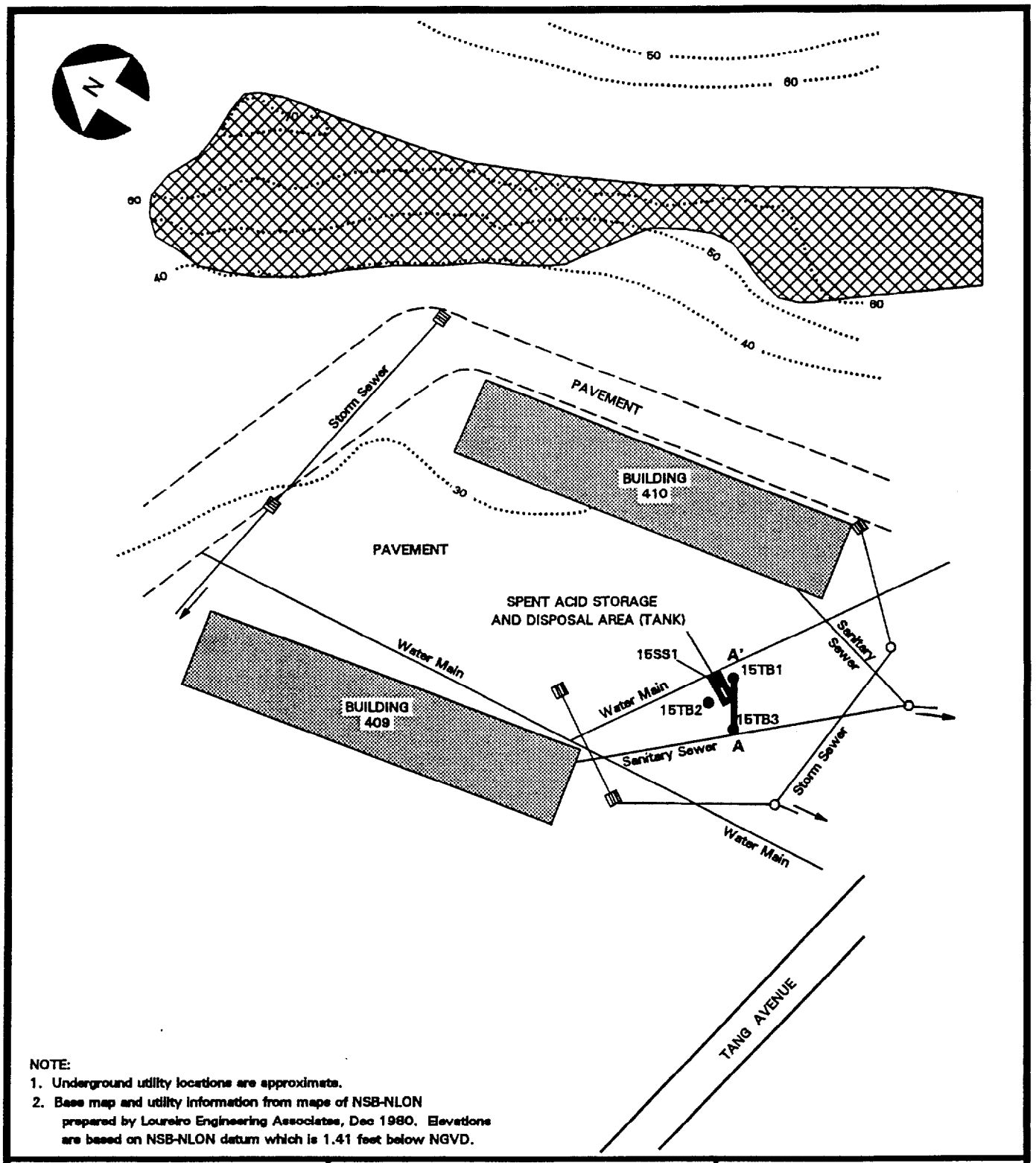
The 1960 USGS Surficial Geology Map (Figure 3-4) shows that this site is located in terrace deposits of the Thames River, which consist of stratified silt, sand and gravel that was deposited by glacial meltwater. Subsurface soil conditions observed during soil sampling are consistent with this description.

Subsurface material at this site consists of fine- to medium-grained sands and silt with traces of clay. Where clay is present, it usually occurs in discreet, silty lenses of less than a half-inch in thickness. Rust colored staining and mottling were common in borings 15TB1 and 15TB3 located on the east and south side of the spent acid tank, respectively.

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

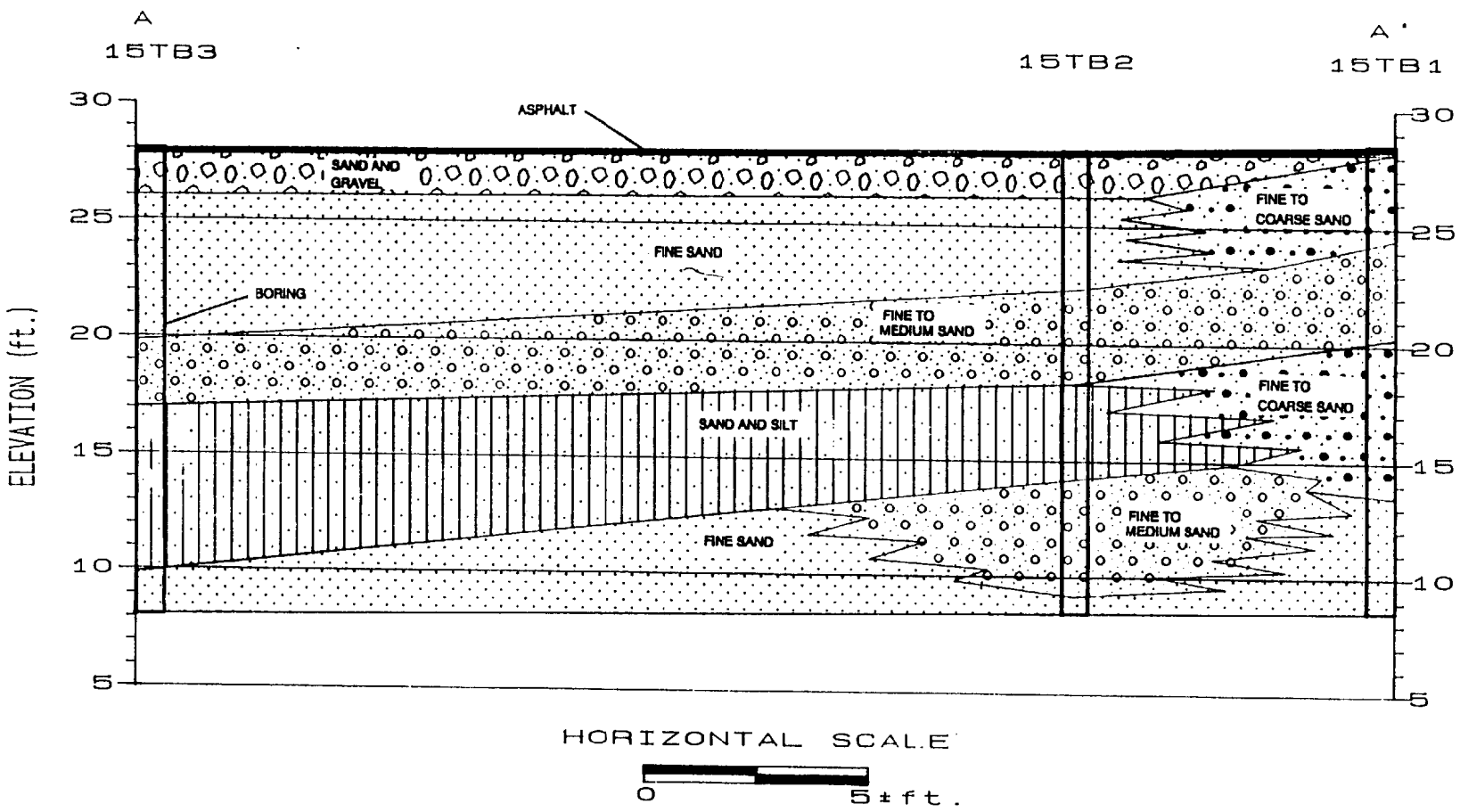
3.7.4 Former Gasoline Station

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

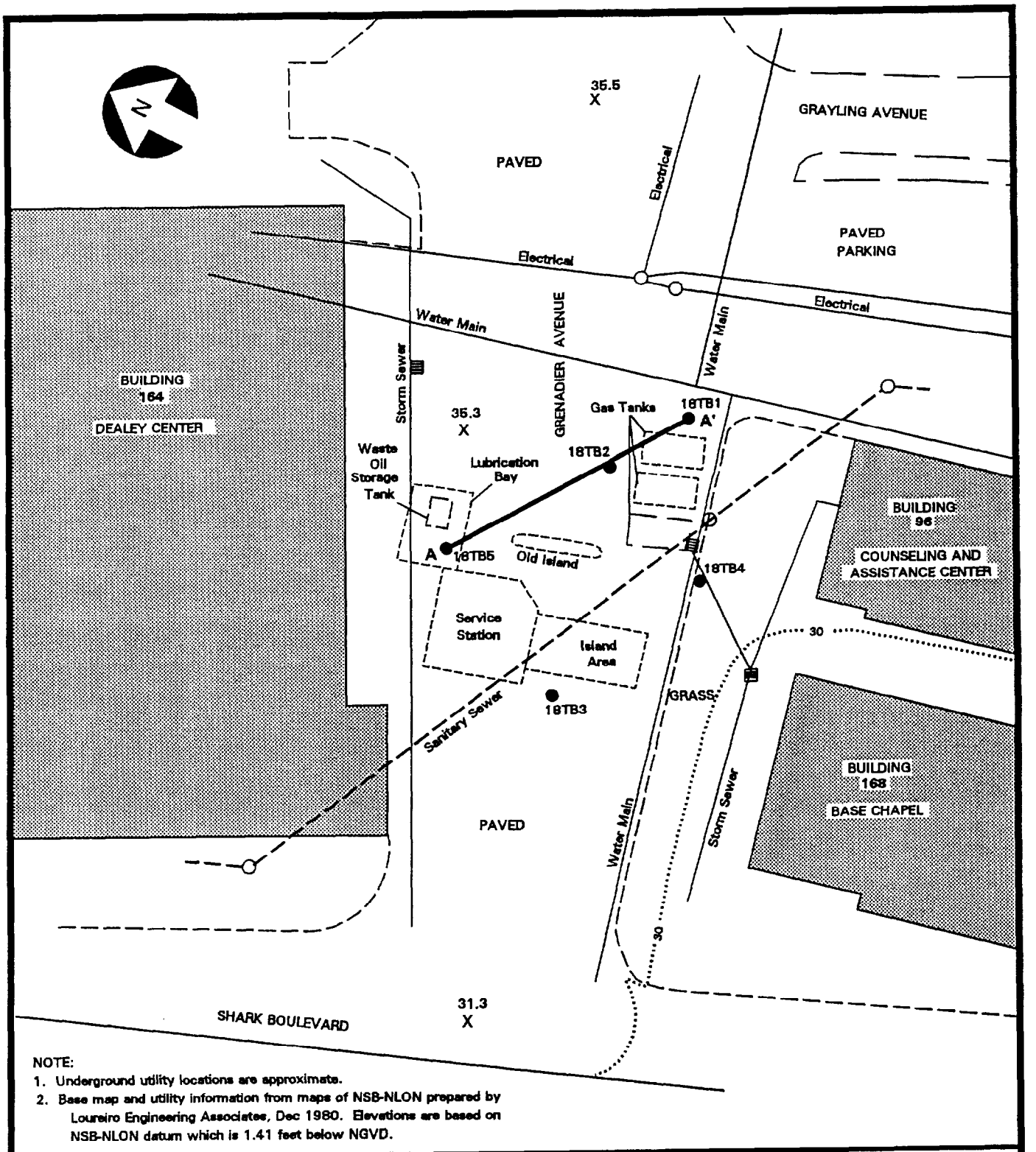


NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

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



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



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ···95··· - Existing Grade – – – – - Former Structure ▤ - Catch Basin ○ - Manhole ● TB1 - Test Boring ▒ - Building 78.2 X - Spot Grade Approximate Scale 0 20 40'	FIGURE 3-14 GEOLOGIC CROSS-SECTION LOCATION FORMER GASOLINE STATION ATLANTIC ENVIRONMENTAL SERVICES, INC.

Cross-section A-A' is provided as Figure 3-15.

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

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

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

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

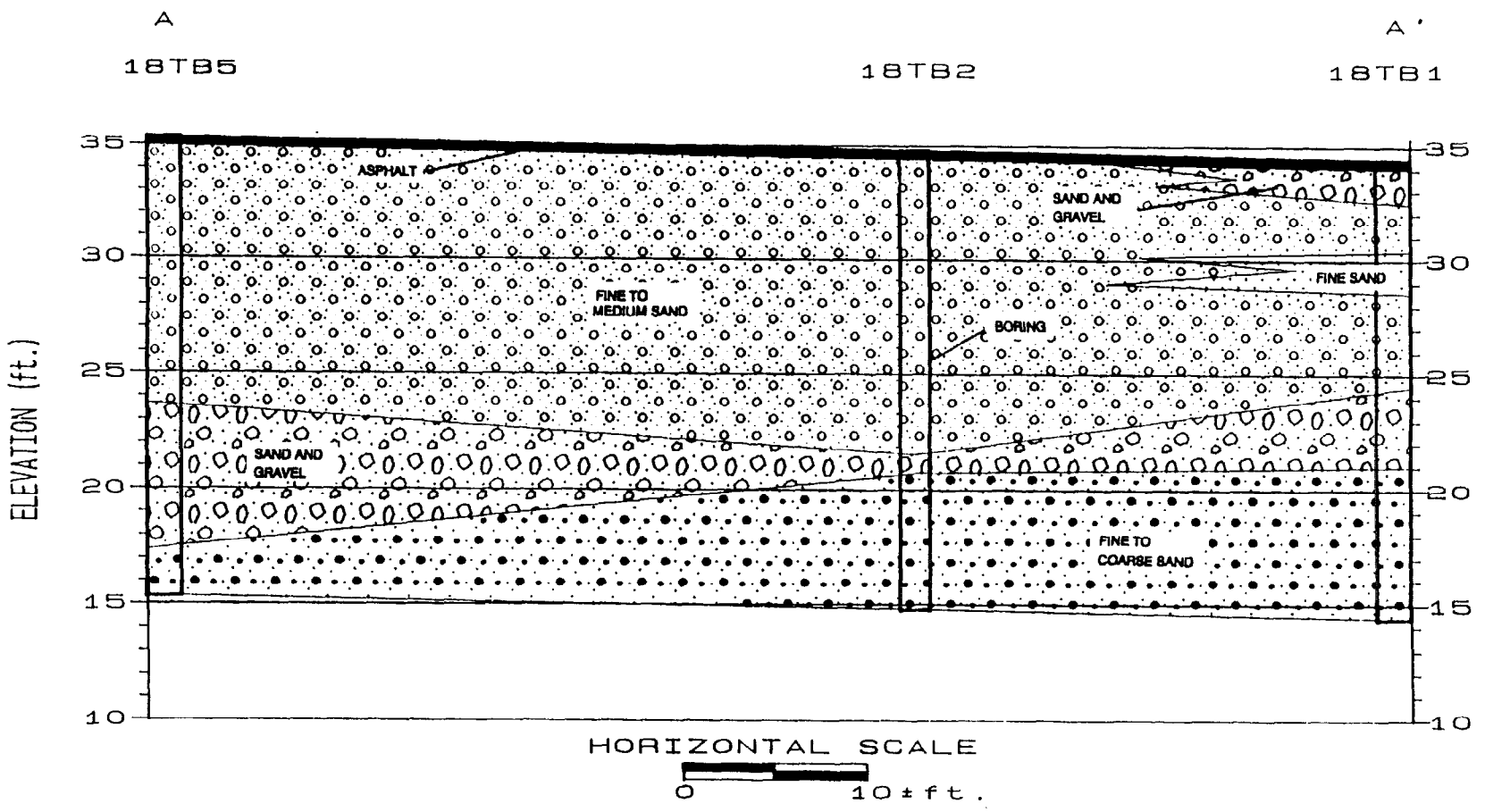
No ground water monitoring was performed at this site, however, based on topography, ground water likely flows west to the Thames River.

3.7.5 Area A and OBDA

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

The 1967 USGS Bedrock Geology Map (Figure 3-2) indicates that the bedrock underlying the majority of Area A is biotite-quartz-feldspar gneiss of the Mamacoke Formation. Figure 3-2 shows that all of the Area A Landfill and the Overbank Disposal Area, the southern portion of the Area A Wetland, and the northern and eastern portions of the Area A Downstream Watercourses is underlain by bedrock of the Mamacoke Formation. The northernmost portion of the wetland is underlain by a gneissic biotite granite that is mapped as the Granite Gneiss Member of the Sterling Plutonic Group. The southwestern portion of the Area A Downstream Watercourses is mapped as an equigranular gneissic granite known as the Alaskite Gneiss Member of the Sterling Plutonic Group.

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



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

FIGURE 3-15
GEOLOGIC CROSS-SECTION A - A'
FORMER GASOLINE STATION

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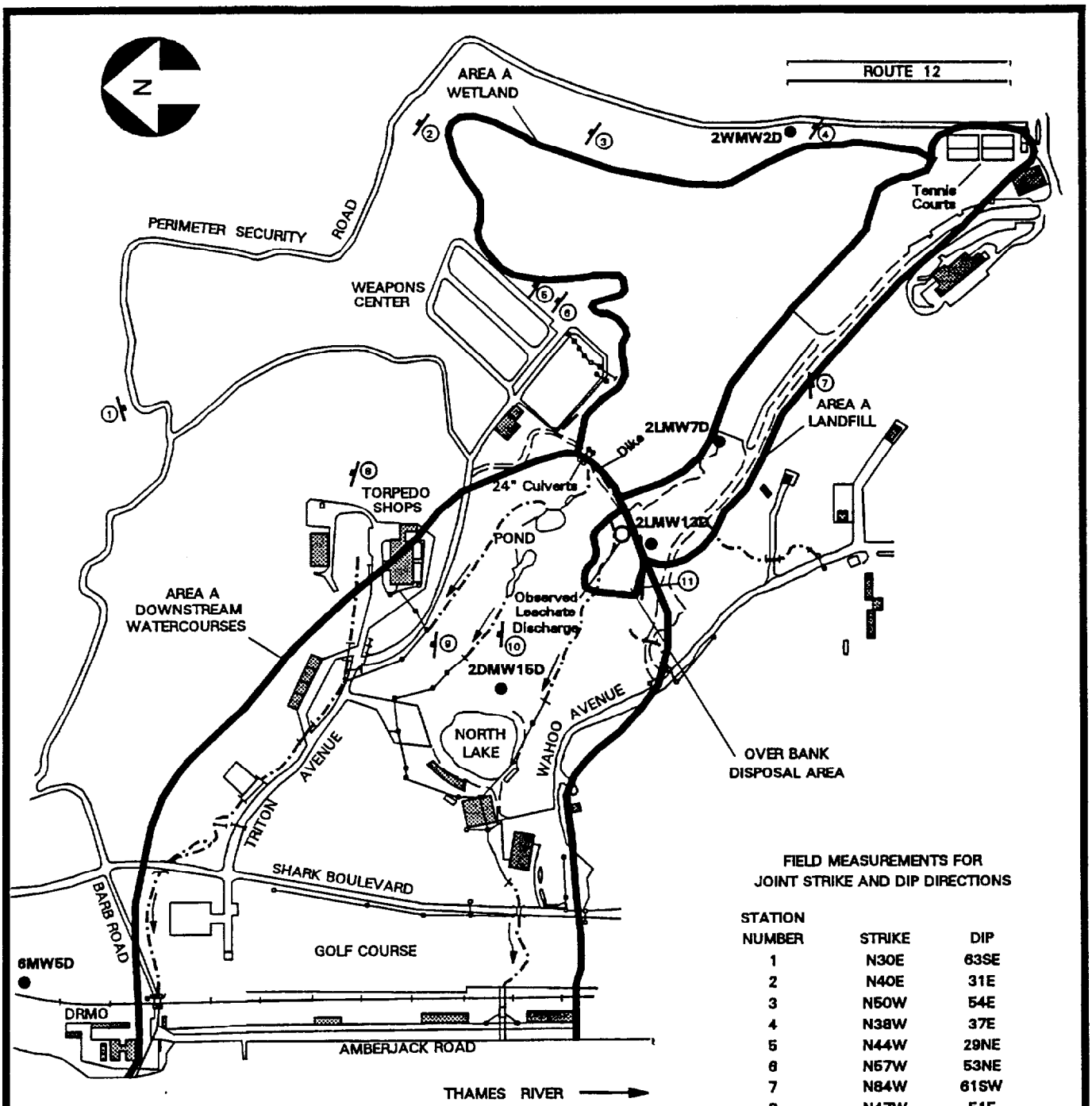


FIELD MEASUREMENTS FOR JOINT STRIKE AND DIP DIRECTIONS

STATION NUMBER	STRIKE	DIP
1	N30E	63SE
2	N40E	31E
3	N50W	54E
4	N38W	37E
5	N44W	29NE
6	N57W	53NE
7	N84W	61SW
8	N47W	51E
9	S68E	45SW
10	S77E	21SW
11	N59W	70NW

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

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

LEGEND
- Storm Culvert
- Strike and dip direction of joints with station location number.
- Coring Location
- Building
- Watercourse
Approximate Scale
0 200 400'

FIGURE 3-16
BEDROCK STRUCTURES AND CORING LOCATIONS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

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

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

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

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

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

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

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

mapped prior to or during the time the dredge and fill operation was in progress.

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

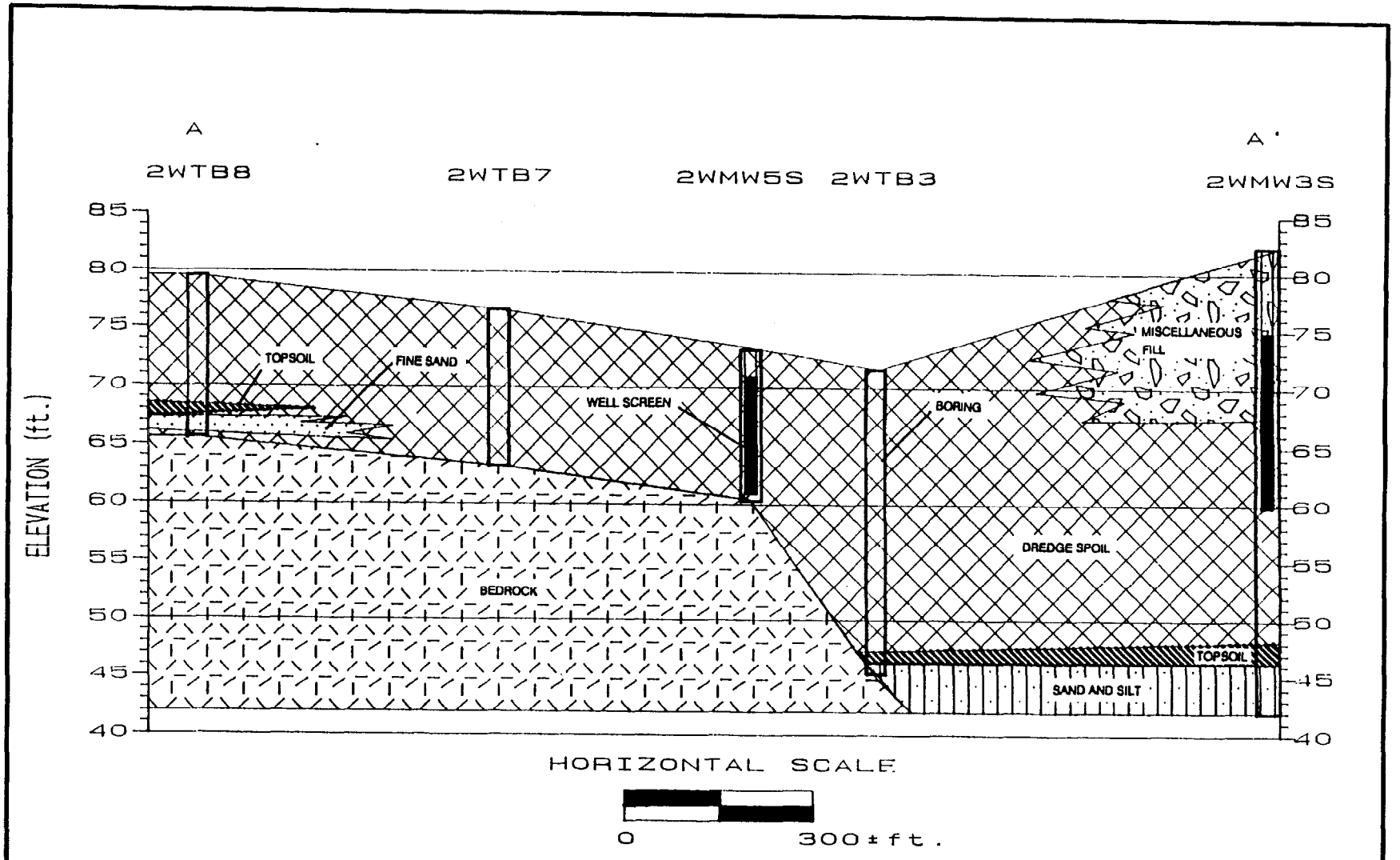
Area A Landfill: The 1983 SCS Soils Map (Figure 3-1) shows the majority of the Area A Landfill as Udorthents-Urban Land. The southwestern slope of the Landfill (which also includes the CBU Drum Storage Area and the Rubble Fill at Bunker A-86) is classified as Hollis-Charlton Rock, 15-45% slopes. Both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

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

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

Downstream Water Courses/OBDA: The 1983 SCS Soils Map (Figure 3-1) shows the Area A Downstream Watercourses as Udorthents-Urban Land to the north and west of North Lake. The portion of the Downstream Watercourses between the earthen dike and North Lake is depicted as Charlton-Hollis, 3-15% slopes. Both classifications are consistent with observed soil conditions, topography and development in this area. The Over Bank Disposal Area is also shown as Hollis-Charlton Rock, 15-45% slopes. This classification is consistent with observed site soil conditions and topography.

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



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NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

FIGURE 3-17
GEOLOGIC CROSS-SECTION A - A'
AREA A

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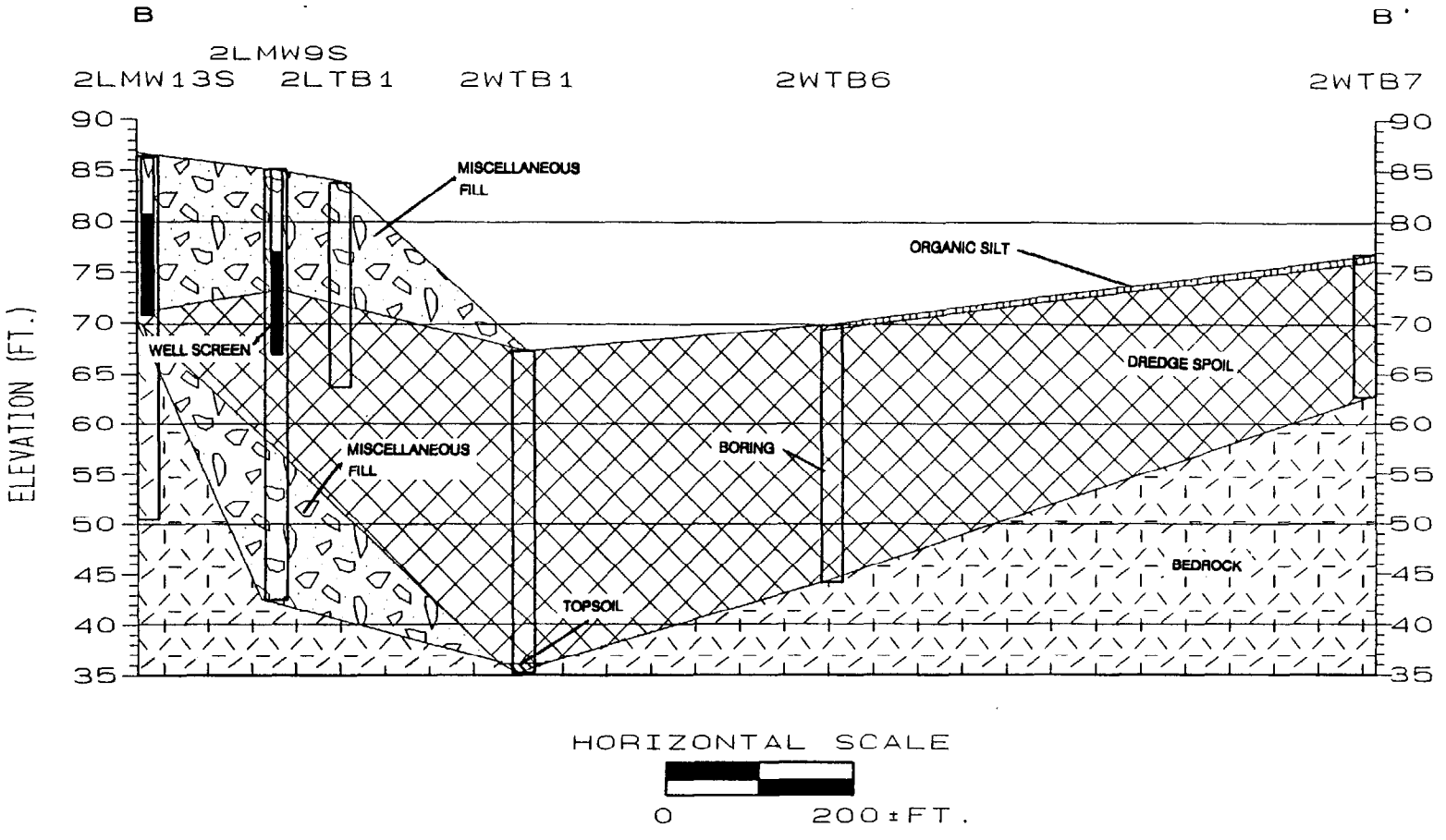

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FIGURE 3-18
GEOLOGIC CROSS-SECTION B - B'
AREA A

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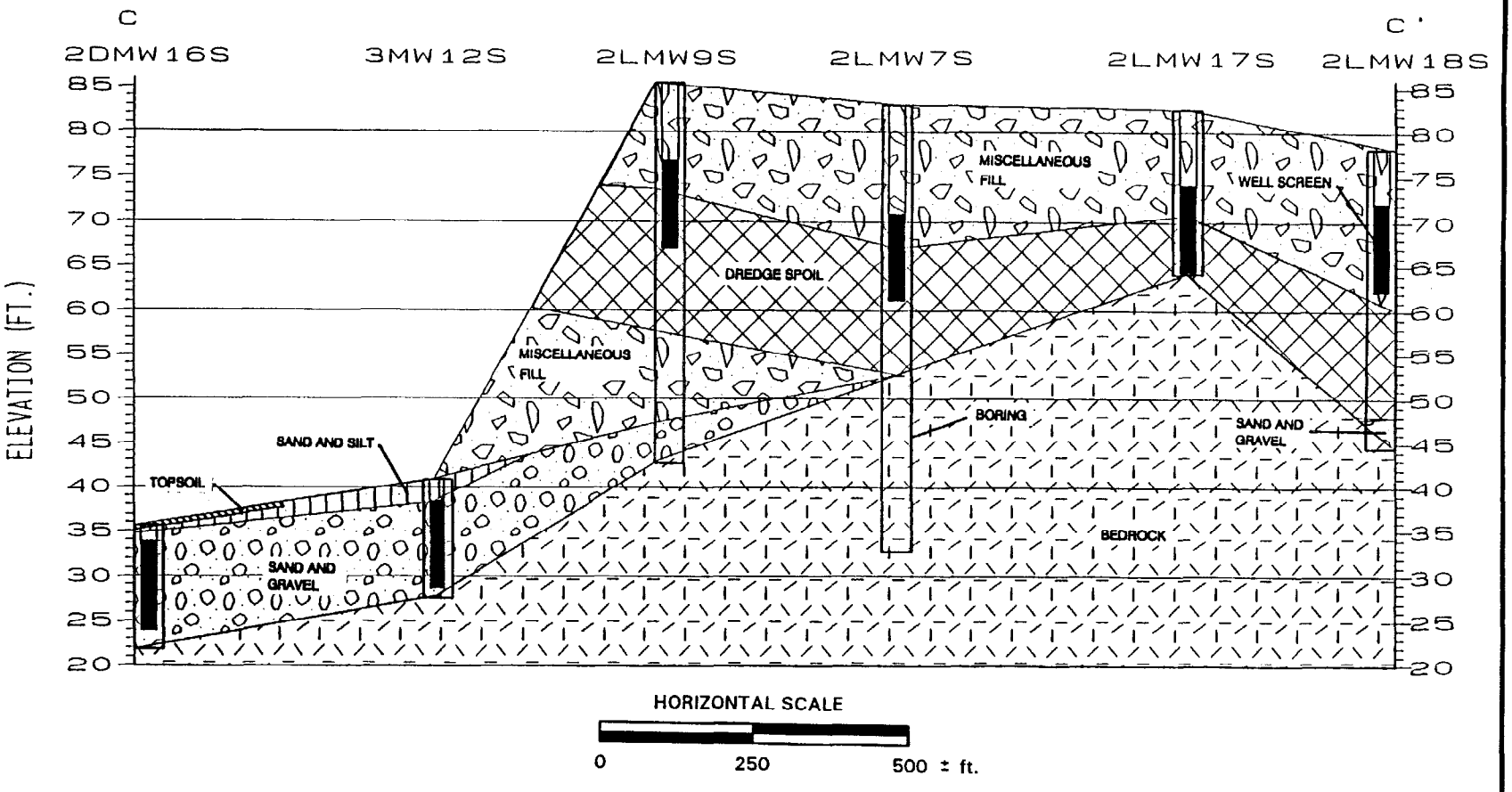

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FIGURE 3-19
GEOLOGIC CROSS-SECTION C - C'
AREA A

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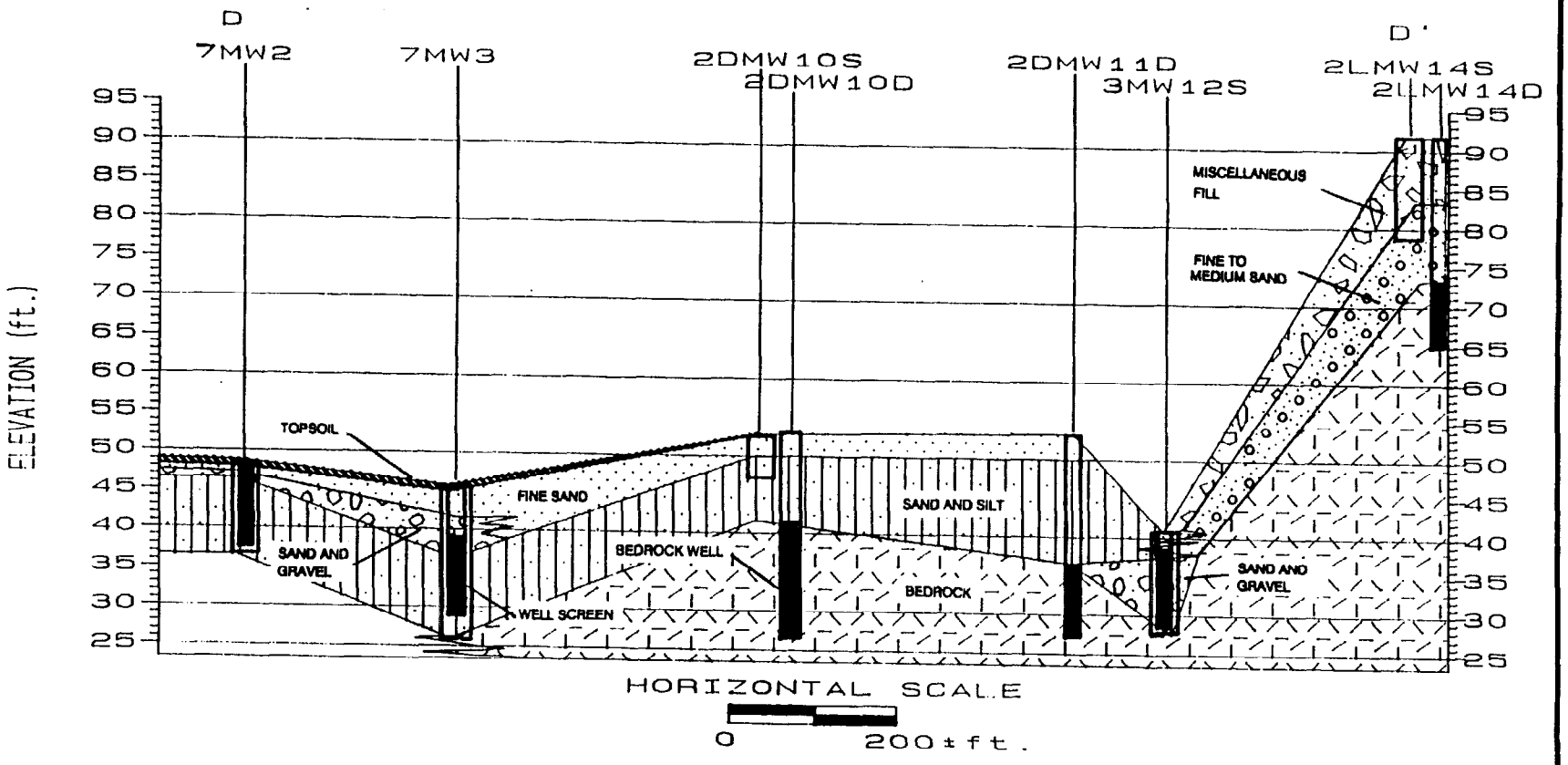
The Area A Downstream and Over Bank Disposal Area (OBDA) are physically separated from the Area A Wetland by an earthen dike and from the Area A Landfill by a steep slope. Cross-section C-C' (Figure 3-19) shows the relative elevations of the Landfill, Downstream and OBDA. The subsurface is also distinct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

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

Slug displacement test data from six overburden wells were analyzed in order to estimate the *in situ* hydraulic conductivity of the overburden materials throughout Area A. The majority of the wells were screened ten feet into various depths of fill material and dredge spoil (see boring logs for wells 2WMW3S, 2LMW7S, 2LMW8S, AND 3MW12S). Well 2WMW5S is screened only in the dredge spoil. Well 2DMW16S is screened four feet in coarse sand and gravel, two feet in very fine sand and silt, and four feet in medium sand and gravel. The geometric mean hydraulic conductivity of the fill material and the dredge spoil combined was calculated to be **3.2** feet/day. The hydraulic conductivity of the dredge spoil was calculated to be **1.0** feet/day. The hydraulic conductivity of the material surrounding well 2DMW16S (Downstream Area) was calculated to be **6.8** feet/day.

The velocity of ground water flow through sediments in the landfill and wetland portions of Area A was estimated to be 0.04 feet/day, using a hydraulic conductivity of **3.2** feet/day, a porosity of 0.30 (Freeze and Cherry, 1979) and a hydraulic gradient of approximately 0.004 from Plate 3-2. The ground water flow velocity through the soils in the Area A downstream, using a hydraulic conductivity of **6.8** feet/day, 0.30 for the porosity, and 0.01 for the hydraulic gradient (from Plate 3-2), was calculated to be **0.02** feet/day.

To characterize the bedrock aquifer in the study area, 17 monitoring wells were installed in Area A, one well was installed at the Torpedo Shops and one was installed upgradient at the DRMO. To further characterize ground water flow in the bedrock aquifer at the boundaries of the site, ground water elevations were measured in five offsite wells located to the north, east and southeast of Area A. The procedure for calculating water level elevations in offsite wells is as follows: the ground surface elevation estimate for each offsite well was obtained from either Town of Ledyard topographic maps (contour interval, ten feet) or NSB-NLON maps



INSTALLATION RESTORATION STUDY
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LEGEND

FIGURE 3-20
GEOLOGIC FENCE DIAGRAM D - D'
AREA A

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(contour interval, two feet). When the former were used, elevations were corrected to NSB-NLON datum. Using an electronic water level indicator, Atlantic personnel measured depth to water from the top of the well casing. When possible, the wells were pumped for twenty minutes and the water levels measured again. The lowest water table elevations were used when comparing water levels offsite to those onsite and when constructing ground water elevation contour maps. **The lowest water table elevation was used because it represents a worst case condition with respect to ground water gradient between on-base wells and off-base wells (e.g., does well drawdown create a condition where on-base ground water contamination could migrate to offsite wells).** Well data and elevation estimates are listed in Table 3-1. The accuracy of well water elevations derived from Town of Ledyard maps is estimated to be ±5 feet. The accuracy of elevation from NSB-NLON maps is estimated to be ±1 foot.

TABLE 3-1
SUMMARY OF OFFSITE RESIDENTIAL WELL ELEVATION DATA

Well Number	Address	Ground Elevation (Source)	Approximate Water Elevation (feet)
OSW-8*	1292 Route 12	82 (NSB-NLON)	74.8*
O8W-12	1444 Route 12	138 (Ledyard)	123.4
OSW-24	1298 N. Pleasant Valley Road	171 (Ledyard)	161.5
OSW-28	1469 Route 12	119.6 (NSB-NLON)	98.7
OSW-29*	1323 Route 12	115 (NSB-NLON)	80.1*

* Indicates static water level, no pumping conducted.

Onsite and offsite data was compiled to make a **potentiometric** map for the bedrock aquifer which is presented as Plate 3-3.

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

Vertical hydraulic head **differences** were assessed at paired wells within the Area A Landfill. The data generated indicates that there is an upward flow component, which is expected due to the landfill's location adjacent to the wetland. The exception is at 2LMW9S&D, where there is a strong downward gradient. This apparently is due to the proximity of these

wells to the dike, where there is a steep drop in topographic and ground water elevation. The vertical head **difference** at the two paired well locations within the downstream area is not significant. At 3MW12S&D, a ± 1 foot **vertical head difference with an** upward gradient was recorded, while at 2DMW16S&D (near North Lake), no significant vertical **head difference** was recorded.

Also of concern regarding this investigation is whether or not ground water discharges into North Lake. The ground water elevation in well 20MW16S is higher than the elevation of North Lake, indicating that ground water from the overburden aquifer can be expected to be discharging into North Lake. At times when the lake is lowered the chances are even greater that ground water discharges into it. As discussed above, there is no significant head difference between wells 20M16S & D (paired wells in the overburden and bedrock, respectively), suggesting that bedrock ground water does not discharge into North Lake. Section 8.0 includes a recommendation for ground water elevation monitoring to further evaluate the ground water flow regime at North Lake.

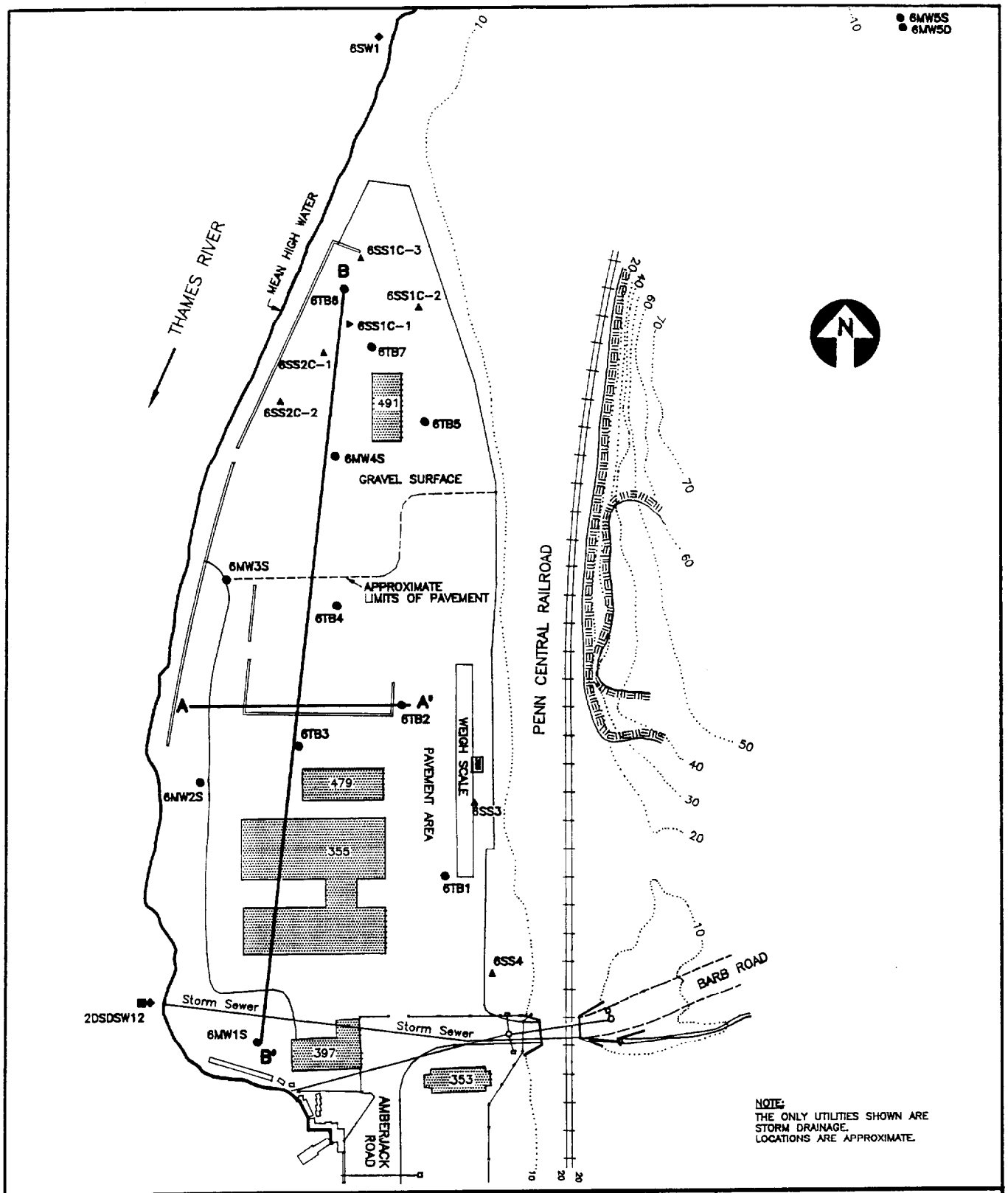
Slug displacement tests were conducted in bedrock wells 2WMW1D, 2WMW2D, 2WMW3D, and 2WMW6 in the Area A Wetland. The calculated transmissivities using slug displacement test data from the aforementioned wells are **245** ft^2/day, **1195** ft^2/day, **4.6** ft^2/day, and **16** ft^2/day, respectively, assuming a porous aquifer thickness of 150 feet. Slug displacement tests were conducted in bedrock wells 2LMW7D and 2LMW18D in the Area A Landfill. The open bedrock interval in well 7D is eight feet, and in well 18D it is ten feet. The calculated transmissivity from well 7D slug test data is 69 ft^2/day, and from well 18D it is **216** ft^2/day, assuming a porous aquifer thickness of 150 feet. Two bedrock wells, 2DMW10D and 2DMW16D, were slug tested in Area A Downstream. The open interval in well 10D extends 16 feet into bedrock. The bedrock transmissivity was calculated to be 20 ft^2/day, using data collected from well 10D. The open bedrock interval in well 16D is 47 feet. The calculated transmissivity, using data from well 16D, is **4** ft^2/day. The transmissive properties of the discrete fracture(s)/joint(s) intersected by these wells probably are greater than the calculated values. The wide range of transmissivity values generated from the test data indicate the high variability of transmissive properties within the fractured bedrock below the site.

3.7.6 DRMO

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

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

The 1967 USGS Bedrock Geologic Map (Figure 3-2) shows the DRMO site as artificial fill underlain by a biotite-quartz-feldspar gneiss of the Mamacoke Formation. The northernmost portion of the DRMO is mapped as a gneissic biotite granite known as the Granite Gneiss



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GROTON, CONN.

LEGEND

- MW1 – Monitoring Well
- TB1 – Test Boring
- SD1 – Sediment Sample
- SS1 – Surface Soil Sample
- SW1 – Surface Water Sample
- ·····10····· – Existing Contour
- Building
- Exposed Bedrock

Approximate Scale
0 30 60'

FIGURE 3–21
GEOLOGIC CROSS–SECTION LOCATIONS
DRMO

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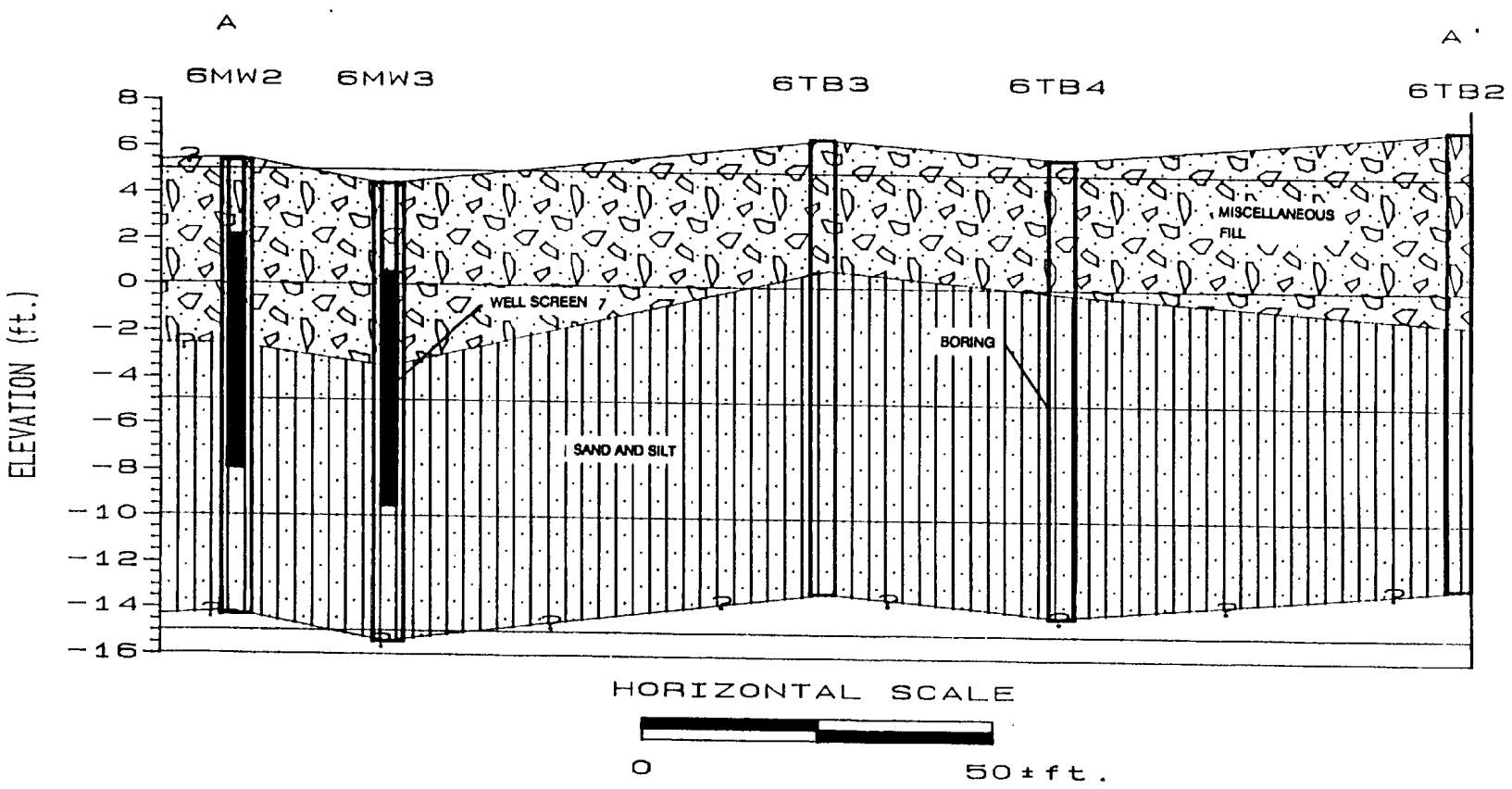

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FIGURE 3-22
GEOLOGIC CROSS-SECTION A - A'
DRMO

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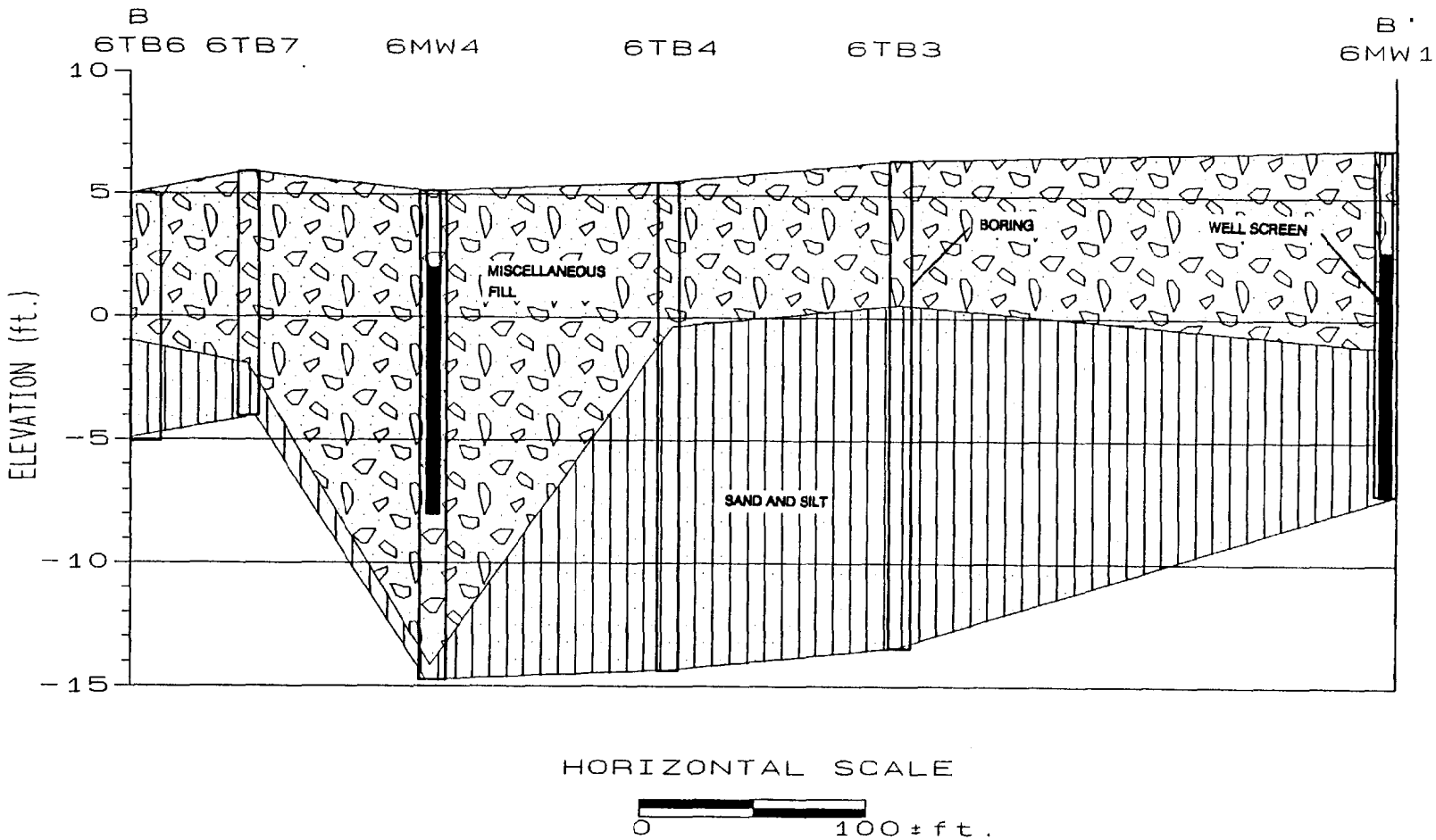

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FIGURE 3-23
GEOLOGIC CROSS-SECTION B - B'
DRMO

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Member of the Sterling Plutonic Group. An outcrop of the Westerly granite is also mapped on the east side of the DRMO site. Field observations of fill material and bedrock outcrops are generally consistent with mapped classifications, although the Westerly Granite was not positively identified in the field. Bedrock was encountered northeast of the DRMO site (6MW5D) at a depth of 25 feet below grade. Twenty feet of bedrock was cored at this location. The mineralogy and texture of the core sample is consistent with that described as the Granite Gneiss Member of the Sterling Plutonic Group. Weathered and partially covered bedrock outcrops were present on the east side of the DRMO site adjacent to the railroad tracks. In addition, a prominent bedrock cliff is located to the east of both the DRMO site and railroad tracks.

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

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

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

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

Slug displacement tests were conducted in overburden wells 6MW4S and 6MW5S in DRMO. Single well pumping tests were conducted in overburden well 6MW2 and bedrock well 6MW5D. Well 6MW4S is screened two feet in fill material and eight feet in underlying fine

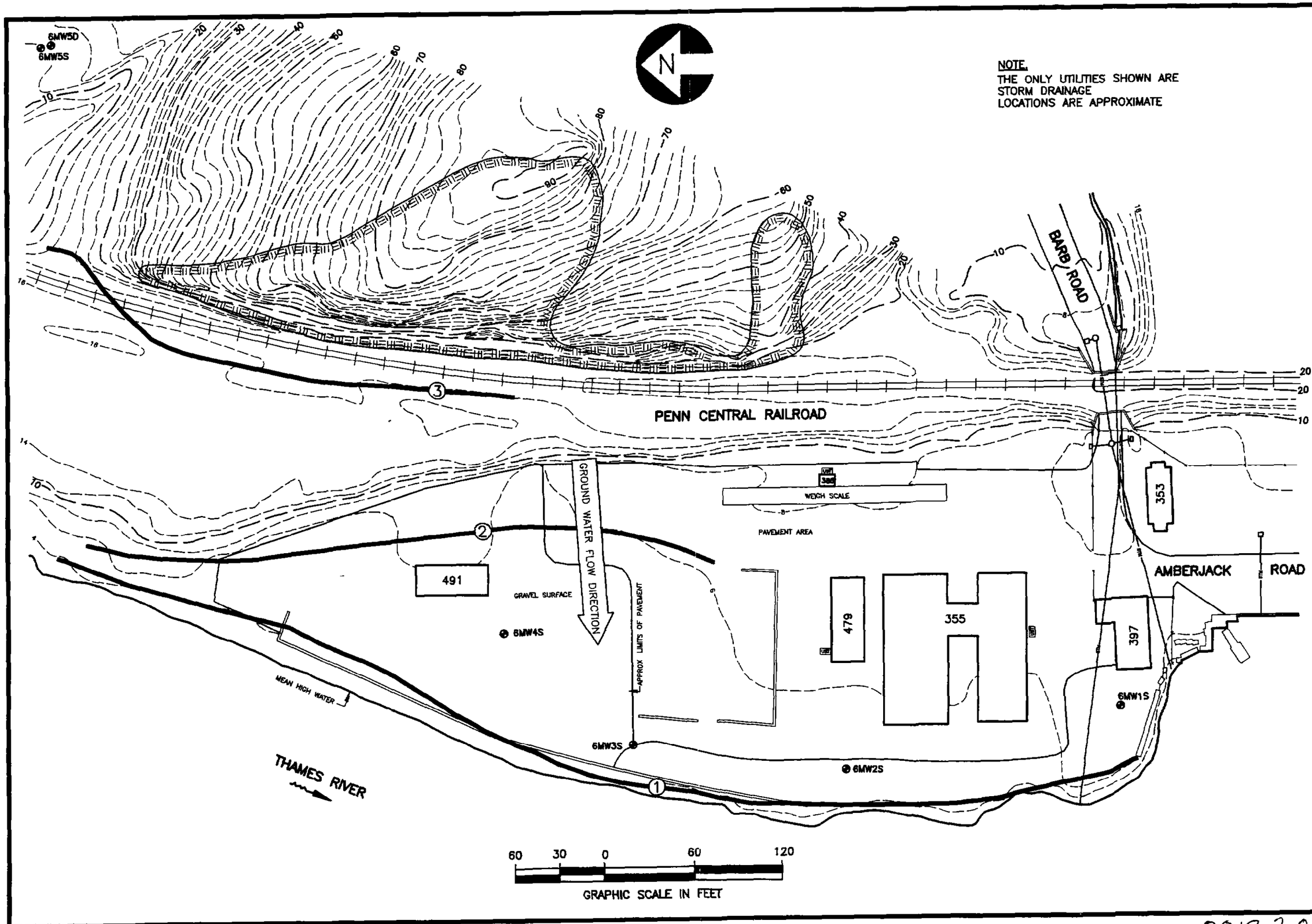

FIGURE 3-24
GROUND WATER CONTOUR MAP
DRMO

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LEGEND

10 — EXISTING CONTOUR
123 — BUILDING NUMBER
EXPOSED BEDROCK
UNDERGROUND STORAGE TANK
STM — STORM SEWER
GROUND WATER CONTOUR
6MW1S MONITORING WELL

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to coarse sand and gravel. The slug test method was ineffective in determining the hydraulic conductivity of this combination of material due to its high permeability. Well 6MW5S is screened ten feet in fine to coarse sand and gravel with a trace of silt. The hydraulic conductivity of this material was calculated to be **7.2** feet per day. Overburden well 6MW2 is screened five feet in fine to coarse sand and gravel, four feet of silt and clay, and one foot of fine to coarse sand and silt. Well 6MW2 was pumped at a rate of 15 gallons per minute for 62 minutes. The maximum drawdown caused by this pumping was 0.89 feet. Analyses for the pump test data (Cooper and Jacob Method, 1946) indicate that the hydraulic conductivity of these materials is 70 feet per day. Estimating the average hydraulic conductivity and the porosity of these sediments to be 50 feet per day and 0.35, respectively (Freeze and Cherry, 1979), and using a hydraulic gradient of 0.005 from Figure 3-24, the calculated ground water low velocity would be 0.7 feet per day. The volume of water discharged from the overburden to the Thames River is estimated to be approximately 23,100 cubic feet per day (172,800 gpd), based on a flow velocity of 0.7 feet per day, a saturated thickness of 50 feet and a 660 foot length of area perpendicular to the flow path. It is noted that flow to the river is likely higher during low tide.

Bedrock well 6MW5D (ten foot open bedrock interval) was pumped at a rate of 12.5 gallons per minute for 60 minutes and experienced a maximum drawdown of 2.49 feet. Steady-state conditions were reached in the well within the first ten minutes of pumping. Data analyses indicate that the transmissivity of the bedrock in the vicinity of this well is **1,670** square feet per day, assuming a porous aquifer thickness of 150 feet.

3.7.7 Lower Subase

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

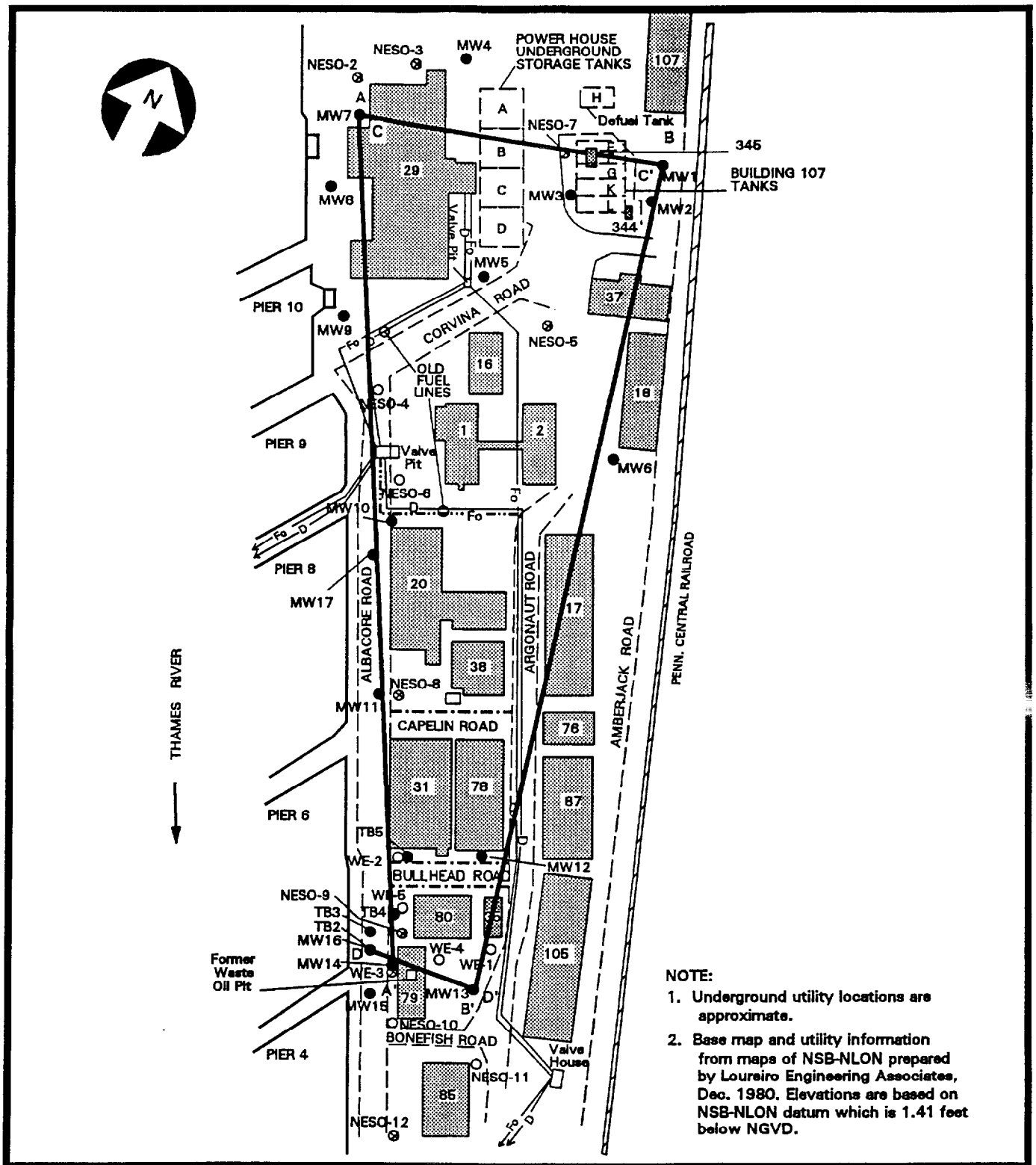
Geologic cross-sections were prepared from boring data. Figure 3-25 shows monitoring well and test boring locations as well as the location of cross-sections referred to in the text.

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

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

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

Data collected for this investigation indicates that the Lower Subase is underlain by a layer of sand and gravel which is ten to 20 feet thick on the west side of the Lower Subase and



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NAVAL SUBMARINE BASE - NEW LONDON

GROTON, CT

LEGEND

- MW1 - Monitoring Well
- TB1 - Test Boring
- NESO-1 - NESO Well
- WE-1 - Wehran Well
- Destroyed Well
- Fo - Out of Service Fuel Oil Line
- Building
- D - Diesel Line
- Fo - Fuel Oil Line

Approximate Scale: 0 100 200'

FIGURE 3-25

GEOLOGIC CROSS-SECTION LOCATIONS

LOWER SUBASE

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

Seventeen ground water monitoring wells screened in the overburden were installed in the Lower Subase. Seven additional wells installed during previous environmental investigations were also used for this investigation. Water levels at 16 Lower Subase wells and points on the river were monitored hourly during a 12 hour tidal cycle (April 18, 1991) to determine what effect the changing water level in the river has on ground water flow at the Lower Subase. Figures 3-28 and 3-29 present the ground water elevation contours at low tide and high tide, respectively. At low tide ground water flows west toward the Thames River. At high tide, ground water flows east from the river in the western portion of the site and flows west toward the river in the eastern portion of the site. Thus, a small portion of the overburden aquifer at the Lower Subase ebbs and flows with the tide. This tidal effect appears to diminish with distance from the river, and therefore, it is likely that the reversal of ground water flow direction at high tide does not extend farther than 300 feet inland from the river.

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

3.8 Climatology

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

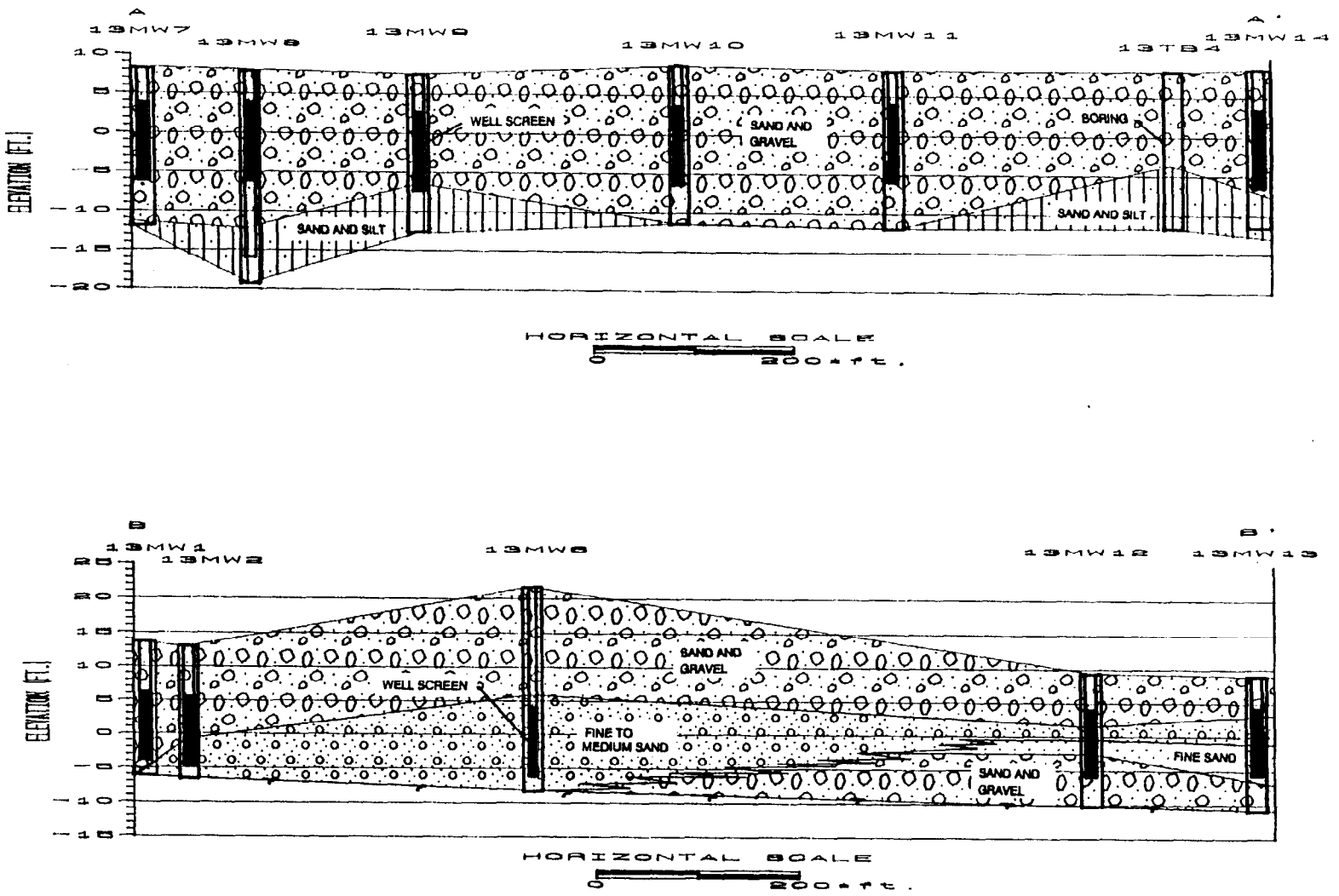

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FIGURE 3-26
GEOLOGIC CROSS-SECTIONS A - A' & B - B'
LOWER SUBASE

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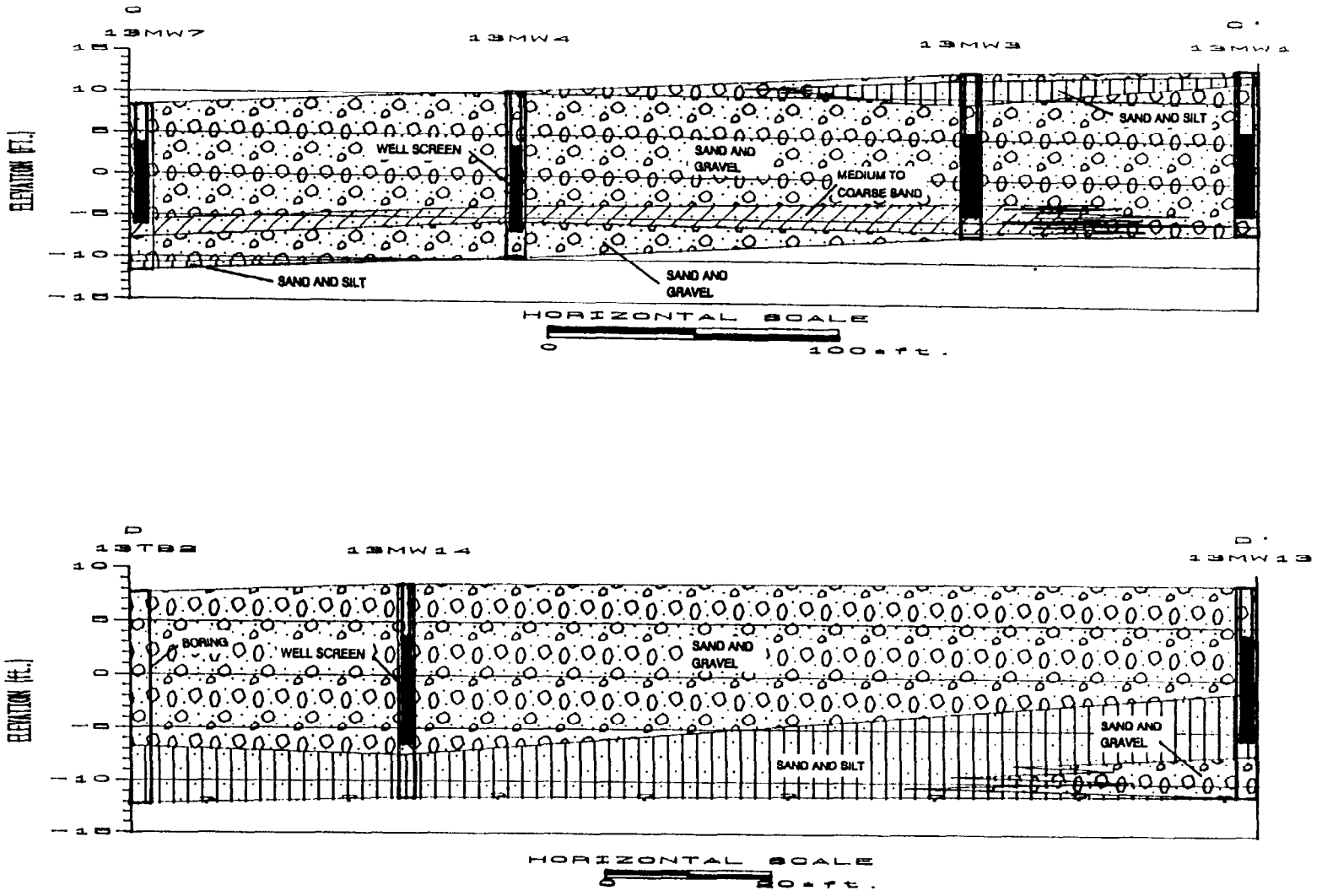

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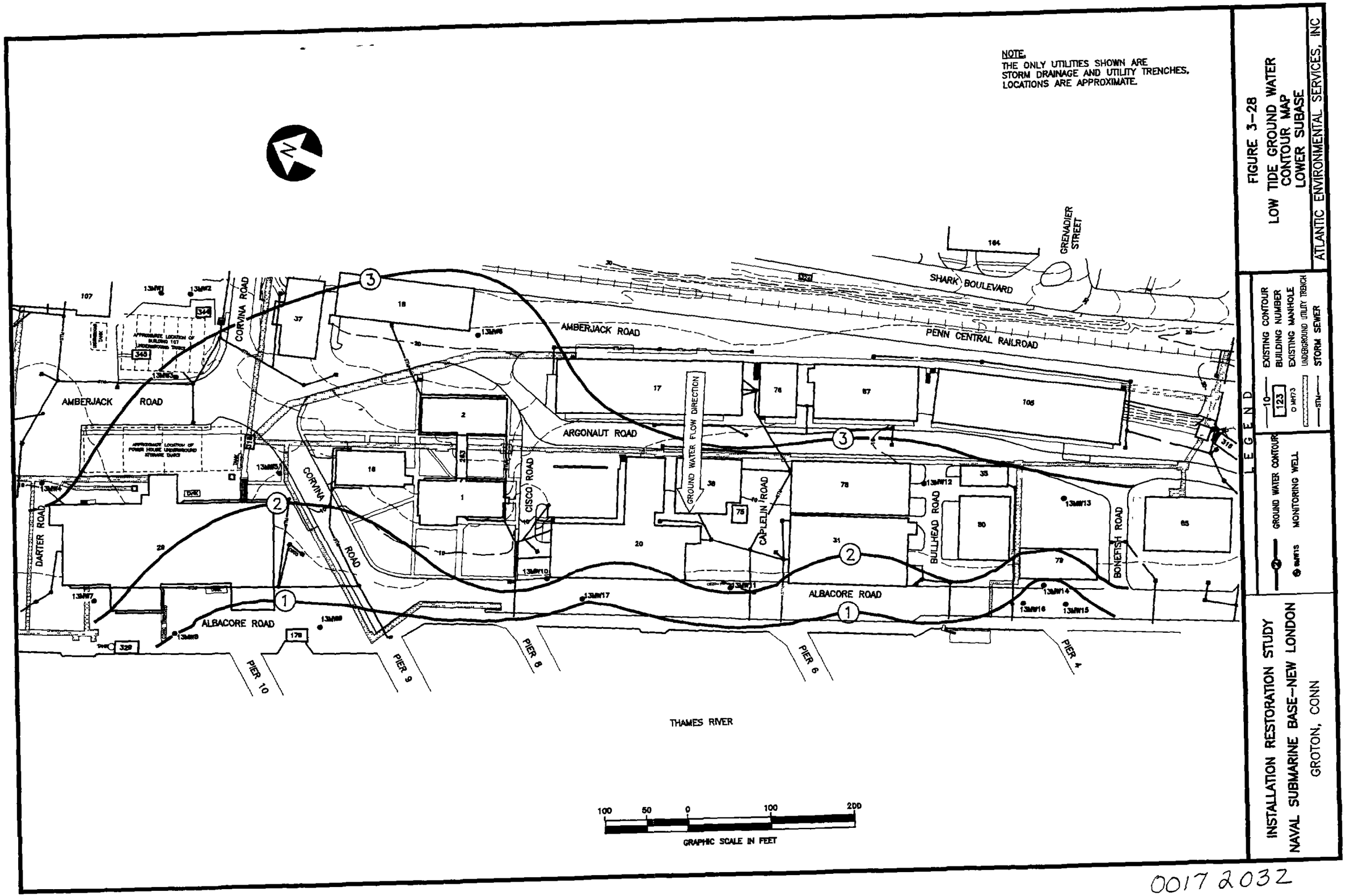
FIGURE 3-27
GEOLOGIC CROSS-SECTIONS C - C' & D - D'
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.


NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE AND UTILITY TRENCHES. LOCATIONS ARE APPROXIMATE.
N
AMBERJACK ROAD
CORVINA ROAD
DARTER ROAD
ALBACORE ROAD
ARGONAUT ROAD
CISCO ROAD
CAPELIN ROAD
BULLHEAD ROAD
BONEFISH ROAD
SHARK BOULEVARD
GRENADIER STREET
PENN CENTRAL RAILROAD
GROUND WATER FLOW DIRECTION
PIER 10
PIER 9
PIER 8
PIER 6
PIER 4
THAMES RIVER
GRAPHIC SCALE IN FEET
100 50 0 100 200
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXISTING MANHOLE
UNDERGROUND UTILITY TRENCH
STORM SEWER
GROUND WATER CONTOUR
MONITORING WELL
FIGURE 3-28
LOW TIDE GROUND WATER CONTOUR MAP
LOWER SUBASE
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GROTON, CONN

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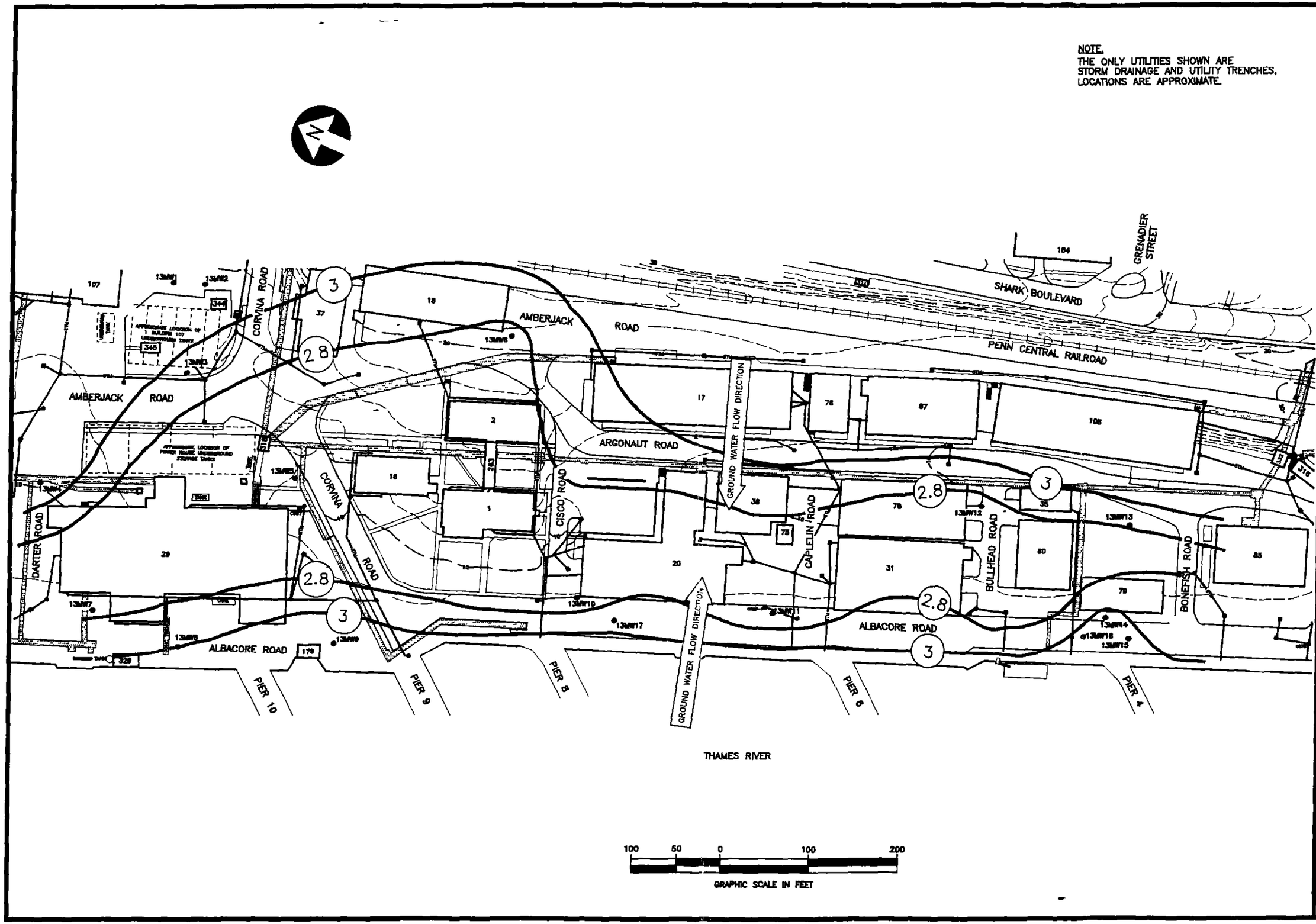


FIGURE 3-29
HIGH TIDE GROUND WATER CONTOUR MAP
LOWER SUBBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC

LEGEND

- EXISTING CONTOUR
- BUILDING NUMBER
- EXISTING MANHOLE
- UNDERGROUND UTILITY TRENCH
- STORM SEWER
- GROUND WATER CONTOUR
- MONITORING WELL

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

0017 2 042

region are laden with moisture from the ocean; in addition, some storms are tropical and occasional storms are of hurricane intensity.

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

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

3.9 Demography

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

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

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

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

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

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

	GROTON						LEDYARD			
	Town of Groton[1]			*Neighborhoods in the Vicinity of NSB–NLON*[2]			*Town of Ledyard*[1]			*Gales Ferry Section 3 of Ledyard*
				Northwest	Pleasant Valley	Naval Sub Base				
Total Population – 1980	41062			5520	4374	4099	13735			7473
Total Population – 1990	45144			NA	NA	NA	14913			*7802
Total Households – 1980	NA			1391	1216	63	---			2282
Median Age – 1980	25.5			19.9	23.5	21.4	27.4			27.1
		Male	Female					Male	Female	
	Total	22473	18589				Total	6940	6795	
	0–4	1885	1699				0–4	549	515	
	5–9	1519	1532				5–9	585	555	
	10–14	1508	1395				10–14	752	727	
	15–19	2729	1432				15–19	742	709	
	20–24	4138	2120				20–24	623	547	
	25–29	2700	2002				25–29	598	572	
	30–34	1843	1534				30–34	611	635	
	34–39	1266	1085				34–39	621	642	
	40–44	789	804				40–44	470	457	
	45–49	715	762				45–49	382	371	
	50–54	814	845				50–54	346	324	
	55–59	805	863				55–59	261	262	
	60–64	631	667				60–64	179	186	
	65–69	450	582				65–69	101	117	
	70–74	289	428				70–74	67	86	
	75–79	163	351				75–79	30	40	
	80–84	142	254				80–84	16	28	
	85+	87	234				85+	7	22	
	Median Age	24.3	27.6				Median Age	26.8	28.1	

NOTES

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

4.0 NATURE AND EXTENT OF CONTAMINATION

4.1 Introduction

This section presents an evaluation of the chemical analytical data on a site by site basis for all media sampled. The chemical concentrations are compared to Applicable or Relevant and Appropriate Requirements (ARARs) and "to be considered" (TBC) values. These refer to cleanup standards and other substantive environmental protection criteria promulgated by law, and relevant guidance criteria. For metals in soils analyzed on a mass weight basis, soil concentrations are also compared to established background levels. Further discussion on state and federal laws and guidance is presented in Section 4.2. Background levels for metals are discussed in Section 4.3.

It is noted that media samples which exceed the criteria, guidance, or background levels described above do not necessarily represent a human health or environmental risk. The health and environmental risk assessment, presented in Section 6.0, is an equally important aspect of the decision making process which is considered in making final conclusions and recommendations (Section 7.0) for each site.

Several analytes tested for as part of the analytical program include compounds which are recognized as potential laboratory contaminants. These compounds include acetone, carbon disulfide, 2-butanone, and phthalates. Although data validation guidelines provide measures for minimizing the reporting of laboratory contaminants, some questionable results are not rejected based on data validation procedures. Therefore, low levels of these compounds may not be representative of the sample, but rather due to laboratory contamination. Data validation procedures are described in Section 2.11.3 and Appendix C.

4.2 Applicable or Relevant and Appropriate Requirements

CERCLA or Superfund cleanups pursuant to Section 121(d) of SARA must attain Federal and State ARARs (Applicable, Relevant and Appropriate Requirements). As defined further in the National Contingency Plan, applicable requirements mean those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, requirement, or other circumstance at a CERCLA site.

If a requirement is not applicable, it still may be relevant and appropriate. Relevant and appropriate requirements mean those cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site, that their use is well suited to the particular site.

In addition to ARARs, other state or federal advisories, criteria, or guidance can be identified as "to be considered" for a particular release. The "to be considered" (TBC) category consists of any state or federal guidance that may be useful in evaluating site chemical concentrations or developing a remedy. The chemical specific values for TBCs are included as a screening criteria. Final decisions will consider these TBCs, however, they will weigh more

heavily on ARARs and the health and environmental risk assessment.

In accordance with EPA guidance (CERCLA Compliance with Other Laws Manual, USEPA, August 1989), ARARs are grouped into three categories; i.e., chemical specific, location specific, and action specific. Appendix D provides a listing of all potential Federal and State ARARs arranged by category. Appendix D also provides a detailed discussion regarding whether or not, or under what circumstances, the requirement would be applicable, or relevant and appropriate. In addition to explaining the rationale for determining when the requirement would be an ARAR, the discussion specifies when a requirement is "to be considered" (TBC). At the end of the summary of potential ARARs are other TBCs appropriate to NSB-NLON.

Table 4-1 lists the status of potential ARARs and TBCs specific to each of the investigation sites. As is evident from an examination of Table 4-1, a particular requirement is not necessarily applicable to all sites. Some of the major differences between individual sites that determine the status of ARARs at NSB-NLON include: the existence of hazardous, solid, or PCB containing waste, the presence of underground storage tanks, and the environmental site setting, e.g., wetlands, floodplains, coastal zones, etc.

These tables will be revised as studies at the site progress into the feasibility stages. The status of ARARs and TBCs, particularly action specific ARARs, will become clear during the detailed analysis of alternatives in the feasibility study.

Table 4-2 provides a list of the most stringent chemical specific ARARs and TBCs by media. These values are used in this report section to screen sample media concentrations for each site. For example, if there were two standards for the same media, the lower number would be used. In the case of **antimony**, which has a water quality criteria for aquatic life in fresh water of 1600 ppb, and a criteria for fish consumption to protect human health of 45,000 ppb, the lower standard of 1600 is shown in Table 4-2.

4.3 Inorganics Background Concentrations

Inorganic background concentrations were established to allow comparison of metal concentrations (mass weight basis) detected at each site to naturally-occurring background concentrations. These background concentrations do not fall in the ARAR or TBC category, because they are not federal or state law or guidance. However, this is an established procedure to evaluate inorganic concentrations at a site. Values above background are assumed to be related to site usage.

Inorganic background concentrations were generally based on published U.S. Geological Survey data (Shacklette and Boerngen, 1984). The values presented in Table 4-3 are concentrations for the Eastern United States calculated for the upper 95 percent value limit (e.g., only 5 percent of recorded values exceeded this amount). Values for silver and cadmium, which were not reported by USGS, were established based on a review of other published data as referenced on Table 4-3. **Actual background concentrations at NSB-NLON are less than these published values based on a review of samples 2WMW2S (0-2), 6MW5S (0-2), 6MW5S (8-10), and 13MW6 (14-16).**

TABLE 4–1A
STATUS OF CHEMICAL SPECIFIC ARARs

ARAR	CBU Drum Storage Area			Rubble Fill at Bunker A–86			Torpedo Shops			Goss Cove Landfill			OBDANE		
	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Hazardous Waste Standards			•			•			•			•			•
RCRA Solid Waste Standards			•		•				•		•			•	
RCRA UST Standards			•			•		•				•			•
Safe Drinking Water Act	• ○			• ○			• ○			• ○			• ○		
Water Quality Criteria	• ○			• ○			• ○			• ○			• ○		
Clean Air Act NESHAPs		•			•			•			•			•	
Clean Air Act NAAQs		•			•			•			•			•	
Toxic Substance Control Act			•			•		•		○		•			•
FIFRA			•			•			•			•			•
STATE OF CONNECTICUT															
Hazardous Waste Management			•			•			•			•			•
Solid Waste Management			•		•				•		•			•	
Underground Storage Tanks			•			•		•				•			•
Pesticide/PCB			•			•			•			•			•
Air Pollution Control	•			•			•			•			•		
Water Quality Standards	• ○			• ○			• ○			• ○			• ○		
Water Pollution Control	○		•	○		•	○		•	○		•	○		•
Standards for Drinking Water	• ○			• ○			• ○			• ○			• ○		

TABLE 4–1A (continued)
STATUS OF CHEMICAL SPECIFIC ARARs

ARAR	Spent Acid Storage/Disposal			Former Gas Station			Area A and OBDA			DRMO			Lower Subase		
	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Hazardous Waste Standards	•					•			•	•			•		
RCRA Solid Waste Standards			•			•		•			•				•
RCRA UST Standards			•	•					•			•	•		
Safe Drinking Water Act	• ○			• ○			• ○			• ○			• ○		
Water Quality Criteria	• ○			• ○			• ○			• ○			• ○		
Clean Air Act NESHAPs		•			•			•			•			•	
Clean Air Act NAAQs		•			•			•			•			•	
Toxic Substance Control Act			•			•	○		•	○		•			•
FIFRA			•			•	○		•			•			•
STATE OF CONNECTICUT															
Hazardous Waste Management	•					•			•	•			•		
Solid Waste Management			•			•		•			•				•
Underground Storage Tanks			•	•					•			•	•		
Pesticide/PCB			•			•			•			•			•
Air Pollution Control	•			•			•			•			•		
Water Quality Standards	• ○			• ○			• ○			• ○			• ○		
Water Pollution Control	○		•	○		•	○		•	○		•	○		•
Standards for Drinking Water	• ○			• ○			• ○			• ○			• ○		

NOTE: See Appendix D for further definition of ARARs

TABLE 4–1B
STATUS OF LOCATION SPECIFIC ARARs

ARAR	CBU Drum Storage Area			Rubble Fill at Bunker A–86			Torpedo Shops			Goss Cove Landfill			OBDANE		
	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Location Standards			•			•			•			•			•
CWA Section 404, Rivers and Harbors Act			•			•			•		•				•
Executive Orders 11990 and 11988 RE: Protection of Wetlands & Floodplains			•			•			•		•				•
National Historic Preservation Act			•			•			•			•			•
Endangered Species Act			•			•			•			•			•
Wild and Scenic Rivers Act			•			•			•			•			•
Fish and Wildlife Coordination Act			•			•			•		•				•
Coastal Zone Management Act			•			•			•		•				•
Wilderness Act			•			•			•			•			•
Clean Air Act NAAQs		•			•			•			•			•	
STATE OF CONNECTICUT															
Inland Wetlands and Watercourses			•			•			•			•			•
Tidal Wetlands			•			•			•			•			•
Sanitation of Watersheds			•			•			•			•			•
Agricultural Lands Preservation			•			•			•			•			•
Connecticut Siting Council HMM Facility Siting Regulations			•			•			•			•			•
Coastal Zone Management			•			•			•		•				•
Hazardous Waste Management			•			•			•			•			•
Stream Channel Encroachment			•			•			•			•			•
Aquifer Protection Areas			•			•			•			•			•
Regulation of Dredge and Fill in Tidal, Coastal or Navigable Waters			•			•			•		•				•
Storage of Hazardous Substances Near a Watercourse			•			•			•		•				•

TABLE 4–1B (continued)
STATUS OF LOCATION SPECIFIC ARARs

ARAR	Spent Acid Storage/Disposal			Former Gas Station			Area A and OBDA			DRMO			Lower Subase		
	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR	• ARAR O TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Location Standards			•			•			•	•			•		
CWA Section 404, Reverse Harbors Act			•			•		•			•			•	
Executive Orders 11990 and 11988 RE: Protection of Wetlands & Floodplains			•			•		•			•			•	
National Historic Preservation Act			•			•			•			•			•
Endangered Species Act			•			•			•			•			•
Wild and Scenic Rivers Act			•			•			•			•			•
Fish and Wildlife Coordination Act			•			•		•			•			•	
Coastal Zone Management Act			•		•				•		•			•	
Wilderness Act			•			•			•			•			•
Clean Air Act NAAQs		•			•			•			•			•	
STATE OF CONNECTICUT															
Inland Wetlands and Watercourses			•			•		•				•			•
Tidal Wetlands			•			•			•			•			•
Sanitation of Watersheds			•			•			•			•			•
Agricultural Lands Preservation			•			•			•			•			•
Connecticut Siting Council HMM Facility Siting Regulations		•				•			•		•			•	
Coastal Zone Management			•		•				•		•			•	
Hazardous Waste Management			•			•				•			•		
Stream Channel Encroachment			•			•			•			•			•
Aquifer Protection Areas			•			•			•			•			•
Regulation of Dredge and Fill in Tidal, Coastal or Navigable Waters			•			•			•		•			•	
Storage of Hazardous Substances Near a Watercourse			•			•		•			•			•	

NOTE: See Appendix D for further definition of ARARs

TABLE 4–1C
STATUS OF ACTION SPECIFIC ARARs

ARAR	CBU Drum Storage Area			Rubble Fill at Bunker A–86			Torpedo Shops			Goss Cove Landfill			OBDANE		
	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Hazardous Waste Standards			•			•			•			•			•
RCRA UST Standard S/S			•			•		•				•			•
RCRA Solid Waste Regulations					•				•		•			•	
Underground Injection Control		•			•			•			•			•	
DOT Hazardous Materials Transportaion			•			•			•			•			•
OSHA Standards	•			•			•			•			•		
USEPA NPDES		•			•			•			•			•	
USEPA & Corporation of Engineers, Rules on Activities in Wetlands & Watercourses			•			•			•		•				•
Clean Air Act NSPS		•			•			•			•			•	
PCB Regulations Under TSCA			•			•		•		○	•				•
National Environmental Policies Act		•			•			•			•			•	
Air/Superfund National Technical Guidance	○			○			○			○			○		
RCRA RFI Guidance	○			○			○			○			○		
STATE OF CONNECTICUT															
Water Pollution Control		•			•			•			•			•	
Solid Waste Management			•		•				•		•			•	
Hazardous Waste Management			•			•			•			•			•
Safe Storage/Transportation of Chemicals			•			•			•			•			•
Connecticut Siting Council, HMM Facility Siting Regulations			•			•			•			•			•
Regulations for the Well Drilling Industry		•			•			•			•			•	
Air Pollution Control		•			•			•			•			•	
Transportation of Oils & Chemical Liquids		•			•			•			•			•	
Underground Storage Tanks			•			•		•				•			•
Connecticut OSHA			•			•			•			•			•
Control of Noise Regulations		•			•			•			•			•	
Connecticut Water Diversion Policy Act		•			•			•			•			•	
Guidelines for Soil Erosion and Sediment Control	○			○			○			○			○		

TABLE 4–1C (continued)
STATUS OF ACTION SPECIFIC ARARs

ARAR	Spent Acid Storage/Disposal			Former Gas Station			Area A and OBDA			DRMO			Lower Subase		
	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR	• ARAR ○ TBC	Potential ARAR	Not ARAR
FEDERAL															
RCRA Hazardous Waste Standards		•				•			•		•			•	
RCRA UST Standard S/S			•		•				•			•		•	
RCRA Solid Waste Regulations			•			•		•			•				•
Underground Injection Control		•			•			•			•			•	
DOT Hazardous Materials Transportaion		•				•			•		•			•	
OSHA Standards	•			•			•			•			•		
USEPA NPDES		•			•			•			•			•	
USEPA & Corporation of Engineers, Rules on Activities in Wetlands & Watercourses			•			•		•			•			•	
Clean Air Act NSPS		•			•			•			•			•	
PCB Regulations Under TSCA			•			•	○	•		○	•				•
National Environmental Policies Act		•			•			•			•			•	
Air/Superfund National Technical Guidance	○			○			○			○			○		
RCRA RFI Guidance	○						○			○			○		
STATE OF CONNECTICUT															
Water Pollution Control		•			•			•			•			•	
Soilid Waste Management			•			•		•			•				•
Hazardous Waste Management		•				•			•		•			•	
Safe Storage/Transportation of Chemicals		•				•			•		•			•	
Connecticut Siting Council, HMM Facility Siting Regulations		•				•			•		•			•	
Regulations for the Well Drilling Industry		•			•			•			•			•	
Air Pollution Control		•			•			•			•			•	
Transportation of Oils & Chemical Liquids		•			•			•			•			•	
Underground Storage Tanks			•		•				•			•		•	
Connecticut OSHA			•			•			•			•			•
Control of Noise Regulations		•			•			•			•			•	
Connecticut Water Diversion Policy Act		•			•			•			•			•	
Guidelines for Soil Erosion and Sediment Control	○			○			○			○			○		

NOTE: See Appendix D for further definition of ARARs

TABLE 4–2
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m^3		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
INORGANICS																			
Aluminum		200											•						Secondary MCL
									200									•	Aluminum Metal and Oxide
Antimony					1600									•					Aquatic Life Chronic
		5										•							
								14								•			Water and Fish Ingestion
									10									•	
Arsenic	50										•								
				50 TCLP													•		
					0.14		0.14									•			Fish Consumption
									0.05									•	
Barium	1000					1000		1000			•								State of Connecticut DOHS
	2000										•								U.S. EPA
				1000 TCLP													•		
									10									•	
Beryllium		1.0										•							
					0.13		0.13							•		•			Fish Consumption
									0.01									•	
Cadmium	10										•								State of Connecticut DOHS
	5										•								U.S. EPA
					0.66		9.3									•			Chronic Aquatic
				10 TCLP													•		
									0.4									•	
Calcium										40								•	For Calcium Oxide
Chromium	50										•								State of Connecticut DOHS
	100										•								U.S. EPA
				50 TCLP													•		
					11		50							•		•			Chronic Aquatic Hex Cr
									2.5									•	
Cobalt									2.0									•	
Copper	1000										•								State of Connecticut DOHS
	1300												•						U.S. EPA Action Level
				1000 TCLP													•		
					4.8		2.9									•			Chronic Aquatic Life
									20									•	
Iron		300											•						Secondary MCL
										20								•	Iron Salts
Lead	15												•						U.S. EPA Action Level
	50										•								State of Connecticut DOHS
				50 TCLP													•		
				500000											•				

TABLE 4-2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m^3		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
Lead (continued)					1.3		8.5									•			Chronic Aquatic Life
									3									•	
Manganese		50											•						Secondary MCL
					100		100							•					Fish Consumption
										20								•	Fumes
Mercury	2										•								
				2 TCLP													•		
					0.012		0.025							•		•			Aquatic Chronic
										1								•	Vapor
Nickel		100										•							
					88		8.3									•			Aquatic Chronic
									0.3									•	
Potassium																			
Selenium	10										•								State of Connecdticut
	50										•								U.S. EPA
				10 TCLP													•		
					5		71									•			Aquatic Chronic
									4									•	
Silver	50										•								State of Connecticut DOHS
		100											•						Lifetime Health Advisory
				50 TCLP													•		
					0.12									•					Aquatic Chronic
					1.2		2.3									•			Aquatic Acute
									0.2									•	
Sodium		28000									•								Notification Level
Thallium		1										•							
					6.3		6.3									•			Fish Consumption
									2									•	
Vanadium		20											•						Lifetime Health Advisory
Zinc		5000											•						Secondary MCL
					12.3		86									•			Aquatic Chronic
										100								•	Zinc Oxide Fume
Boron		600											•						Health Advisory
										200								•	Boron Oxide
Cyanide	200										•								State of Connecticut Only
					5.2		1							•		•			Aquatic Chronic
									100									•	
RADIOLOGICAL CONSTITUENTS (pCi/L)																			
Gross Alpha	5										•								CTDOS Screening Level Only
	15										•								U.S. EPA
Gross Beta	50										•								Screening Level Only

TABLE 4-2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
VOLATILE ORGANICS																			
Acetone									11800									●	
Benzene	5										●								
		1													●				Action Level
				1													●		
					40		40							●					Fish Consumption
									150									●	
2-Butanone		1000				1000		1000							●				Action Level
(Methy ethyl ketone)				1000													●		
		200											●						Lifetime Health Advisory
									11800									●	
Carbon Disulfide									60									●	
Chlorobenzene		488												●					Water and Fish Ingestion
					50		129							●					Chronic Aquatic
									7000									●	Above Standards for Chlorinated Benzene
Chloroform	100										●								CTDOS Std. for Total Trihalometnanes
					15.7		15.7							●					Fish Consumption
				100													●		
									250									●	
Chloromethane		3											●						Draft Lifetime Health Advisory
2-Chlorophenol		40											●						Draft Lifetime Health Advisory
					2000									●					Chronic Aquatic
4-Chloroniline																			
1,1 Dichloroethane										8000								●	
1,2 Dichloroethane	5										●								
		1													●				Action Level
				1													●		
					243		243							●					Fish Consumption
									20									●	
1,1 Dichloroethene	7									7	●								MCLG = 7.0
				7													●		
					1.85		1.85							●					Std. for Ttl. Dichloroethenes; Fish Consump
1,2 Dichloroethene	70										●								
					1.85		1.85							●					Std. for Ttl. Dichloroethenes; Fish Consump
									15800									●	

TABLE 4–2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
Ethylbenzene	700										●								
		1400												●					
					3280		3280							●					Fish Consumption
							430							●					Aquatic Acute
									8700									●	
Methylene Chloride (Dichloromethane)		25													●				Action Level
				25													●		
		5										●							
									7000									●	
4–Methyl–2–Pentanone																			
1,1,2,2–Tetrachloroethane		0.17												●					Water and Fish Consumption
					10.7		10.7							●					Fish Consumption
										34.4								●	
Tetrachloroethene	5										●								
					8.85		8.85							●		●			Fish Consumption
									1700									●	
Toluene	1000										●				●				CTDOHS Action Level
				1000													●		
							5000							●					Aquatic Chronic
					17500									●					Aquatic Acute
									7500									●	
1,1,1 Trichloroethane	200										●								
				200													●		
					1 g/l									●					Fish Consumption
									38000									●	
							31200							●					Aquatic Acute
1,1,2–Trichloroethane					41.8		41.8							●					Fish Consumption
									225									●	
		5										●							PMCLG = 3
Trichloroethene	5										●								
				5													●		
					80.7		80.7							●		●			Fish Consumption
									1350									●	
Vinyl Acetate									600									●	

TABLE 4-2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
Vinyl Chloride	2										●								
				2													●		
					525		525							●		●			Fish Consumption
									50									●	
Xylene	10000				10000		10000				●								
									8680									●	
Petroleum	Remove Free Product																		RCRA UST
						10000		10000											CTDEP Emergency Permit Effluent Std.
SEMI-VOLATILE ORGANICS																			
Other Semi-Volatile Organics																			
Benzoic Acid																			
Bis(2-ethyl-hexylphthalate)																			
Dibenzofuran																			
Di-n-butylphthalate					154000		154000							●					Fish Ingestion
		35000												●					Water and Fish Ingestion
1,2 Dichlorobenzene (ortho)					763									●					Chronic Aquatic Toxicity
							2600							●					Fish Ingestion Only
		600										●							
1,3 Dichlorobenzene (meta)					763									●					Chronic Aquatic Toxicity
							2600							●		●			Fish Ingestion Only
		600										●							
1,4 Dichlorobenzene (para)	75										●								
				75													●		
							2600							●		●			Fish Ingestion Only
					763									●					Chronic Aquatic Toxicity
									9000									●	
Diethylphthalate		5000											●						Lifetime Health Advisory
					1.8 g/l		1.8 g/l							●					Fish Consumption
									100									●	
2,4-Dimethylphenol																			
4,6-Dinitro-2-Methylphenol																			
Isophorone		100											●						Draft Lifetime Health Advisory
					600		600									●			Aquatic Acute Criteria
									460									●	

TABLE 4-2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]							
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
2-Methylphenol																			
4-Methylphenol																			
2-Nitroaniline																			
N-Nitrosodiphenylamine		4.9				4.9		4.9						●					Water and Fish Consumption
					16.1		16.1							●		●			Fish Consumption Only
N-Nitros-D-n-																			
Propylamine																			
Phenol		4000											●						Lifetime Health Advisory
							4600PPM									●			Fish ingestion
					2560									●					Aquatic Chronic
									380									●	
1,2,4-Trichlorobenzene		9										●							
					50		129							●					Aquatic Chronic Criteria for
																			Chlorinated Benzenes
										800								●	
Polyaromatic Hydrocarbons																			
PAHs (total)							300							●					Aquatic Acute
		0.0028												●					Water and Fish Ingestion
																			Standard for Total PAHs
					0.031		0.031							●					Fish Ingestion Only
									0.1									●	Benzene Soluable Fraction
Acenaphthene					520		710							●					Aquatic Chronic
Acenaphthylene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Anthracene					110PPM		110PPM									●			Fish Ingestion Only
		9600														●			Water and Fish Ingestion
Benzo(a)anthracene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Benzo(b)fluoranthene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Benzo(k)fluoranthene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Benzo(g,h,i)perylene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Benzo(a)pyrene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion

TABLE 4–2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
Chrysene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Dibenzo(a,h)anthracene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Fluoranthene		42												●					Water and Fish Ingestion
							16							●					Chronic Aquatic
					54									●					Fish Consumtion Only
Fluorene					14PPM		14PPM									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Indeno(1,2,3–cd)pyrene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
2–Methyl–napthalene																			
Naphthalene					620									●					Aquatic Chronic
								2350						●					Aquatic Acute
		20											●						Lifetime Health Advisory
									1000									●	
Phenanthrene					0.031		0.031									●			Fish Ingestion Only
		0.0028														●			Water and Fish Ingestion
Pyrene					11000		11000									●			Fish Ingestion Only
		960														●			Water and Fish Ingestion
PESTICIDES/PCBs																			
4,4–DDD					0.00084		0.00084									●			Fish Ingestion Only
		0.00083														●			Water and Fish Ingestion
4,4–DDE					0.00059		0.00059									●			Fish Ingestion Only
		0.00059														●			Water and Fish Ingestion
4,4–DDT					0.00059		0.00059									●			Fish Ingestion Only
		0.00059														●			Water and Fish Ingestion
				500															FFDC Act Tolerance Level
									5									●	
Delta BHC					100		0.34							●					Aquatic Acute
Endrin	0.2										●								State of Connecticut Only
		2										●							
					0.0023		0.0023							●		●			Aquatic Chronic
									2									●	
Endrin Ketone																			

TABLE 4-2 (continued)
SUMMARY OF CHEMICAL SPECIFIC ARARs AND TBCs BY MEDIA

PARAMETER	MEDIA										SOURCE OF ARAR OR TBC[2]								
	Ground Water ppb		*Soil* ppb[1]		*Fresh Surface Water* ppb		*Marine Surface Water* ppb		*Air* ug/m³		MCL	PMCL	USEPA	WQC	CTDOHS	WQS	CTDEP	HLV	OTHER OR COMMENTS
	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC	ARAR	TBC									
Methoxychlor	100										•								State of Connecticut DOHS
	40										•								U.S. EPA
					0.03		0.03							•					Aquatic Chronic
									200									•	
PCBs					0.000045		0.000045									•			Fish Ingestion Only
		1													•				Action Level
				10000															TSCA Spill Clean-up Guidance
		0.5										•							
									0.01									•	

NOTES

1) Values given are on a mass basis (ug/kg) unless TCLP is indicated. Where TCLP is indicated, values area measured in a TCLP extract.
2) **MCL:** Maximum contaminant level pursuant to the USEPA Safe Drinking Water Act or CTDOHS Standards of Water Quality (Reference 1 and 2).
PMCL: Proposed maximum contaminant level proposed by the USEPA under the Safe Drinking Water Act (Reference 1).
USEPA: United States Environmental Protection Agency (Reference 1).
WQC: Water quality criteria pursuant to Section 304 of the Clean Water Act (Reference 3).
CTDOHS: Connecticut Department of Health Services (Reference 4).
WQS: CTDEP Numerical Water Quality Standard (Reference 5).
CTDEP: Connecticut Department of Environmental Protection guidance (Reference 6).
HLV: Hazards limiting value pursuant to Connecticut's hazardous ait pollutant regulations (Section 22a-174-29 RCSA) (Reference 7).

REFERENCES:

1. USEPA, November 1991, *Drinking Water Regulations and Health Advisories*, Office of Water.
2. CTDOHS, January 28, 1992, *Section 19-13-B102(e), Regulations of Connecticut State Agencies* Water Supply Section.
3. USEPA, 1986, *Quality Criteria for Water 1986*, EPA 440/5-86-001.
4. CTDOHS, June 1990, *Water Quality Standards for Public Water Supply Wells*, Water Supply Section.
5. CTDEP, January 1992, *Water Quality Standards*, Water Management Bureau.
6. CTDEP, undated, *Contaminated Soils Removal & Disposal Guidelines.*
7. CTDEP, February 1989, *Section 229-174-29, Regulations of Connecticut State Agencies*, Air Management Bureau.

TABLE 4-3 NATURAL BACKGROUND LEVELS FOR INORGANIC COMPOUNDS	
Parameter	**Upper 95% Background Limit (ppm)[1]**
Aluminum	272,000
Antimony	2.95
Arsenic	31.5
Barium	1600
Beryllium	3.52
Cadmium	7.0
Calcium	32,300
Chromium	223
Cobalt	39
Copper	102
Iron	115,000
Lead	53.2
Magnesium	26,500
Manganese	3790
Mercury	0.51
Nickel	76.7
Potassium	12,000
Selenium	1.79
Silver	5
Sodium	51,800
Thallium	5[3]
Vanadium	271
Zinc	178
Boron	109

1. The upper 95% limit is from Shacklette and Boerngen USGS Paper 1270 using the formula M x D^2 where M is the geometric mean and D is the geometric deviation.
2. Dragun (1988)
3. Lisk (1972)

Inorganic concentrations for the same sample were compared based on TCLP extraction analysis and mass weight analysis. The reasonableness of the results was evaluated considering the 20:1 dilution used for TCLP extraction, compared with the mass weight analysis, which should yield the total metal concentrations. In some cases, a sample would contain a metal based on the TCLP results, whereas no metals were detected in the mass weight analysis. In these cases, the TCLP results are considered anomalous. Likewise, if the TCLP results, factoring in the 20:1 dilution, yielded higher results than on a mass weight analysis, these results are also considered anomalous. Furthermore, some TCLP results show nearly complete leachability of metals based on this test procedure. In some cases, natural inorganic background levels can have corresponding TCLP values which exceed CTDEP TBC action levels. In these samples, exceeding the TBC values was not considered significant.

4.4 CBU Drum Storage Area

The field investigation at this site consisted of surface soil sampling and analysis.

4.4.1 Surface Soil

Seven (7) surface soil samples were collected for analysis from this site, from three sample locations, to screen for potential releases from past drum storage. Sample locations are depicted on Figure 4-1. The site analytical program for the surface soil samples is summarized in Section 2.0, Table 2-5.

Surface soil analytical results are summarized in Tables 4-4 (organics) and 4-5 (inorganics). Relatively low levels of volatile organics (VOCs), semi-volatile organics (SVOs), total petroleum hydrocarbons, and metals were detected in some of the samples. Field measured organic vapor readings above background levels, and slight petroleum odors, were noted at 1SS1D and 1SS3D; total petroleum hydrocarbons and VOCs were present at the highest levels at sample 1SS3D. No soil staining was observed at the site. VOC concentrations were below TBC values. Relatively low concentrations of SVOs were detected at 1SS4C (composite of 1SS1S and 1SS2S). The pesticide DDD was also detected at 1SS4C at a concentration of 55 ppb.

The chemicals detected are generally consistent with the oil stored at this site and indicate that a minor release may have occurred. The presence of low levels of DDD is likely associated with the past Area A pesticide applications.

Lead exceeded the TCLP TBC levels of 0.05 ppm at sample 1SS1S (0.6 ppm). Lead also slightly exceeded the established background concentration at 1SS4C (composite of 1SS1C and 1SS2C). The lead may have been associated with waste oil previously stored at this site.

4.5 Rubble Fill at Bunker A-86

The field investigation at this site consisted of surface soil sampling and analysis.

Five (5) surface soil samples were collected for analysis from this site, from two sample locations, to screen for potential releases from discarded construction materials and one drum partially filled with an oil liquid. Sample locations are depicted on Figure 4-2. The site analytical program for the surface soil samples is summarized in Section 2.0, Table 2-5.

Surface soil analytical results are summarized in Tables 4-6 (organics) and 4-7 (inorganics). Sample 4SS1D and 4SS2S contained solvents (trichloroethene, tetrachloroethene) in the 1-2 ppb range, below TBC values of 5 ppb. Sample 4SS1D was collected adjacent to a 55 gallon oil drum discussed in Section 1.2.4.2 Neither sample 4SS1D, 4SS2S, or any other surface soil samples registered an organic vapor reading above background, based on field measurements, or were discolored in appearance. Sample 4SS3C, a composite of 4SS1S and 4SS2S, was analyzed for SVOs, PCBs and inorganics. A total SVO concentration of 24,950 ppb was detected. The SVOs consisted of polynuclear aromatic hydrocarbons (PAHs) which may

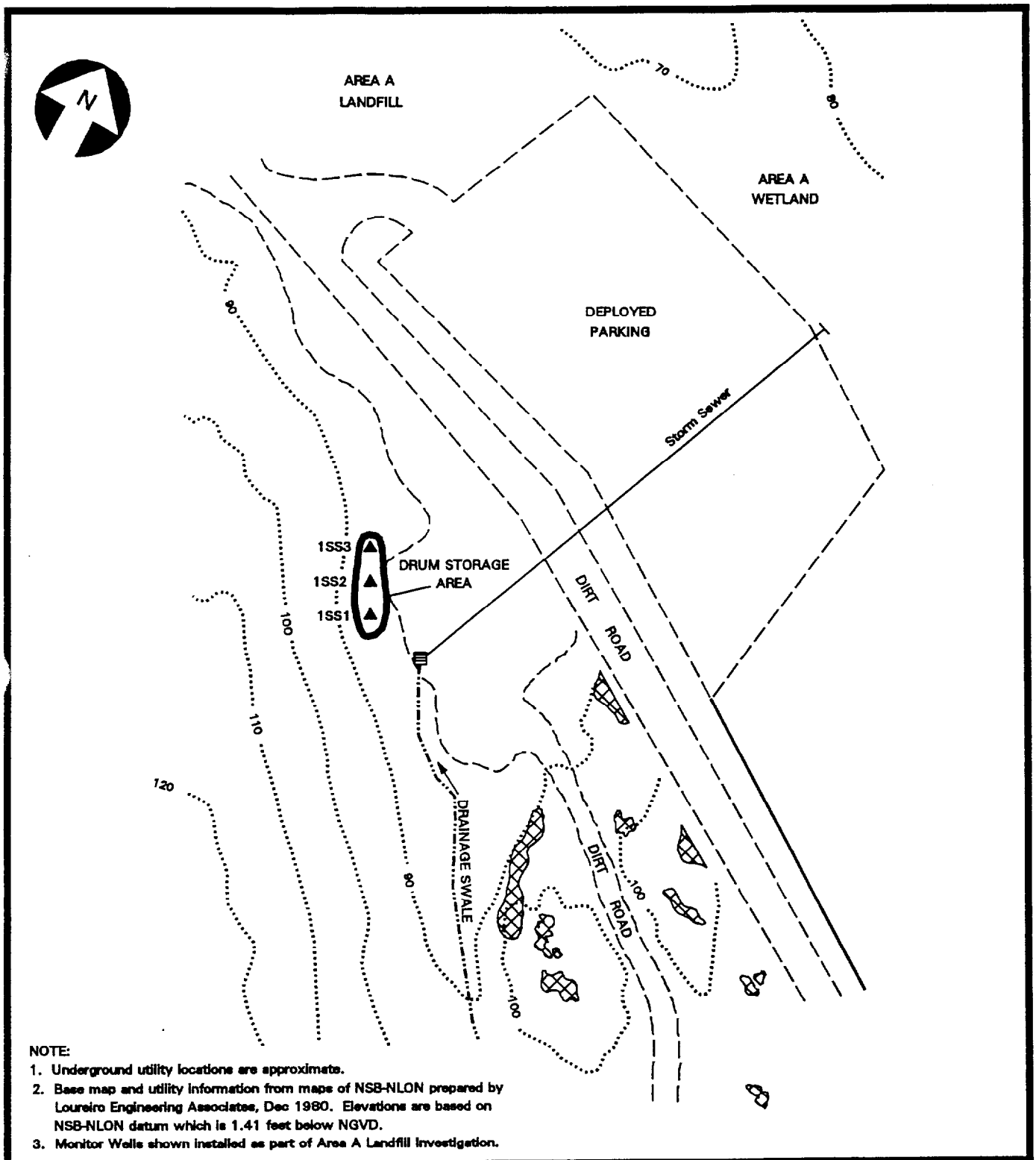

N
AREA A
LANDFILL
AREA A
WETLAND
DEPLOYED
PARKING
Storm Sewer
1SS3
1SS2
1SS1
DRUM STORAGE
AREA
DIRT ROAD
DIRT ROAD
DRAINAGE SWALE
70
80
90
100
110
120
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.
3. Monitor Wells shown installed as part of Area A Landfill Investigation.
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT
LEGEND
- Exposed Bedrock
- Catch Basin
MW1 - Monitoring Well
SS1 - Surface Soil Sample
96 - Existing Grade
- Building
- Watercourse
Approximate Scale
0 20 40'
FIGURE 4-1
FIELD SAMPLING PLAN
CBU DRUM STORAGE AREA
ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4–4
CBU DRUM STORAGE AREA
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	1SS1S	1SS1D	1SS2S	1SS2D	1SS3S	1SS3D	1SS4C
		SAMPLE DEPTH (in)	0–6	12–18	0–6	12–18	0–6	12–18	0–6
TCL VOLATILE ORGANICS (ppb)									
Methylene Chloride	25		ND	ND	NA	1 J	NA	ND	NA
Ethylbenzene	--		ND	ND	NA	ND	NA	6 J	NA
Xylene (total)	--		ND	ND	NA	ND	NA	300	NA
Total Volatile Organics						1		306	
TCL SEMI–VOLATILE ORGANICS (ppb)									
Noncarcinogenic PAH									
Fluoranthene	--		NA	NA	NA	NA	NA	NA	450 J
Pyrene	--		NA	NA	NA	NA	NA	NA	370 J
Total Noncarcinogenic PAH									820
TCL PESTICIDES/PCBs (ppb)									
4,4'DDD	--		NA	NA	NA	NA	NA	NA	55
TCLP PCBs (ppb)									
TCLP PCBs	--		ND	NA	ND	NA	ND	NA	NA
TOTAL PETROLEUM HYDROCARBONS (ppm)									
Total Petroleum Hydrocarbons	--		1600 J	730	110	140	220	9800	NA

NOTES:

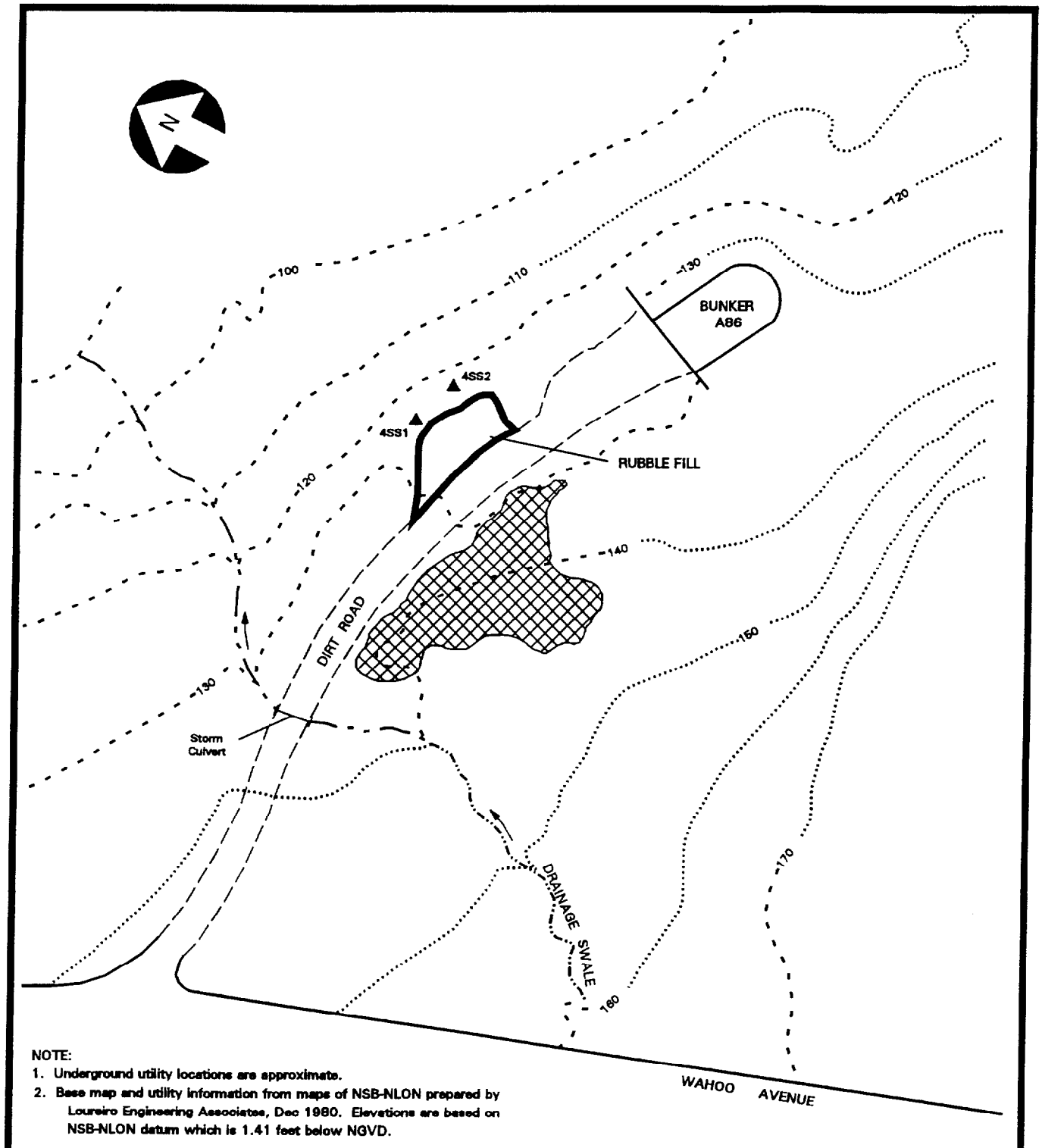
1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explantion. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–5
CBU DRUM STORAGE AREA
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: SAMPLE DEPTH (in)	1SS1S 0–6	1SS1D 12–18	1SS2S 0–6	1SS2D 12–18	1SS3S 0–6	1SS3D 12–18	1SS4C 0–6
TAL INORGANICS (ppm)									
Aluminum	272000		NA	NA	NA	NA	NA	NA	8730
Antimony	2.95		NA	NA	NA	NA	NA	NA	ND R
Arsenic	31.5		NA	NA	NA	NA	NA	NA	2.1 B
Barium	1600		NA	NA	NA	NA	NA	NA	42.8 B
Beryllium	3.52		NA	NA	NA	NA	NA	NA	0.59 BJ
Cadmium	7.0		NA	NA	NA	NA	NA	NA	2.1
Calcium	32300		NA	NA	NA	NA	NA	NA	2830
Chromium	223		NA	NA	NA	NA	NA	NA	16.1
Cobalt	39		NA	NA	NA	NA	NA	NA	6.8 B
Copper	102		NA	NA	NA	NA	NA	NA	30.9 J
Iron	115000		NA	NA	NA	NA	NA	NA	12300
Lead	53.2		NA	NA	NA	NA	NA	NA	59.3
Magnesium	26500		NA	NA	NA	NA	NA	NA	4070
Manganese	3790		NA	NA	NA	NA	NA	NA	228
Mercury	0.51		NA	NA	NA	NA	NA	NA	ND
Nickel	76.7		NA	NA	NA	NA	NA	NA	13.7
Potassium	12000		NA	NA	NA	NA	NA	NA	255 BJ
Selenium	1.79		NA	NA	NA	NA	NA	NA	0.93 BJ
Silver	5		NA	NA	NA	NA	NA	NA	ND
Sodium	51800		NA	NA	NA	NA	NA	NA	93.2 BJ
Thallium	5		NA	NA	NA	NA	NA	NA	ND
Vanadium	271		NA	NA	NA	NA	NA	NA	16.2
Zinc	178		NA	NA	NA	NA	NA	NA	64.9 J
Boron	109		NA	NA	NA	NA	NA	NA	ND
Cyanide	--		NA	NA	NA	NA	NA	NA	ND
TCLP METALS (ppm)									
PARAMETER	**TBC**								
Arsenic	0.05		ND	NA	ND	NA	ND	NA	NA
Barium	1		0.31 J	NA	0.22 J	NA	0.33 J	NA	NA
Cadmium	0.01		ND	NA	ND	NA	ND	NA	NA
Chromium	0.05		ND	NA	ND	NA	ND	NA	NA
Lead	0.05		0.6	NA	ND	NA	ND	NA	NA
Mercury	0.002		ND	NA	ND	NA	ND	NA	NA
Selenium	0.01		ND	NA	0.0021 J	NA	ND	NA	NA
Silver	0.05		ND R	NA	ND R	NA	ND R	NA	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shade numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ••• 95 ••• - Existing Grade - Exposed Bedrock ▲ SS1 - Surface Soil Sample - Building - Watercourse Approximate Scale 0 20 40'	FIGURE 4-2 FIELD SAMPLING PLAN RUBBLE FILL AT BUNKER A86 ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4–6
RUBBLE FILL AT BUNKER A–86
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: / SAMPLE DEPTH (in)	4SS1S 0–6	4SS1D 12–18	4SS2S 0–6	4SS2D 12–18	4SS3C 0–6
TCL VOLATILE ORGANICS (ppb)							
Trichloroethene	5		NA	ND	2 J	ND	NA
Tetrachloroethene	5		NA	2 J	1 J	ND	NA
Total Volatile Organics				2	3		
TCL SEMI–VOLATILE ORGANICS (ppb)							
Noncarcinogenic PAH							
Acenaphthylene	--		NA	NA	NA	NA	320 J
Fluorene	--		NA	NA	NA	NA	290 J
Phenanthrene	--		NA	NA	NA	NA	4400
Anthracene	--		NA	NA	NA	NA	440 J
Fluoranthene	--		NA	NA	NA	NA	5800
Pyrene	--		NA	NA	NA	NA	6000
Total Noncarcinogenic PAH							17250
Probable Carcinogenic PAH							
Benzo(a)anthracene	--		NA	NA	NA	NA	2700
Chrysene	--		NA	NA	NA	NA	3200
Benzo(a)pyrene	--		NA	NA	NA	NA	1800 J
Total Probable Carcinogenic PAH							7700
TCL PESTICIDES/PCBs (ppb)							
Delta–BHC	--		NA	NA	NA	NA	42
Methoxychlor	--		NA	NA	NA	NA	370 X
TCLP PCBs (ppb)							
TCLP PCBs	--		ND	NA	ND	NA	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

3) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–7
RUBBLE FILL AT BUNKER A–86
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: SAMPLE DEPTH (in)	4SS1S 0–6	4SS1D 12–18	4SS2S 0–6	4SS2D 12–18	4SS3C 0–6
TAL INORGANICS (ppm)							
Aluminum	272000		NA	NA	NA	NA	17700
Antimony	2.95		NA	NA	NA	NA	ND R
Arsenic	31.5		NA	NA	NA	NA	127
Barium	1600		NA	NA	NA	NA	49.6 B
Beryllium	3.52		NA	NA	NA	NA	0.83 BJ
Cadmium	7		NA	NA	NA	NA	1.3 B
Calcium	32300		NA	NA	NA	NA	2150
Chromium	223		NA	NA	NA	NA	8.8
Cobalt	39		NA	NA	NA	NA	2.7 B
Copper	102		NA	NA	NA	NA	6.6 J
Iron	115000		NA	NA	NA	NA	14500
Lead	53.2		NA	NA	NA	NA	32.9
Magnesium	26500		NA	NA	NA	NA	2460
Manganese	3790		NA	NA	NA	NA	208
Mercury	0.51		NA	NA	NA	NA	ND
Nickel	76.7		NA	NA	NA	NA	7.8 B
Potassium	12000		NA	NA	NA	NA	769 BJ
Selenium	1.79		NA	NA	NA	NA	1.1 BJ
Silver	5		NA	NA	NA	NA	ND
Sodium	51800		NA	NA	NA	NA	ND
Thallium	5		NA	NA	NA	NA	ND
Vanadium	271		NA	NA	NA	NA	38
Zinc	178		NA	NA	NA	NA	59.9 J
Boron	109		NA	NA	NA	NA	ND
Cyanide	--		NA	NA	NA	NA	ND
TCLP METALS (ppm)							
PARAMETER	**TBC**						
Arsenic	0.05		ND	NA	ND	NA	NA
Barium	1		0.11 J	NA	0.12 J	NA	NA
Cadmium	0.01		ND	NA	ND	NA	NA
Chromium	0.05		ND	NA	ND	NA	NA
Lead	0.05		ND	NA	ND	NA	NA
Mercury	0.002		ND	NA	ND	NA	NA
Selenium	0.01		0.0027 J	NA	ND	NA	NA
Silver	0.05		ND R	NA	ND R	NA	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

[illegible] indicates a concentration of parts per billion; ppm is parts per million.

[illegible] means not detected, less than detection limit. Refer to Section 2.2 for further explanation. N[illegible] s not analyzed.

be indicative of an oil release.

Samples analyzed for metals by TCLP methods did not exceed TBC values. Arsenic exceeded the established background concentration at 4SS3C. The concentration of arsenic (127 ppm) was one of the highest detected compared with all other site investigations. Pesticides were also detected at 4SS3C at a concentration of 42 ppb for delta-BHC and 370 ppb for methoxychlor. Both of these compounds are insecticides. **The presence of these constituents are either associated** with past Area A pesticide applications and/**or due to a release at this site.**

4.6 Torpedo Shops

The field investigation of this site consisted of a soil gas survey, test borings, ground water monitoring wells, and soil and ground water analysis. The sediment and surface water analysis results are included in the Area A discussion.

4.6.1 Soil Gas

A total of 28 soil gas sample points were analyzed within the north and south septic systems which formerly served the Torpedo Shops. The soil gas sample locations are shown on Figure 4-3.

Benzene and unknown volatile organics were found in low levels at several points at the south septic system. These points included SG-3, SG-5, SG-7 and SG-15.

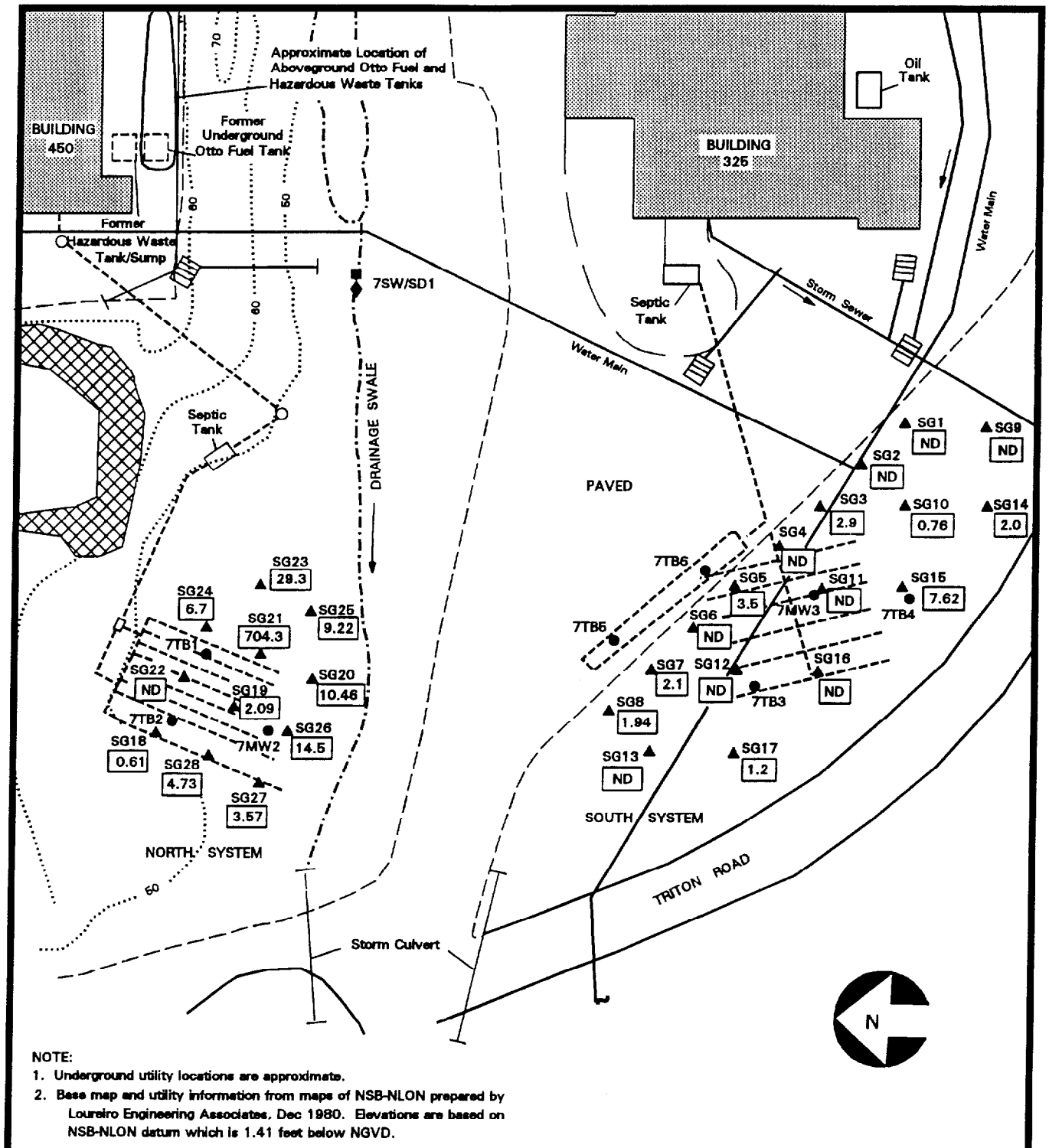
Benzene, toluene, 1,1-dichloroethene, and unknown volatile organics were found in low to high levels at the north septic system. These points included SG-20, SG-21, SG-23, SG-24, SG-25, SG-26, SG-27 and SG-28. The highest concentration of an unknown VOC (possible toluene) was detected at SG-21. Soil gas volatile organic concentrations are shown on Figure 4-3.

Complete soil gas data is provided in Appendix A.

4.6.2 Subsurface Soil

Nine subsurface soil samples were collected to screen for potential releases of chemicals to the two former septic systems. Test boring and ground water monitoring well locations are shown on Figure 4-4. The site analytical program for the surface soil samples is summarized in Section 2.0, Table 2-5.

Subsurface soil analytical results are summarized in Tables 4-8 (organics) and 4-9 (inorganics). The analytical results are discussed below separately for the north and south septic systems. None of the subsurface soil samples had any visual indication of contamination or field measured organic vapor concentrations above background levels.



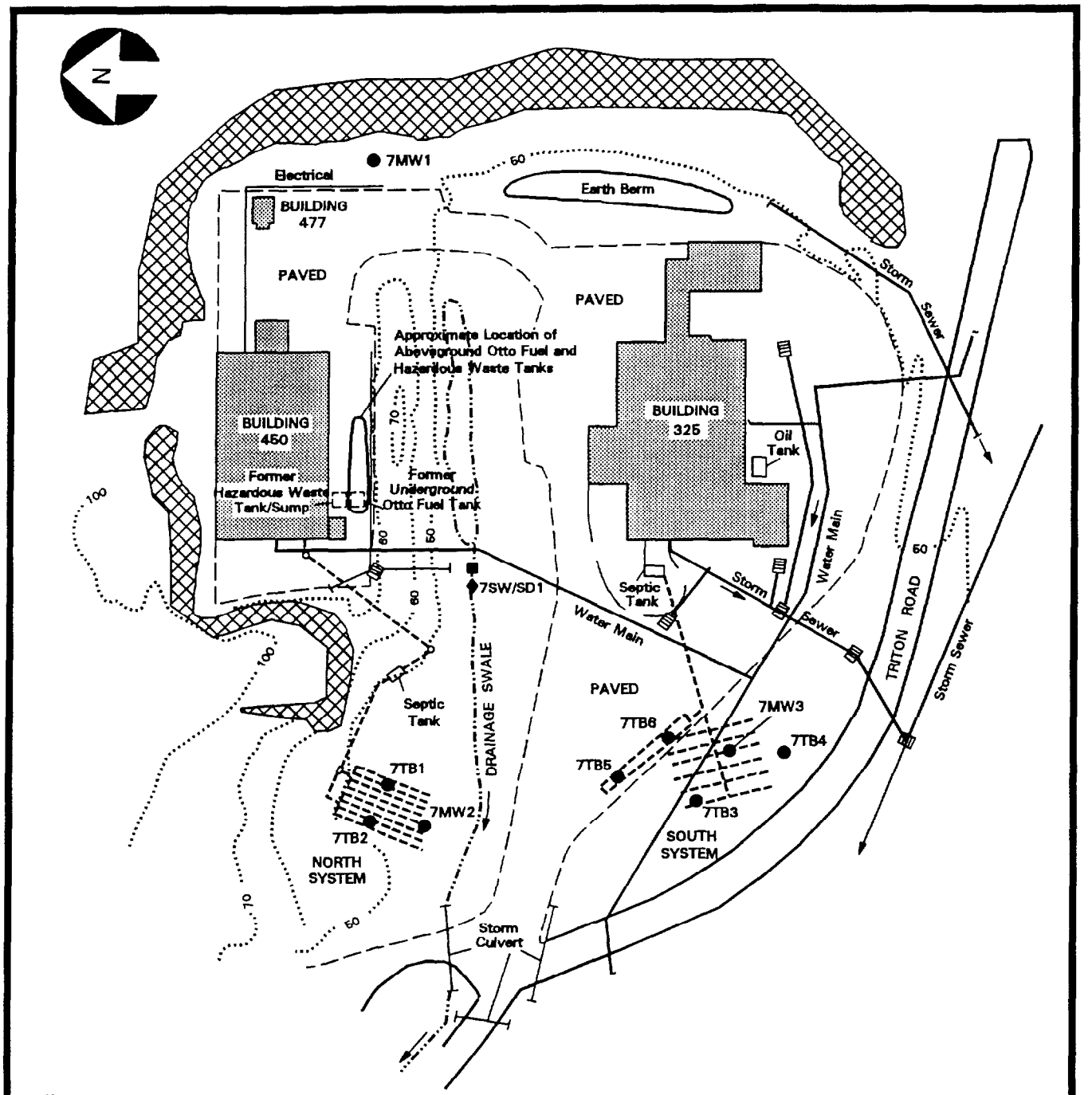
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CT

LEGEND
- Exposed Bedrock
- TB1- Test Boring
- MW1- Monitoring Well
- SD1- Sediment Sample
- SW1- Surface Water Sample
- SG1 - Soil Gas Point
- 2.9 - Concentration (volt seconds)
- 95 - Existing Grade
- Former Septic System
- Building
- Watercourse
- Catch Basin
Approximate Scale 0 40'

FIGURE 4-3
SOIL GAS SAMPLE POINTS AND CONCENTRATIONS
TORPEDO SHOPS

ATLANTIC ENVIRONMENTAL SERVICES, INC



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock - Catch Basin TB1 - Test Boring MW1 - Monitoring Well SD1 - Sediment Sample SW1 - Surface Water Sample 95 - Existing Grade - Former Septic System - Building - Watercourse Approximate Scale 0 40 80'	FIGURE 4-4 FIELD SAMPLING PLAN TORPEDO SHOPS ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4–8
TORPEDO SHOPS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	7MW1 0–2	7MW2 2–4	7MW3 6–8	7TB1 2–4	7TB2 2–4	7TB3 4–6	7TB4 4–6	7TB5 6–8	7TB6 6–8
TCL VOLATILE ORGANICS (ppb)											
Methylene Chloride	20		ND	4 J	ND	ND	3 J	ND	ND	3 J	ND
Acetone	--		ND	ND	ND	ND	ND	ND	ND	170	77 B
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	ND	5 J	3 J
2–Butanone	1000		ND	ND	ND	ND	ND	ND	ND	32	ND
Benzene	1		ND	ND	ND	ND	ND	ND	ND	4 J	ND
Total Volatile Organics				4			3			214	80
TCL SEMI–VOLATILE ORGANICS (ppb)											
Noncarcinogenic PAH											
Acenaphthene	--		ND	47 J	ND	ND	ND	ND	ND	ND	ND
Fluorene	--		ND	43 J	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	--		170 J	560	ND	ND	ND	ND	ND	ND	ND
Anthracene	--		ND	55 J	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	--		390 J	580	ND	ND	43 J	60 J	ND	ND	ND
Pyrene	--		330 J	550	ND	ND	41 J	46 J	ND	ND	ND
Total Noncarcinogenic PAH			890	1835			84	106			
Probable Carcinogenic PAH											
Benzo(a)anthracene	--		270 J	210 J	ND	ND	ND	ND	ND	ND	ND
Chrysene	--		380 J	280 J	ND	ND	ND	44 J	ND	ND	ND
Benzo(b)fluoranthene	--		610 Y	270 JY	ND	ND	ND	61 JY	ND	ND	ND
Benzo(k)fluoranthene	--		510 Y	290 JY	ND	ND	ND	48 JY	ND	ND	ND
Benzo(a)pyrene	--		570	290 J	ND	ND	ND	40 J	ND	ND	ND
Indeno(1,2,3–cd)pyrene	--		540	230 J	ND	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	--		63 J	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	--		540	190 J	ND	ND	ND	ND	ND	ND	ND
Total Probable Carcinogenic PAH			3483	1760				193			
Phthalates											
bis(2–ethylhexyl)phthalate	--		ND	130 J	ND	180 J	190 J	ND	ND	ND	ND
Diethylphthalate	--		ND	ND	ND	ND	ND	ND	ND	94 J	ND
Di–n–butylphthalate	--		ND	60 J	ND	100 J	ND	130 J	170 J	65 J	88 J
Other Semi–Volatile Organics											
4–Methylphenol	--		ND	560	ND	ND	ND	ND	ND	ND	ND
Benzoic Acid	--		ND	86 J	ND	ND	ND	90 J	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)											
4,4'–DDE	--		ND	ND	ND	ND	ND	210 X	ND	ND	ND
Aroclor–1254	10000		ND	600 X	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–9
TORPEDO SHOPS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	7MW1 0–2	7MW2 2–4	7MW3 6–8	7TB1 2–4	7TB2 2–4	7TB3 4–6	7TB4 4–6	7TB5 6–8	7TB6 6–8
TAL INORGANICS (ppm)											
Aluminum	272000		13700	13100	8460	16900	13500	10200	11000	19800	12300
Antimony ●	2.95		19.4 J	ND J	14.2 J	ND J	19.4 J	17.9 J	17.3 J	ND J	16.6 J
Arsenic	31.5		1.4 B	2.3 JB	2.2 B	1.9 JB	2.1 JB	1.4 B	2.7	2.8 J	2.6
Barium	1600		159	80.4	56.1	55.2	68.3	64.4	35.2 B	47.4 B	32.5 B
Beryllium	3.52		0.58 B	0.61 B	0.46 B	0.75 B	0.68 B	0.52 B	0.57 B	0.87 B	0.54 B
Cadmium	7		4.6	4.4	2.1	3.3	3.2	2.9	2.5	4.7	2.3
Calcium	32300		5830	1380 J	1540	600 JB	1100 JB	1680	909 B	1510 JB	1040 B
Chromium	223		18.4 J	15.7	13.6 J	16.7	16.9	14 J	18 J	24.9	20.7 J
Cobalt	39		14.8	6.7 B	6.6 B	7.6 B	8.1 B	7 B	5.5 B	7.5 B	6 B
Copper	102		39.8 J	21 J	19 J	12.2 J	20 J	23.7 J	17.1	9.7 J	14.5 J
Iron	115000		21600	14500 J	10600	16100 J	13800 J	13600	12100	14000 J	10400
Lead	53.2		7.1 J	12.2 J	11.2 J	9.7 J	11.9 J	9.2 J	3.4 J	11.1 J	3.6 J
Magnesium	26500		6440	4140 J	3590	2610 J	3240 J	4190	3010	3120 J	2740
Manganese	3790		300 J	277 J	229 J	239 J	273 J	364 J	141 J	138 J	103 J
Mercury	0.51		ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	76.7		14.4 J	12.9 J	10 J	15 J	14.4 J	8.4 JB	11.2 J	13.8 J	8.2 JB
Potassium	12000		5360 J	2710	2440 J	625 B	1940	2600 J	1080 JB	793 B	575 JB
Selenium	1.79		ND	ND	ND	ND	ND	ND	ND	0.77 B	ND
Silver ●	5		5.5 J	ND	4.9 J	ND	3	4.7 J	5.3 J	ND	5.4 J
Sodium	51800		366 JB	117 JB	108 JB	54.8 JB	118 JB	112 JB	87.6 JB	192 JB	167 JB
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		45.8	32.3	22.7	32.7	31	28.5	25.6	35.1	27.8
Zinc	178		62.9 J	48.4 J	35.2 J	43 J	46.9 J	46.9 J	26.8 J	33.7 J	28.6 J
Boron ●	109		110	50	45	50	50	45	49	130	82
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)											
PARAMETER	**TBC**										
Arsenic	0.05		0.13 J	0.19 J	ND	0.15 J	0.24 J	ND	0.17 J	0.38 J	0.16 J
Barium	1		0.44 J	0.33 J	0.24 J	0.39 J	0.49 J	0.18 J	0.19 J	0.37 J	0.26 J
Cadmium	0.01		ND	ND	ND	ND	ND	0.0095 J	ND	ND	ND
Chromium	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium ●	0.01		ND	ND	ND	ND	0.14 J	ND	ND	0.11 J	ND
Silver	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limits. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

North System: Three subsurface soil samples were collected from this septic system. Methylene chloride was detected at low concentrations in sample 7MW2 (4 ppb) and 7TB2 (3 ppb); these concentration are below the TBC value of 25 ppb. No other VOCs were detected. Boring 7TB1 was located in close proximity to the highest soil gas point (SG-21).

Semi-volatile organics were also detected at samples 7MW2 and 7TB2. Total PAH concentrations at 7MW2 were 3595 ppb, while at 7TB2 levels were 84 ppb. Low levels of phthalates were detected at 7MW2, 7TB1, and 7TB2. PAHs present in 7MW2 correlated with PAHs detected in the soil sample from 7MW1. This soil sample was from the upgradient well located adjacent to the Torpedo Shop. An odor was encountered while drilling this well. Torpedo Shop personnel felt that the odor was that of "Simple Green" cleaner that is used at the Torpedo Shops, **however, this could not be confirmed by the analyses performed as none of the constituents listed on the "Simple Green" MSDS were analyzed.**

PCB was detected at 600 ppb at sample 7MW2, which is below the TBC value. Arsenic was detected by TCLP analysis at all three subsurface soil samples above TBC values; selenium was also detected above TBC values at 7TB2. Neither arsenic nor selenium exceeded established background concentrations at these sample locations. Antimony exceeded background levels at 7TB2. Also, the arsenic and selenium TCLP results, factoring in dilution, yielded higher concentrations than the mass analysis, suggesting the TCLP results may be anomalous.

South System: Five subsurface soil samples were collected from this septic system. Low concentrations of methylene chloride, acetone, carbon disulfide, and 2-butanone were detected in either sample 7TB5 or 7TB6. As previously discussed, these compounds can be associated with laboratory contaminants, however, methylene chloride is used at the Torpedo Shops, and has been extensively used at NSB-NLON. Benzene was detected at 4 ppb at 7TB5, above the TBC value of 1 ppb. It is noted that these samples were collected at or below the water table interface. This is consistent with the soil gas survey in that the two closest soil gas points to 7TB5 detected benzene. Boring 7TB4 was located directly adjacent to SG15, the highest soil gas measurement.

PAHs detected at 7TB3 are at relatively low concentrations; low levels of phthalates were detected in soil samples collected from the south system.

The pesticide DDE was detected at soil sample 7TB3 at a concentration of 210 ppb. The sample was collected from a 4-6' depth; the source of the pesticide is unknown.

Arsenic was detected by TCLP analysis at sample location 7TB4, 7TB5, and 7TB6 above TBC values; selenium was detected also above TBC values at 7TB5. Neither arsenic or selenium exceeded background concentrations at these sample locations. Similar to the south system, the arsenic and selenium TCLP results, factoring in dilution, yielded higher concentrations than the mass analysis, suggesting the TCLP results may be anomalous. Antimony exceeded background levels at the majority of sample locations. It is possible that the elevated levels of antimony at this site, which was not detected at this level at any other site, could be due to torpedo waste liquids generated during the overhaul process. However, this does not correlate with the detection of antimony in the upgradient soil sample, 7MW1, although

this sample location may not represent background. Silver exceeded background concentrations at three locations and was close to the upper limit of background concentrations at three other locations. The elevated silver concentrations are in the same samples that have elevated antimony concentrations.

4.6.3 Ground Water

The ground water analytical program is summarized in Section 2.0, Table 2-11. Three ground water monitoring wells were installed to screen for potential ground water contamination. An upgradient bedrock well (7MW1) was installed, and an overburden well (7MW2 and 7MW3) in each leaching field area. Well 7MW1 was installed in bedrock due to the shallow depth to bedrock in that area. Ground water analytical results for organics are summarized in Table 4-10 and for inorganics in Table 4-11.

North System: In the north system at 7MW2, 1,1-dichloroethane was detected at 2 ppb; no TBC values exist for this parameter. No SVOs or pesticides/PCBs were detected. No metals were detected which exceeded primary drinking water standards. Iron and manganese were detected in the two downgradient wells (7MW2 and 7MW3) above secondary drinking water standards, which indicates a potential onsite source. Boron exceeded the TBC draft health advisory value in all wells, however, it was also exceeded in the upgradient well. Also, based on analytical data from offsite residential well analysis, the boron levels appear to be a background condition.

South System: Several VOCs were detected in the 7MW3 ground water sample. Solvents detected include 1,1,1 trichloroethane (42 ppb), 1,1 dichloroethane (30 ppb), and 1,1 dichloroethene (1 ppb). These concentrations are below applicable TBC values.

However, the presence of these compounds indicates the potential for an undefined source of contamination resulting in the presence of these compounds in the ground water. The soil gas survey and subsurface soil sampling within the septic system leaching field did not indicate the presence of any significant VOC contamination. It is possible that the source of these solvents is upgradient of this location, in the vicinity of the Torpedo Shop buildings 325 or 450. Also, due to the density of solvents, higher concentrations may be present in the bedrock aquifer.

No metals were detected which exceeded primary drinking water standards. Antimony, manganese, sodium, vanadium and boron exceeded secondary, health advisory, or state/federal guidance, or notification values. The vanadium and antimony may be related to the torpedo overhaul activities at this site. As previously discussed, boron appears to be present at background levels. Antimony exceeded the proposed MCL by over twenty times. Antimony exceeded background levels in the majority of soil samples in the south system, and in the north system. It also exceeded background in the upgradient soil sample 7MW1.

TABLE 4–10
TORPEDO SHOPS
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	7MW1	7MW2	7MW3
TCL VOLATILE ORGANICS (ppb)					
1,1–Dichloroethene	7 ARAR	MCL	ND	ND	1 J
1,1–Dichloroethane	--		ND	2 J	30
1,1,1–Trichloroethane	200 ARAR	MCL	ND	ND	42
Total Volatile Organics				2	73
TCL SEMI–VOLATILE ORGANICS (ppb)					
TCL Semi–Volatile Organics			ND	ND	ND
TCL PESTICIDES/PCBs (ppb)					
TCL Pesticides/PCBs			ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

5) Only the parameters detected are listed above, all others were not detected.

6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.

TABLE 4–11
TORPEDO SHOPS
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	7MW1	7MW2	7MW3
TAL INORGANICS (ppb)					
Aluminum	200 TBC	SMCL	ND	33.4 BJ	32.2 BJ
Antimony	5 TBC	PMCL	ND	ND	108 J
Arsenic	50 ARAR	MCL	ND	ND	ND
Barium[7]	1000 ARAR	MCL	ND	ND	39.5 B
Beryllium	1 TBC	PMCL	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	2.6 B	4 B
Calcium	--		17300	11600	30300
Chromium[7]	50 ARAR	MCL	ND	ND	ND
Cobalt	--		ND	ND	ND
Copper[7]	1000 ARAR	MCL	15.1 BJ	12.1 BJ	13.1 BJ
Iron	300 TBC	SMCL	166 J	24000	140 J
Lead	15 ARAR	Action Level	4.4 BJ	4.3 BJ	3.2 BJ
Magnesium	--		1140 B	2410 B	8760
Manganese	50 TBC	SMCL	21.8 J	879	960
Mercury	2 ARAR	MCL	ND	ND	ND
Nickel	100 TBC	PMCL	ND	ND	ND
Potassium	--		2880 BJ	5000 J	4860 BJ
Selenium[7]	10 ARAR	MCL	ND	ND	ND
Silver[7]	50 ARAR	MCL	ND	ND	38.9
Sodium	28000 TBC	Notif. Level	3950 B	6080	69900
Thallium	1 TBC	PMCL	ND J	ND J	ND J
Vanadium	20 TBC	USEPA HA	ND	ND	20.3 B
Zinc	5000 TBC	SMCL	51.4	12.2 BJ	19.5 BJ
Boron	600 TBC	USEPA HA	1200	1800	4000
Cyanide	200 ARAR	MCL	ND J	ND J	ND J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

5) Radiological constituent values have an assigned +/− range due to sample interference.

6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.

7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

4.7 Goss Cove Landfill

The field investigation at this site consisted of radiation, geophysical, and soil gas surveys. Test borings, ground water monitoring wells, and soil, surface water, and ground water sampling and analysis were also conducted.

4.7.1 Radiation

The following is a summary of the radiological survey results. The complete Radiological Assessment report is provided in a separate bound report.

At Goss Cove, 458 measurements were made. All were well within what is considered normal background radiation for this region. The highest reading was at location F/G-14, which was 16 μR/hr at waist level and 19 μR/hr in contact with the ground. This location is near the base of a granite cliff, which would account for the slightly elevated gamma measurement. No readings in this area exceeded the 20 μR/hr investigation level.

Grid survey points for the radiation, geophysics, and soil gas surveys are shown on Figure 4-5.

4.7.2 Geophysics

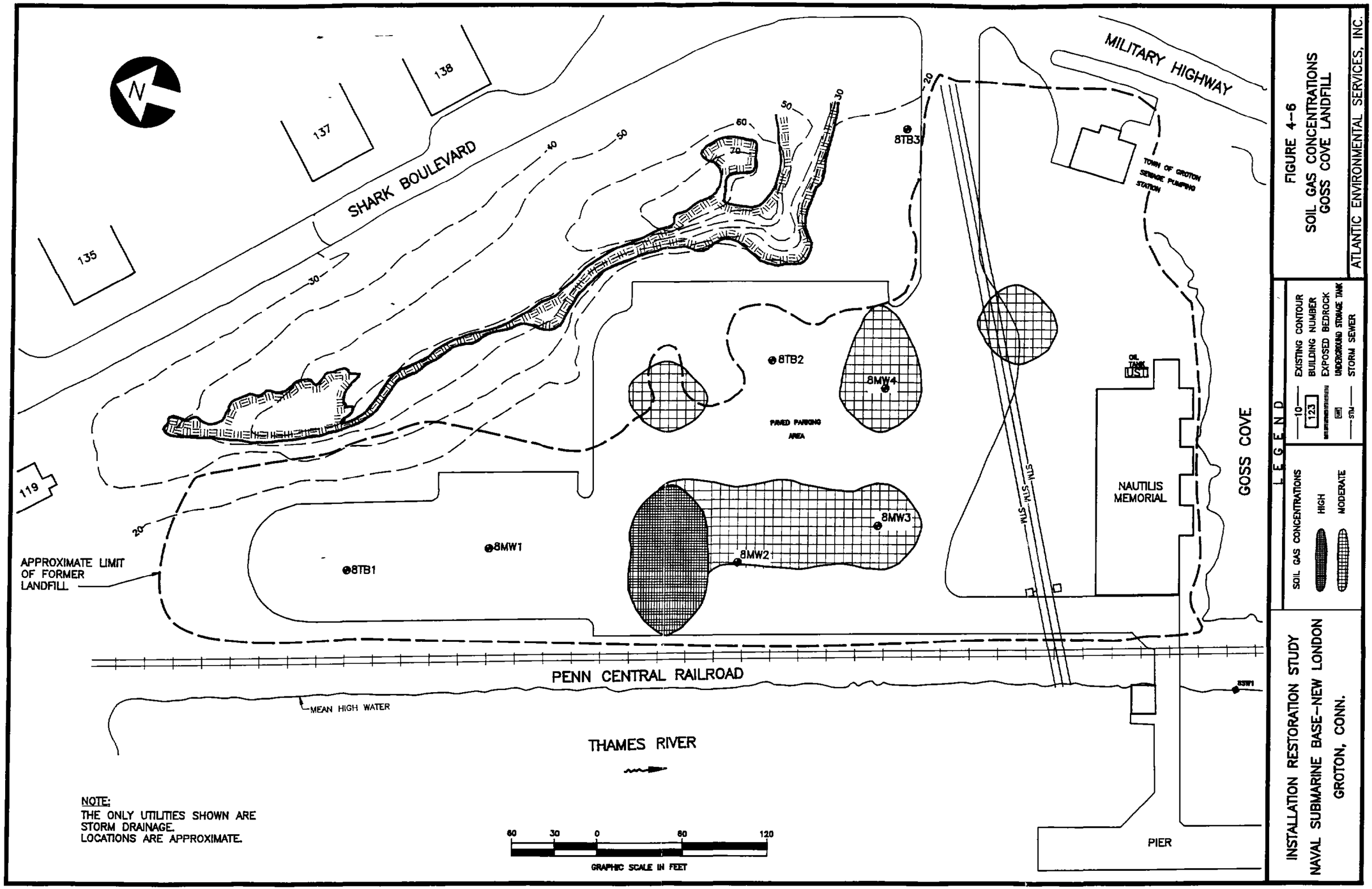
A combination of magnetometry, EM conductivity, and GPR data were acquired at the Goss Cove Landfill to identify the extent of the suspected landfill and to confirm, if possible, the specific locations of buried metal objects. The approximate limit of landfill boundary was inferred from the magnetic and EM conductivity data.

EM conductivity data were acquired along both north-south and east-west oriented grid lines. The interpreted landfill is represented by conductivity values less than zero or greater than 20 mhos/m. Areas northeast of the depicted landfill boundary exhibit little conductivity (or magnetic) variations; values on the south/southwest side of the inferred boundary range up to approximately 200 mmhos/m.

GPR data were acquired in anomalous regions noted during the magnetic and EM surveys, and in areas where the magnetic or conductivity data could not be acquired due to surface metal objects. All of the traverses completed during the GPR survey exhibit reflectors characteristic of landfills, with only occasional areas where GPR penetration depth was limited (by electrically conductive materials near ground surface) or where possibly "earth" fill overlays other backfill materials.

Based upon the geophysical investigations of suspected buried metal objects were identified at the following locations as shown on Figure 4-5: 1) 10 feet southeast of point B15, 2) 25 feet east of point D12, and 3) 15 feet southwest of point B19.

The geophysical report is provided as a separate bound report.


N
SHARK BOULEVARD
MILITARY HIGHWAY
135
137
138
119
30
40
50
60
70
20
8TB1
8TB2
8TB3
8MW1
8MW2
8MW3
8MW4
PAVED PARKING AREA
TOWN OF GROTON SEWAGE PUMPING STATION
OIL TANK
UST
NAUTILIS MEMORIAL
GOSS COVE
STM
APPROXIMATE LIMIT OF FORMER LANDFILL
PENN CENTRAL RAILROAD
MEAN HIGH WATER
THAMES RIVER
PIER
60 30 0 60 120
GRAPHIC SCALE IN FEET
NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE.
LOCATIONS ARE APPROXIMATE.
FIGURE 4-6
SOIL GAS CONCENTRATIONS
GOSS COVE LANDFILL
ATLANTIC ENVIRONMENTAL SERVICES, INC.
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXPOSED BEDROCK
UNDERGROUND STORAGE TANK
STORM SEWER
SOIL GAS CONCENTRATIONS
HIGH
MODERATE
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

0017 2052

4.7.3 Soil Gas

A total of sixty-four (64) soil gas points were analyzed, most of which were located under the paved parking lot.

Trace to low levels of tetrachloroethene with associated trace levels of 1,2 dichloroethene and trichloroethene were found at several points along the eastern portion of the site (SG1, 9, 15, 16, 17, 18, 19, 26). Tetrachloroethene was found in the soil at 8TB2, however, no VOCs were detected at 8MW4, which is a location of moderate levels of VOCs based on soil gas data. Benzene and toluene were also noted in trace to low levels at several soil gas points scattered throughout the site.

Three moderate to high VOC levels (SG45, SG54, and SG64) were noted, containing many unknowns along with benzene, toluene, and xylenes. These chromatographic signatures suggest a petroleum product. These elevated VOC detections are in the vicinity of 8MW2 and 8MW3, where elevated soil concentrations of petroleum hydrocarbons were detected.

A review of the soil gas and geophysical data does not suggest that the detection of any suspected buried metal objects correlate with any high soil gas measurements.

Relative soil gas VOC concentrations are depicted on Figure 4-6. Complete soil gas data is presented in Appendix A.

4.7.4 Subsurface Soil

Seven subsurface soil samples were collected to screen for residual chemicals as a result of past landfilling operations at this site. Sample locations are shown on Figure 4-7. The site analytical program for the subsurface soil samples is summarized in Section 2.0, Table 2-5.

Subsurface soil analytical results are summarized in Tables 4-12 (organics) and 4-13 (inorganics). Figure 4-8 illustrates bar graphs of VOC, SVO, pesticide and PCB concentrations in subsurface soils.

The soil borings showed the depth of fill to range from ten to 20 feet. Fill materials consist of sand and gravel with small quantities of brick, glass sandblast grit, ash, wood, and metal. Minor oil stains or sheens were also observed in approximately one-half of the borings. All soil samples were collected from within the landfill material, and generally at or below the water table.

The highest concentrations of VOCs are present at samples 8MW2 and 8MW3, where benzene, toluene, ethylbenzene, and xylenes are present. Benzene (3 ppb) at 8MW2 and toluene (18,000 ppb) at 8MW3 exceed TBC values of 1 ppb and 1000 ppb, respectively. These samples were collected at or below the ground water table, and had field measured organic vapor readings above background. Although the higher organic vapor readings were generally measured at the ground water elevation, elevated levels were present at all elevations within the borings. Tetrachloroethene was detected at 8TB2 (23 ppb), above the TBC value of 5 ppb.

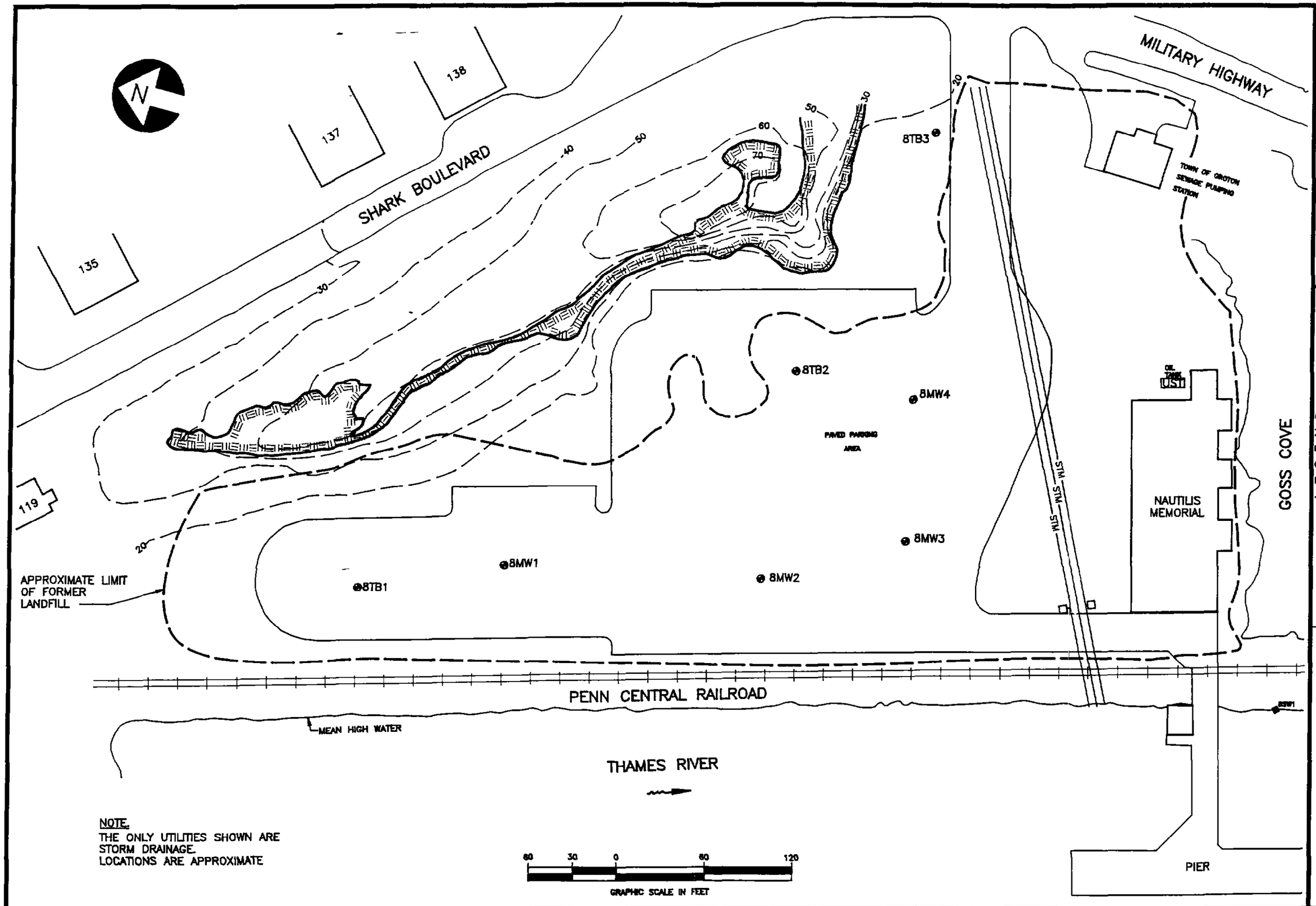


FIGURE 4-7
FIELD SAMPLING PLAN
GOSS COVE LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC

LEGEND

- 10 — EXISTING CONTOUR
- 123 — BUILDING NUMBER
- EXPOSED BEDROCK
- UST — UNDERGROUND STORAGE TANK
- STM — STORM SEWER
- 4MW1 — MONITORING WELL
- 6TB1 — TEST BORING
- 2SW1 — SURFACE WATER SAMPLE

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GROTON, CONN.

0017206Z

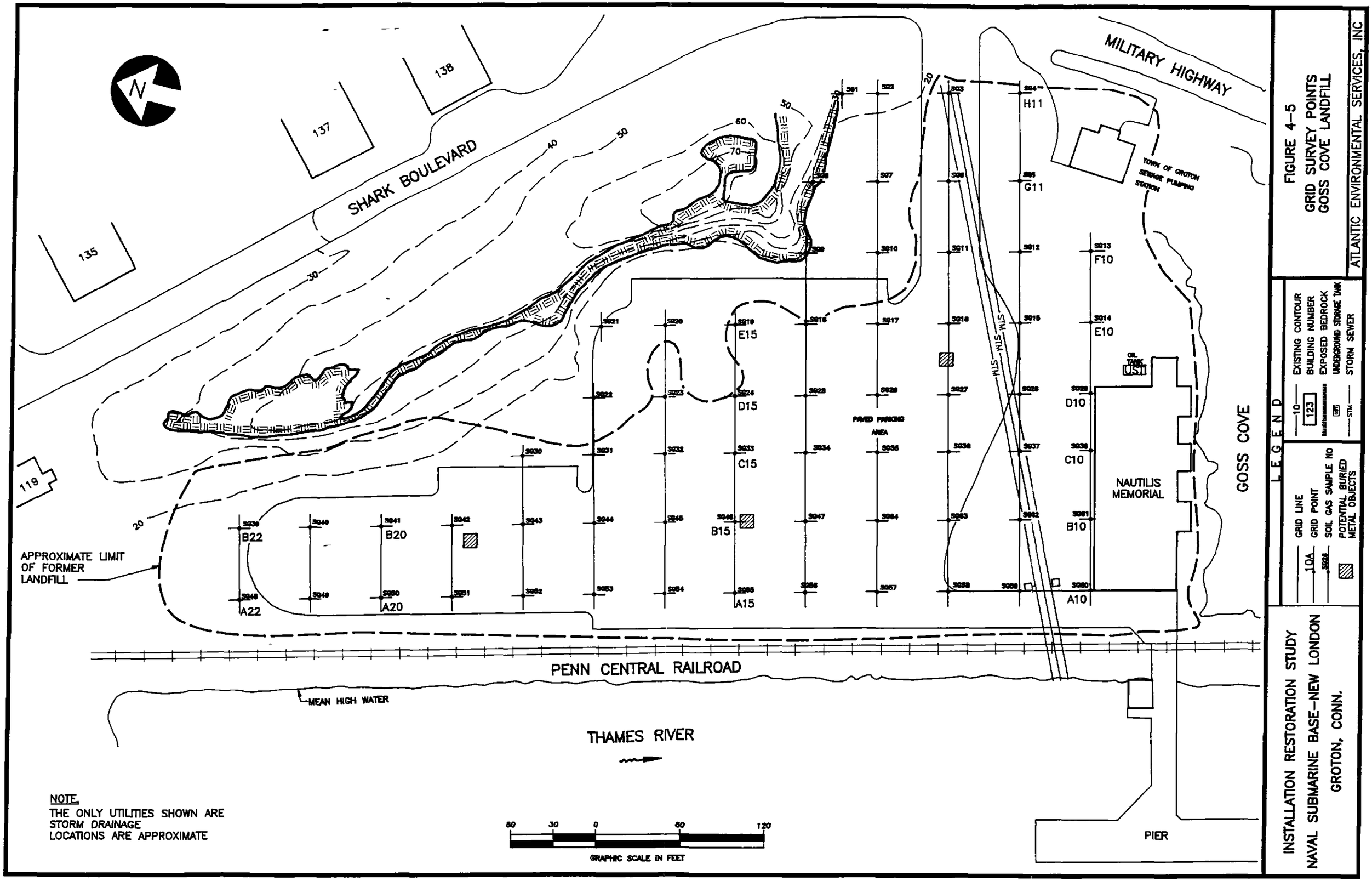
N
SHARK BOULEVARD
MILITARY HIGHWAY
135
137
138
119
TOWN OF GROTON SEWAGE PUMPING STATION
NAUTILIS MEMORIAL
OIL TANK UST
PAVED PARKING AREA
APPROXIMATE LIMIT OF FORMER LANDFILL
PENN CENTRAL RAILROAD
MEAN HIGH WATER
THAMES RIVER
GOSS COVE
PIER
H11
G11
F10
E10
D10
C10
B10
A10
E15
D15
C15
B15
A15
B22
A22
B20
A20
NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE
LOCATIONS ARE APPROXIMATE
GRAPHIC SCALE IN FEET
FIGURE 4-5
GRID SURVEY POINTS
GOSS COVE LANDFILL
ATLANTIC ENVIRONMENTAL SERVICES, INC
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXPOSED BEDROCK
UNDERGROUND STORAGE TANK
STORM SEWER
GRID LINE
GRID POINT
SOIL GAS SAMPLE NO
POTENTIAL BURIED METAL OBJECTS
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

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TABLE 4–12
GOSS COVE LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: / DEPTH (ft):	8MW1 6–8	8MW2 10–12	8MW3 8–10	8MW4 4–6	8TB1 4–6	8TB2 6–8	8TB3 10–12
TCL VOLATILE ORGANICS (ppb)									
Acetone	--		64 BJ	ND	ND	ND	290 J	150 J	ND
Carbon Disulfide	--		3 J	4 J	ND	ND	ND	ND	ND
Benzene	1		ND	3 J	ND	ND	ND	ND	ND
Trichloroethene	5		2 J	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		ND	ND	ND	ND	ND	23 J	ND
Toluene	1000		ND	44 J	18000 J	ND	ND	ND	ND
Ethylbenzene	--		ND	270 EJ	560 J	ND	ND	10 J	ND
Styrene	--		ND	ND	ND	ND	ND	10 J	ND
Xylene (total)	--		ND	2200 EYJ	4400 JY	ND	290 Y	56 JY	ND
Total Volatile Organics			69	2521	22960		580	249	
TCL SEMI–VOLATILE ORGANICS (ppb)									
Noncarcinogenic PAH									
Naphthalene	--		ND	1200 J	ND	ND	56 J	43000	ND
2–Methynaphthalene	--		ND	2100 J	ND	ND	90 J	13000	ND
Acenaphthylene	--		ND	ND	ND	ND	ND	1900 J	420 J
Acenaphthene	--		ND	ND	ND	ND	51 J	33000	310 J
Fluorene	--		ND	1300 J	ND	ND	53 J	27000	970 J
Phenanthrene	--		290 J	6200 J	720 J	590 J	440 J	82000	6500
Anthracene	--		ND	1200 J	ND	ND	89 J	13000	1600 J
Fluoranthene	--		650 J	8400 J	880 J	820 J	380 J	69000	9400
Pyrene	--		630 J	6200 J	470 J	750 J	1300 J	50000	11000
Total Noncarcinogenic PAH			1570	26600	2070	2160	2459	331900	30200
Probable Carcinogenic PAH									
Benzo(a)anthracene	--		390 J	4800 J	320 J	550 J	390 J	19000	5300
Chrysene	--		340 J	7900 J	370 J	630 J	370 J	20000	5800
Benzo(b)fluoranthene	--		460 JY	4100 J	ND	ND	380 Y	19000	4500 Y
Benzo(k)fluoranthene	--		180 JY	3600 JY	ND	ND	99 JY	7600 JY	3500 Y
Benzo(a)pyrene	--		ND	4300 J	ND	ND	330 J	9300	4700
Indeno(1,2,3–cd)pyrene	--		ND	ND	ND	ND	ND	ND	4100
Benzo(g,h,i)perylene	--		ND	ND	ND	ND	ND	ND	3000
Total Probable Carcinogenic PAH			1370	24700	690	1180	1569	74900	30900
Phthalates									
bis(2–ethylhexyl)phthalate	--		ND	ND	310 J	680 J	ND	ND	810 J

TABLE 4–12 (continued)
GOSS COVE LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	8MW1 6–8	8MW2 10–12	8MW3 8–10	8MW4 4–6	8TB1 4–6	8TB2 6–8	8TB3 10–12
Other Semi–Volatile Organics									
4–Methylphenol	--		ND	2200 J	ND	ND	51 J	ND	ND
Isophorone	--		ND	ND	ND	ND	440 J	ND	ND
Dibenzofuran	--		ND	ND	ND	ND	ND	19000	290 J
TCL PESTCIDES/PCBs (ppb)									
4,4'DDE	--		ND	1100 XJ	ND J	ND	ND	ND	47 XR
Endrin	--		ND	36 J	ND J	ND	ND	ND	ND J
4,4'DDD	--		ND	1700 XJ	30 XJ	ND	ND	ND	ND J
4,4'DDT	500		ND	3400 XJ	87 XJ	24 JX	ND	ND	14 J
Methoxchlor	--		ND	55 R	ND J	ND	ND	ND	40 R
Endrin Ketone	--		ND	45 R	ND J	ND	ND	ND	12 R
Aroclor 1248	10000		91 X	ND J	ND J	ND	110 X	4900 X	ND J

NOTES:
1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shade
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–13
GOSS COVE LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	8MW1 6–8	8MW2 10–12	8MW3 8–10	8MW4 4–6	8TB1 4–6	8TB2 6–8	8TB3 10–12
TAL INORGANICS (ppm)									
Aluminum	272000		5840	6980	13500	9500	31200	8100	9920
Antimony	2.95		ND R	ND J	ND J	ND J	ND R	ND R	ND J
Arsenic	31.5		4.4	11.3	1.7 B	12.8	121	4.3	1.3 B
Barium	1600		44.3 J	393	175	170	716	74.3 J	91.3
Beryllium	3.52		0.24 B	0.37 B	0.47 B	1.1 B	2.9	0.28 B	0.35 B
Cadmium	7		1.6 J	8.1 J	2.2 J	2.5 J	20.7	1.8 J	1.7 J
Calcium	32300		1250 J	13000	7770	5980	9080	3730	2350
Chromium	223		11.2	168	21.9	49.1	275	25.4	10.4
Cobalt	39		5.1 B	9.9 B	11.5	24	106	5.3 B	7.3 B
Copper	102		32.7 J	14300	76.9	1280	1120	90.4	25.8 J
Iron	115000		8620	32800	20000	25300	132000	9080	14200
Lead	53.2		87.8 J	1210 J	116 J	1110 J	3020 J	104 J	26.5 J
Magnesium	26500		2150	2950	6910	2050	2520	2510	4880
Manganese	3790		123 J	1080	468	183	281 J	162 J	328
Mercury	0.51		0.27	1.6 J	0.73 J	2.2 J	2	0.12	0.26 J
Nickel	76.7		8.3 B	98.8	17	36.7	170	8.3 B	7.5 B
Potassium	12000		1470	1950 J	6310 J	1610 J	3590	1460	4410
Selenium	1.79		ND	ND	ND	ND	1 B	ND	ND
Silver	5		ND	4.2 J	2.2 BJ	ND	ND	ND	ND
Sodium	51800		128 BJ	847 BJ	777 BJ	518 BJ	1120 J	111 BJ	219 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND
Vanadium	271		16	46.5	42.5	35.8	64.8	18.7	31.5
Zinc	178		100 J	7580	92.5 J	789	3360 J	123 J	94.3
Boron	109		80	262	114	263	406	67	55
Cyanide	--		ND J	ND	ND	ND	ND J	ND J	ND
TCLP METALS (ppm)									
PARAMETER	**TBC**								
Arsenic	0.05		0.17	ND	ND	ND	0.15	0.14	ND
Barium	1		0.33	1.6	0.56	0.69	0.67	0.26	0.61
Cadmium	0.01		ND	0.038	0.009	0.0078	0.013	ND	ND
Chromium	0.05		0.062	0.029 J	0.013 J	0.02 J	0.1	0.27	0.0085 J
Lead	0.05		0.2	4.8	2.2	2.1	1.6	ND	0.16
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND
Silver	0.05		ND R	ND J	ND J	ND J	ND R	0.39 J	0.033 J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

this sample was observed to be discolored and the analytical results correlated with the soil gas results.

SVOs, predominantly PAHs, were detected in all seven subsurface soil samples. The highest SVO concentrations, as illustrated on Figure 4-8, were present at 8MW2 (53,500 ppb), 8TB2 (425,800 ppb), and 8TB3 (61,390 ppb). At 8TB2, dibenzofuran was also present at 19,000 ppb. It is unclear if the detection of the highest levels of SVOs at these sample locations is indicative of the spatial distribution of elevated SVOs at the site, or an artifact of the sample locations. The sample locations were not spatially dense enough to draw specific conclusions regarding extent of elevated SVOs in the subsurface soils. The PAHs are likely associated with the disposal of incinerator ash in this landfill and/or associated with the presence of petroleum hydrocarbons.

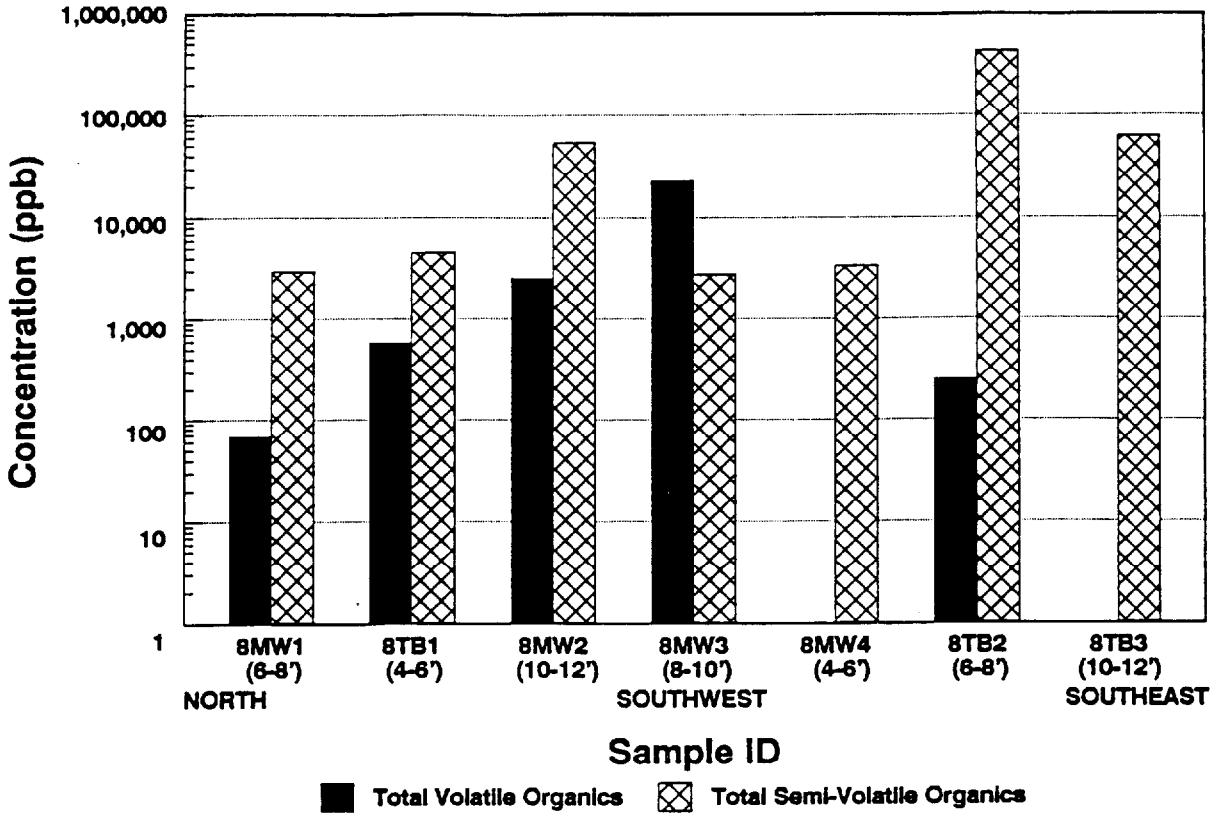
PCBs (Arochlor 1248) were detected at 8MW1 (91 ppb), 8TB1 (110 ppb) and 8TB2 (4900 ppb), all below the TBC value of 10,000 ppb. Pesticides (predominantly DDT, DDD, and DDE), were present at 8MW2, 8MW3, 8MW4 and 8TB3, with the highest concentration of DDT, DDD and DDE (6,200 ppb) present at 8MW2. DDT was present above the TBC value of 500 ppb at 8MW2. Similar to the SVOs, based on the sample density, no specific conclusions are drawn relative to extent of PCB or pesticides in subsurface soil. The presence of PCBs and pesticides are likely associated with past landfill disposal.

Lead was detected by TCLP analysis above TBC values at all samples except 8TB2. Highest TCLP concentrations were present at 8MW2, 8MW3, 8MW4 and 8TB1, but all below the RCRA hazardous waste levels of 5.0 ppm. Other metals present above TBC values include arsenic, barium, cadmium, chromium, and silver. Many inorganic constituents exceeded established background levels based on mass weight analysis. These included arsenic, chromium, cobalt, iron (all from 8TB1), cadmium, copper, iron, lead, mercury, nickel, zinc, and boron. These elevated metals are anticipated to be related to past landfilling activities. The elevated arsenic, cadmium, chromium, and lead correlated with the TCLP results. The elevated lead levels are the most widespread, and may be associated with battery disposal. The mercury detections may be related to meter and light disposal.

4.7.5 Ground Water and Surface Water

Four ground water monitoring wells were installed to screen for potential ground water contamination. One surface water sample was collected in the Thames River downstream of the landfill. The ground and surface water analytical program is summarized in Section 2.0, Table 2-11.

Ground water and surface water analytical results are summarized in Tables 4-14 (organics) and 4-15 (inorganics). The wells were installed within the former landfill; the proposed upgradient well (8MW4) was not installed in the proposed location (location of 8TB3) due to the presence of shallow bedrock conditions. The highest levels of VOCs detected in the ground water were at 8MW2S and 8MW3S, the two downgradient wells. Vinyl chloride (5 ppb) and benzene (2 ppb) were present at 8MW2 above ARAR/TBC values of 2 and 1 ppb, respectively. Petroleum hydrocarbons present in the ground water include toluene, ethylbenzene, and xylene. This is consistent with subsurface soil and soil gas analytical results at the site.



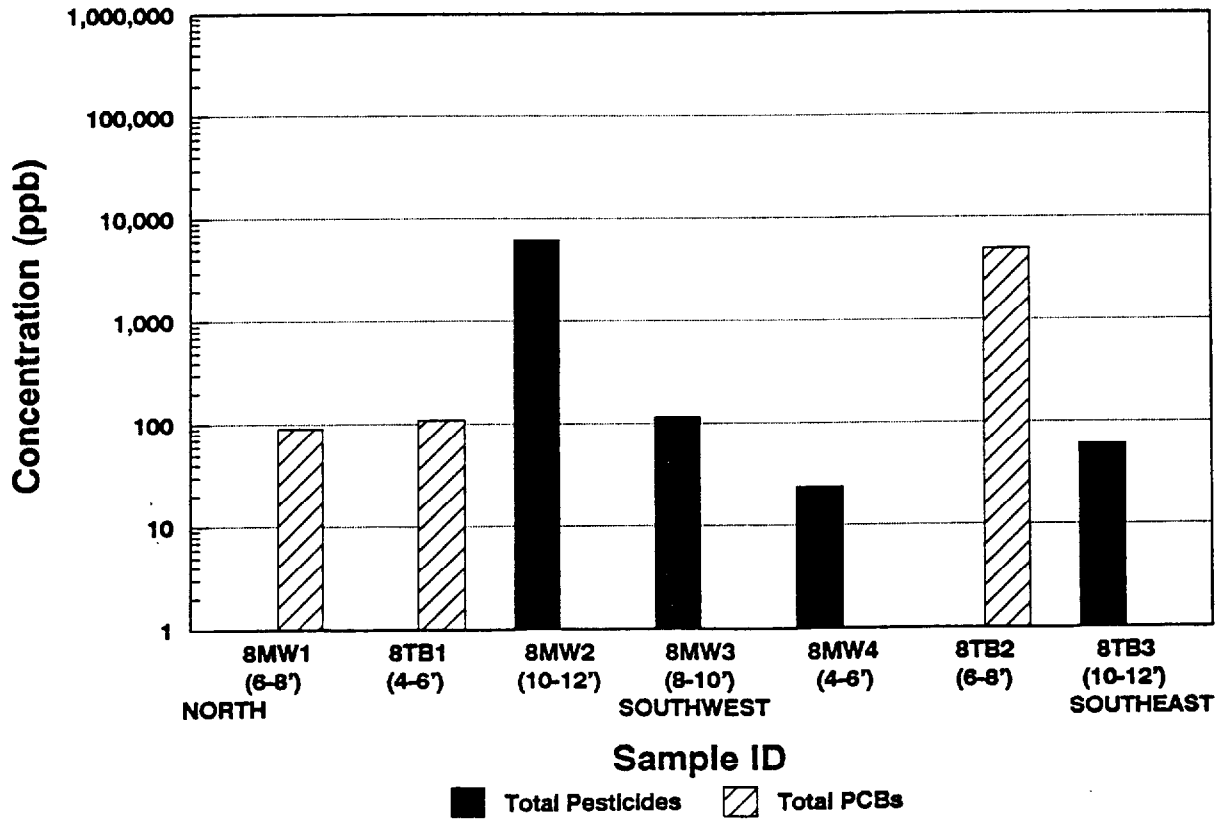


FIGURE 4-8 - GOSS COVE LANDFILL - SUBSURFACE SOIL ANALYTICAL DATA

TABLE 4–14
GOSS COVE LANDFILL
SUMMARY OF GROUND WATER AND SURFACE WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	8MW1S	8MW2S	8MW3S	8MW4S	8SW1
TCL VOLATILE ORGANICS (ppb)							
Vinyl Chloride	2 ARAR	MCL	ND	5 J	ND	ND	ND
Acetone	--		ND	ND J	700	ND	ND
1,2–Dichloroethene (total)	70 ARAR	MCL	1 J	6 J	12 J	3 J	ND
Benzene	5 ARAR	MCL	ND	2 J	ND	1 J	ND
4–methyl–2–pentanone	--		ND	ND J	200 B	ND	ND
Toluene	1000 ARAR	CTDOHS HA	ND	20 J	450	1 J	ND
Ethylbenzene	700 ARAR	MCL	4 J	120 J	120	2 J	ND
Xylene (total)	10000 ARAR	MCL	12 X	380 EYJ	610 Y	15 X	ND
Total Volatile Organics			17	533	2092	22	
TCL SEMI–VOLATILE ORGANICS (ppb)							
Noncarcinogenic PAH							
Napthalene	20 TBC	USEPA HA	4 J	46	62	8 J	ND
2–Methylnaphthalene	--		ND	11 J	12 J	ND	ND
Acenaphthene	--		ND	11 J	7 J	ND	ND
Fluorene	0.0028 TBC	WQS	ND	8 J	7 J	ND	ND
Phenanthrene	0.0028 TBC	WQS	ND	14 J	10 J	2 J	ND
Fluoranthene	42 TBC	WQC	ND	4 J	ND	ND	ND
Total Noncarcinogenic PAH			4	94	98	10	
Other Semi–Volatile Organics							
Phenol	4000 TBC	USEPA HA	ND	26	13 J	ND	ND
2–Methylphenol	--		ND	32	140	3 J	ND
4–Methylphenol	--		ND	500	340	12	ND
2'4–dimethylphenol	--		2 J	200	310	6 J	ND
Benzoic Acid	--		ND	ND	ND	3 J	ND
Dibenzofuran	--		ND	4 J	4 J	ND	ND
TCL PESTICIDES/PCBs (ppb)							
TCL Pesticides/PCBs			ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.

TABLE 4–15
GOSS COVE LANDFILL
SUMMARY OF GROUND WATER AND SURFACE WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	GROUND WATER ARARS/TBC	SAMPLE ID:	8MW1S	8MW2S	8MW3S	8MW4S	SALT WATER ARARS/TBC	8SW1
TAL INORGANICS (ppb)								
Aluminum	200 TBC	SMCL	ND	36.6 B	ND	ND	--	68.4 BJ
Antimony	5 TBC	PMCL	ND	ND	ND	ND	4300 ARAR	ND
Arsenic	50 ARAR	MCL	ND	ND	7 B	3.7 B	0.14 ARAR	ND
Barium[7]	1000 ARAR	MCL	119 B	639	524	1220	--	ND
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	0.13 ARAR	ND
Cadmium	5 ARAR	MCL	ND	2 B	ND	2.4 BJ	9.3 ARAR	ND
Calcium	--		94900	47800	47000	52500	--	81400
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	50 ARAR	ND
Cobalt	--		ND	ND	ND	ND	--	ND
Copper[7]	1000 ARAR	MCL	ND	5.2 BJ	7.8 BJ	5 BJ	2.9 ARAR	12.1 BJ
Iron	300 TBC	SMCL	1890	1380	468	5700	--	215 J
Lead	15 ARAR	Action Level	ND	2.4 B	ND	ND	1.3 ARAR	ND J
Magnesium	--		279000	34600	36200	31100	--	236000
Manganese	50 TBC	SMCL	186	226	117 J	130	100 ARAR	44.2 J
Mercury	2 ARAR	MCL	ND	ND	ND	ND	0.025 ARAR	ND
Nickel	100 TBC	PMCL	ND	ND	ND	ND	8.3 ARAR	ND
Potassium	--		98400	35200	38600	31600	--	73300
Selenium[7]	10 ARAR	MCL	7 J	ND	ND	ND	71 ARAR	4.8 B
Silver[7]	50 ARAR	MCL	ND	28.7	ND	ND	2.3 ARAR	ND
Sodium	28000 TBC	Notif. Level	2670000	152000	284000	31900	--	2E+06
Thallium	1 TBC	PMCL	ND	ND	ND	ND	6.3 ARAR	ND J
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	--	ND
Zinc	5000 TBC	SMCL	8.4 BJ	7.6 BJ	8.4 BJ	17.6 BJ	86 ARAR	14.6 BJ
Boron	600 TBC	USEPA HA	50000	1300	1100	1400	--	38000
Cyanide	200 ARAR	MCL	NDJ	ND J	ND J	ND J	1.0 ARAR	ND J
RADIOLOGICAL CONSTITUENTS (pCi/L)								
Gross Alpha[7]	5 TBC	Screening Level	28.9	0.0	2.6	8.6	--	0.0
Gross Beta	50 TBC	Screening Level	134	33.2	24.4	21.7	--	44.9

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are based on CTDOHs MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise thier MCLs to correspond to U.S. EPAs.

Trichloroethene and tetrachloroethene, present in some soil samples and soil gas samples, were not detected in the ground water. A trichloroethene degradation product, 1,2 dichloroethene, was present at the highest concentrations in the downgradient wells 8MW2S and 8MW3S. No VOCs were present in surface water sample 8SW1.

Low levels of SVOs are present in the ground water, the highest concentrations at downgradient wells 8MW2S and 8MW3S. Primarily the more soluble PAHs, including naphthalene, **fluorene, phenanthrene** and other SVOs (phenols, dibenzofuran) were present. Naphthalene concentrations in 8MW2S and 8MW3S exceed the TBC value of 20 ppb, which is an USEPA health advisory value. **Fluorene and phenanthrene concentrations in wells 8MW2S, 8MW3S, and 8MW4S exceed the TBC value of 0.0028 ppb which is based on the CTDEP WQS for ingestion of water and aquatic organisms.** No pesticides or PCBs were present in the ground water. No SVOs, pesticides, or PCBs were present in the surface water sample 8SW1.

The inorganic results indicate secondary MCLs were exceeded in all wells including sodium, iron, and manganese. Iron and manganese was present at consistent concentrations in all wells. Because there was not a true upgradient background well, it cannot be determined whether the levels are related to background or onsite waste disposal. The only primary MCL exceeded was for barium in 8MW4S, the most upgradient well. Boron exceeded the TBC health advisory value in all wells, and 8SW1. Based on analytical data from offsite residential well analysis, the boron levels appear to be a background condition. Furthermore, the surface water sample was quite high, and this appears to have effected the boron concentration at 8MW1S. This is due to the interaction of ground water and river water based on tidal fluctuation.

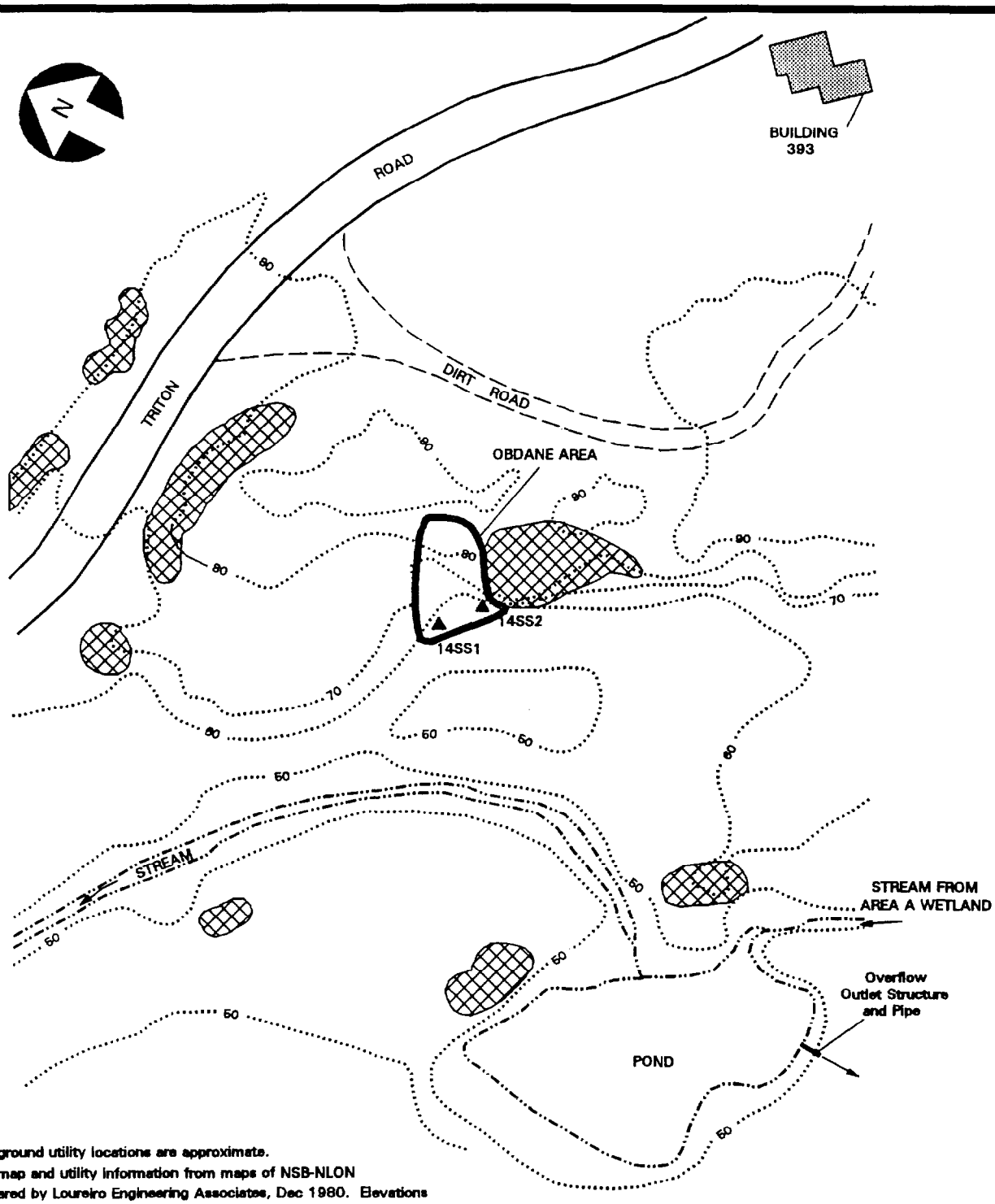
Gross alpha radiation screening values were exceeded in 8MW1S and 8MW4S. Gross beta radiation screening values were also exceeded in 8MW1S. These elevated readings could be the result of naturally occurring radioisotopes which do not meet the gross screening criteria. Further laboratory analysis is required to determine if these levels are associated with naturally occurring radioisotopes.

In summary, the levels of VOCs and SVOs in the soils are having some impact on ground water quality (some slightly above ARARs/TBCs), but overall the concentrations are relatively low. The elevated inorganics in soils, principally arsenic, cadmium, chromium, lead and mercury, are not adversely impacting ground water quality.

4.8 Over Bank Disposal Area (OBDANE)

The field investigation program at this site consisted of surface soil sampling and analysis.

Five (5) surface soil samples were collected for analysis from this site, from two sample locations, to screen for potential releases from several discarded fiber drums. Sample locations are depicted on Figure 4-9. The site analytical program for the surface soil samples is summarized in Section 2.0, Table 2-5.



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 4-9 FIELD SAMPLING PLAN OBDANE
	··· 95 ··· - Existing Grade - Exposed Bedrock ▲ SS1 - Surface Soil Sample	- Building - Watercourse Approximate Scale 0 20 40'	ATLANTIC ENVIRONMENTAL SERVICES, INC.

Surface soil analytical results are summarized in Table 4-16. Sample 14SS2D contained tetrachloroethene at 2 ppb, below the TBC value of 5 ppb. Field measured organic vapor readings above background levels were recorded at 14SS1D, however, no VOCs were detected. No staining was observed in the soil samples collected. No SVOs, PCBs or pesticides were detected in sample 14SS3C, a composite of 14SS1S and 14SS2S. Samples analyzed for metals by TCLP methods did not exceed TBC values. No inorganic compounds exceeded established background levels.

The analytical results do not indicate any significant releases of contaminants at the site.

4.9 Spent Acid Storage and Disposal Area

4.9.1 Subsurface Soil

Seven subsurface soil samples were collected to screen for potential releases of battery acids from the subsurface tank. The samples were collected from three test borings adjacent to the tank and one sample (15SS1) was collected from gravel placed in the tank which has been capped with a concrete surface. Test boring locations are shown on Figure 4-10. The site analytical program for the subsurface soil samples is summarized in Section 2.0, Table 2-5.

Subsurface soil analytical results are summarized in Tables 4-17 (organics) and 4-18 (inorganics). The soils showed no visual evidence of contamination. Field measured organic vapor levels in the soils were detected at levels slightly above background in all borings. Sample 15TB3 was the only sample analyzed for volatile and semi-volatile organics, and contained ethylbenzene (3 ppb), xylene (26 ppb), fluoranthene (39 ppb), and pyrene (76 ppb). These parameters have no ARAR/TBC values, but the concentrations are considered low, and are probably indicative of low levels of petroleum hydrocarbons. Sample 15TB3 was also analyzed for pesticides/PCBs, and none were detected. The sample was rejected by data validation procedures, however, the data is still considered usable. This is because the sample was extracted within the holding time, but not analyzed within the specified time. Once extracted, the chemicals should be stable.

All soil samples collected exceeded TBC levels by TCLP analysis for certain metals. Lead was the most elevated metal detected and was present above TBC levels for all samples except 15TB2 (4-8'). Samples 15TB1 (0-4'), 15TB2 (0-4'), 15TB3 (0-4') and 15SS1 (1-2') all exceeded RCRA TCLP levels and are classified as a RCRA characteristic hazardous waste. Lead is associated with battery acid waste. Only zinc slightly exceeded established background levels at 15TB3, the only sample analyzed on a mass weight basis for inorganics. This sample did not contain the highest metal concentrations for TCLP analysis, and is not considered representative of inorganics on a mass weight basis.

Soil pH values are summarized on Table 2-5 in Section 2.0. Soil pH values at 15TB2 were in the 4.5 range. The elevated levels of lead and low pH values substantiate that a release of battery acid likely occurred. The most elevated levels of lead, classified as a RCRA hazardous waste, were found in the 0-4 foot depth interval.

TABLE 4–16
OBDANE
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (ORGANICS AND INORGANICS)

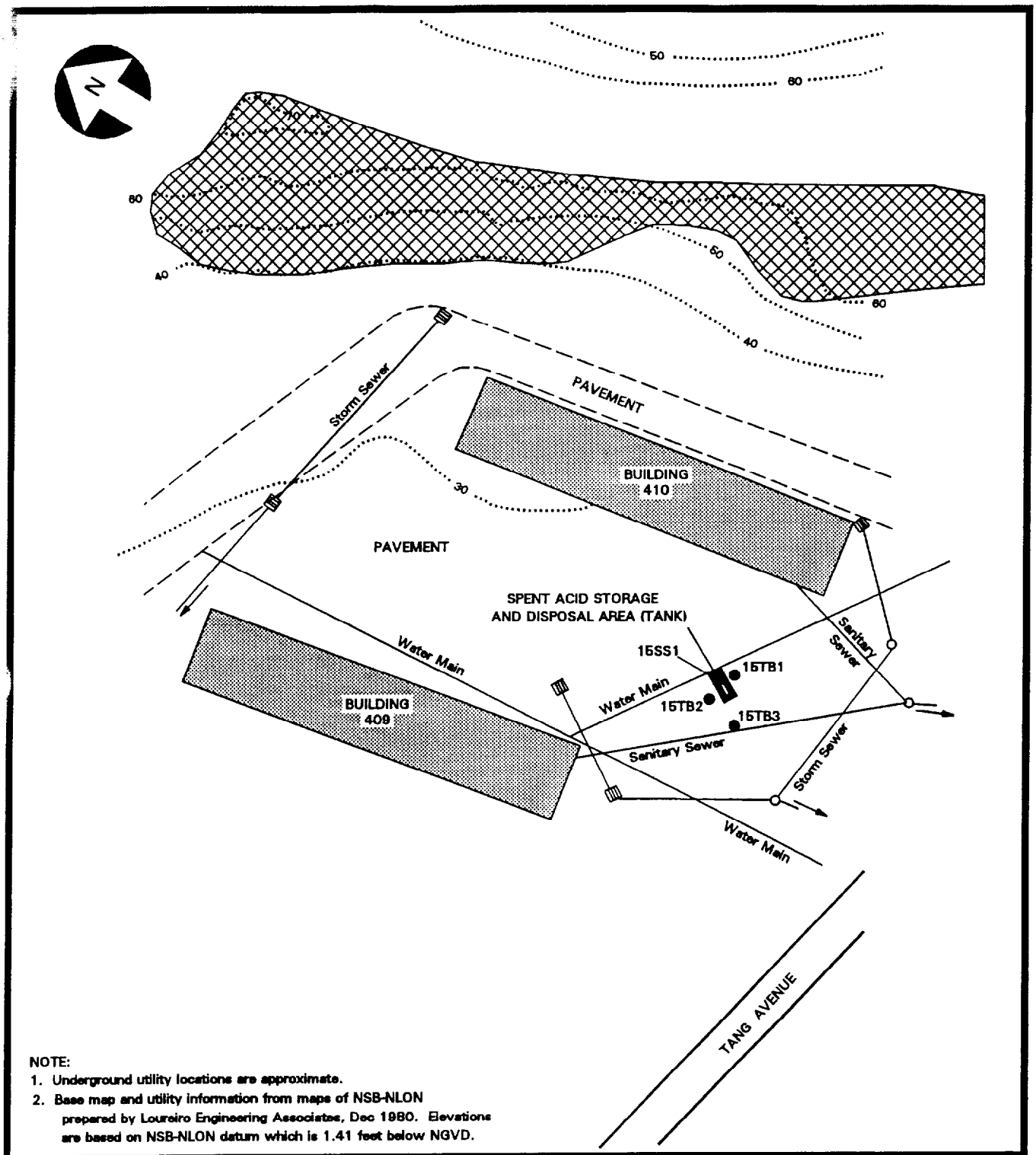
PARAMETER	TBC	SAMPLE ID: / DEPTH (in):	14SS1S 0–6	14SS1D 12–18	14SS2S 0–6	14SS2D 12–18	14SS3C 0–6
TCL VOLATILE ORGANICS (ppb)							
Tetrachloroethene	5		NA	ND	ND	2 J	NA
Total Volatile Organics						2	
TCL SEMI–VOLATILE ORGANICS (ppb)							
TCL Semi–Volatile Organics	––		NA	NA	NA	NA	ND
TCL PESTICIDES/PCBs (ppb)							
TCL Pesticides/PCBs	––		NA	NA	NA	NA	ND
TCL METALS (ppm)							
PARAMETER	**BACKGROUND**						
Aluminum	272000		NA	NA	NA	NA	4360
Antimony	2.95		NA	NA	NA	NA	ND R
Arsenic	31.5		NA	NA	NA	NA	1.3 B
Barium	1600		NA	NA	NA	NA	30.4 B
Beryllium	3.52		NA	NA	NA	NA	0.25 BJ
Cadmium	7		NA	NA	NA	NA	1.2
Calcium	32300		NA	NA	NA	NA	1530
Chromium	223		NA	NA	NA	NA	7.3
Cobalt	39		NA	NA	NA	NA	3.3 B
Copper	102		NA	NA	NA	NA	8.7 J
Iron	115000		NA	NA	NA	NA	7320
Lead	53.2		NA	NA	NA	NA	16 J
Magnesium	26500		NA	NA	NA	NA	1870
Manganese	3790		NA	NA	NA	NA	199
Mercury	0.51		NA	NA	NA	NA	ND
Nickel	76.7		NA	NA	NA	NA	6.5 B
Potassium	12000		NA	NA	NA	NA	1130 BJ
Selenium	1.79		NA	NA	NA	NA	0.52 BJ
Silver	5		NA	NA	NA	NA	ND
Sodium	51800		NA	NA	NA	NA	ND
Thallium	5		NA	NA	NA	NA	ND
Vanadium	271		NA	NA	NA	NA	12.9
Zinc	178		NA	NA	NA	NA	25.5 J
Boron	109		NA	NA	NA	NA	ND
Cyanide	––		NA	NA	NA	NA	ND

TABLE 4–16 (continued)
OBDANE
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS AND INORGANICS)

PARAMETER	TBC	SAMPLE ID:	14SS1S	14SS1D	14SS2S	14SS2D	14SS3C
		DEPTH (in):	0–6	12–18	0–6	12–18	0–6
TCLP METALS (ppm)							
Arsenic	0.05		ND	NA	ND	NA	NA
Barium	1		0.1 J	NA	0.11 J	NA	NA
Cadmium	0.01		0.0079	NA	ND	NA	NA
Chromium	0.05		ND	NA	ND	NA	NA
Lead	0.05		ND	NA	ND	NA	NA
Mercury	0.002		ND	NA	ND	NA	NA
Selenium	0.01		ND	NA	ND	NA	NA
Silver	0.05		ND R	NA	ND R	NA	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected for volatile organics, semi–volatile organics, or pesticides/PCBs are listed above, all others were not detected.



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

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

LEGEND

- Exposed Bedrock
- Catch Basin
- Manhole
- TB1 - Test Boring
- SS1 - Surface Soil Sample
- 95 - Existing Grade
- Building

Approximate Scale
0 20 40'

FIGURE 4-10
FIELD SAMPLING PLAN
SPENT ACID STORAGE
AND DISPOSAL AREA

ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4–17
SPENT ACID STORAGE AND DISPOSAL AREA
SUMMARY OF SUBSURFACE AND SURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: / DEPTH (ft):	15TB1 0–4	15TB1 4–8	15TB2 0–4	15TB2 4–8	15TB3 0–4	15TB3 4–8	15SS1 1–2
TCL VOLATILE ORGANICS (ppb)									
Ethylbenzene	--		NA	NA	NA	NA	NA	3 J	NA
Xylene (total)	--		NA	NA	NA	NA	NA	26 Y	NA
Total Volatile Organics								29	
TCL SEMI–VOLATILE ORGANICS (ppb)									
Noncarcinogenic PAH									
Fluoranthene	--		NA	NA	NA	NA	NA	39 J	NA
Pyrene	--		NA	NA	NA	NA	NA	76 J	NA
Total Noncarcinogenic PAH								115	
TCL PESTICIDES/PCBs (ppb)									
TCL Pesticides/PCBs	--		NA	NA	NA	NA	NA	ND R	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–18
SPENT ACID STORAGE AND DISPOSAL AREA
SUMMARY OF SUBSURFACE AND SURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	15TB1 0–4	15TB1 4–8	15TB2 0–4	15TB2 4–8	15TB3 0–4	15TB3 4–8	15SS1 1–2
TAL INORGANICS (ppm)									
Aluminum	272000		NA	NA	NA	NA	NA	13900	NA
Antimony	2.95		NA	NA	NA	NA	NA	ND R	NA
Arsenic	31.5		NA	NA	NA	NA	NA	2.7	NA
Barium	1600		NA	NA	NA	NA	NA	50.3 J	NA
Beryllium	3.52		NA	NA	NA	NA	NA	0.48 B	NA
Cadmium	7		NA	NA	NA	NA	NA	4.2 J	NA
Calcium	32300		NA	NA	NA	NA	NA	973 BJ	NA
Chromium	223		NA	NA	NA	NA	NA	23.4	NA
Cobalt	39		NA	NA	NA	NA	NA	7.8 B	NA
Copper	102		NA	NA	NA	NA	NA	18.2 J	NA
Iron	115000		NA	NA	NA	NA	NA	13100	NA
Lead	53.2		NA	NA	NA	NA	NA	19.8 J	NA
Magnesium	26500		NA	NA	NA	NA	NA	4300	NA
Manganese	3790		NA	NA	NA	NA	NA	132 J	NA
Mercury	0.51		NA	NA	NA	NA	NA	ND	NA
Nickel	76.7		NA	NA	NA	NA	NA	15.3	NA
Potassium	12000		NA	NA	NA	NA	NA	1680	NA
Selenium	1.79		NA	NA	NA	NA	NA	ND	NA
Silver	5		NA	NA	NA	NA	NA	ND	NA
Sodium	51800		NA	NA	NA	NA	NA	115 BJ	NA
Thallium	5		NA	NA	NA	NA	NA	ND	NA
Vanadium	271		NA	NA	NA	NA	NA	30.2	NA
Zinc	178		NA	NA	NA	NA	NA	187 J	NA
Boron	109		NA	NA	NA	NA	NA	ND	NA
Cyanide	--		NA	NA	NA	NA	NA	ND J	NA
TCLP METALS (ppm)									
PARAMETER	**TBC**								
Arsenic	0.05		0.22	ND	ND	ND	ND	ND	ND
Barium	1		0.42	0.18	0.41	0.19	0.76	0.37	0.14
Cadmium	0.01		0.015	ND	0.0061	ND	0.042	0.022	ND J
Chromium	0.05		0.11	0.067	0.1	0.066	0.065	ND	ND
Lead	0.05		42 *	2.3	9.2 *	ND	5.6 *	0.46	10 J*
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND
Silver	0.05		0.0099 J	0.012 J	0.013 J	0.0096 J	0.011 J	0.012 J	ND J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explantion. NA indicates not analyzed.
5) * indicates RCRA characteristic hazardous waste level of 5 ppm exceeded.

4.10 Former Gasoline Station

The field investigation at this site consisted of a soil gas and geophysical survey. Test borings and subsurface soil sampling and analysis were also conducted.

4.10.1 Geophysics

GPR data were acquired at the former location of a gasoline station. Grid survey points for the geophysics and soil gas surveys are shown on Figure 4-11. A complete discussion of the geophysics investigation is provided in a separate bound report.

Numerous point targets were noted on GPR recordings from this area, indicating either many pipes/conduits or boulders. One anomaly indicative of a tank was observed in the vicinity of the former tank locations. Near this location, GPR reflectors possibly indicative of backfilling were noted. The general area of disturbed soils fits the suspected location of suspected underground storage tanks. Based on the GPR results alone, it appears that only one of the tanks is still in the ground, in the approximate location of the center tank.

4.10.2 Soil Gas

A total of eleven soil gas sample points were analyzed, all under the road pavement. Sample locations and results are indicated on Figure 4-12. All samples results indicated no volatile organics with the exception of SG-11 near the gas tank area. It contained low levels of toluene and trace levels of benzene. This corresponds to the finding of benzene in the soil at 18TB2, which is adjacent to SG11.

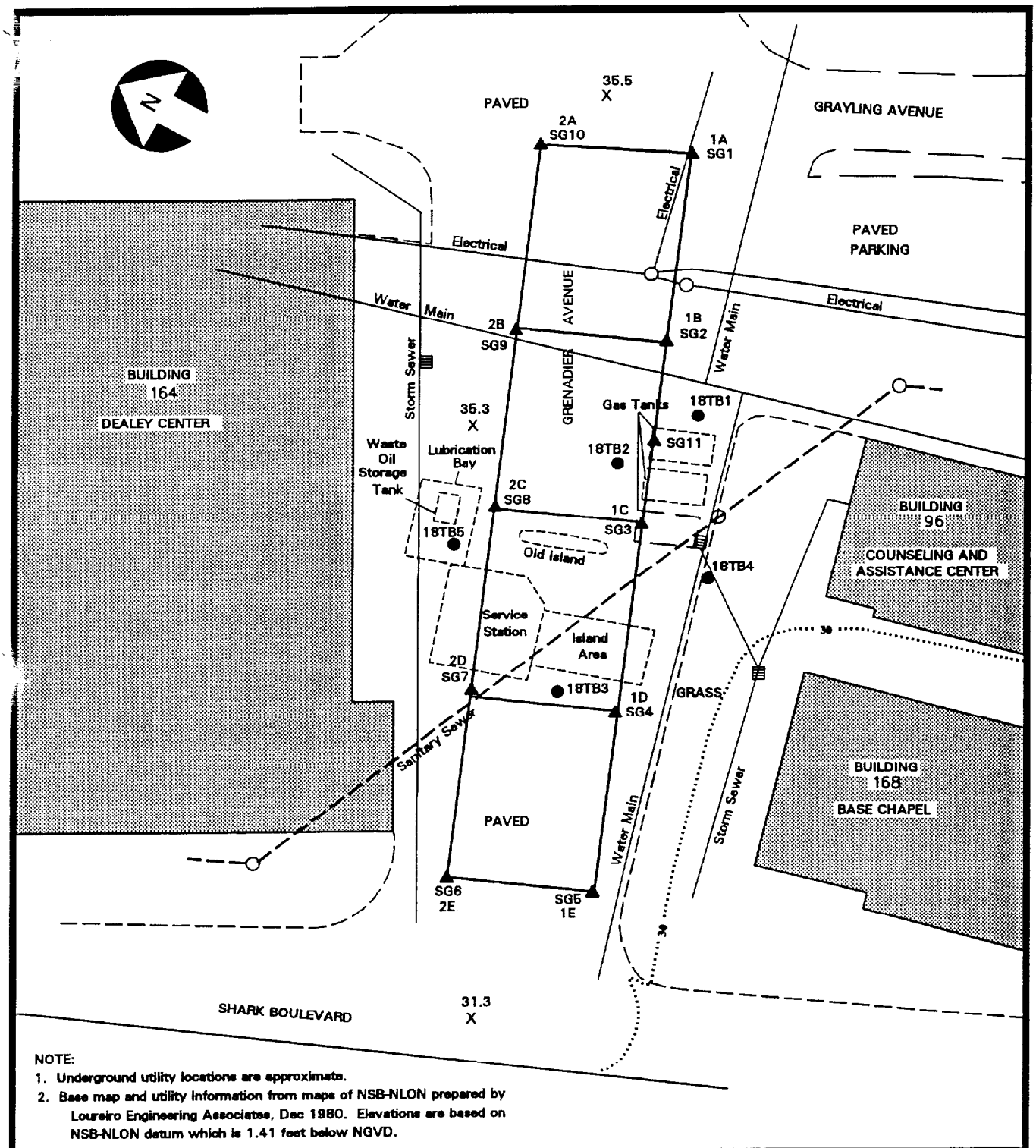
Complete soil gas data is provided in Appendix A.

4.10.3 Subsurface Soil

Five subsurface soil samples were collected from five test borings to screen for potential releases from the former gasoline station. This includes potential releases from underground pipes, fuel storage tanks, and releases from vehicle maintenance activities. Test boring locations are shown on Figure 4-13. The site analytical program for the subsurface soil samples is summarized in Section 2.0, Table 2-5.

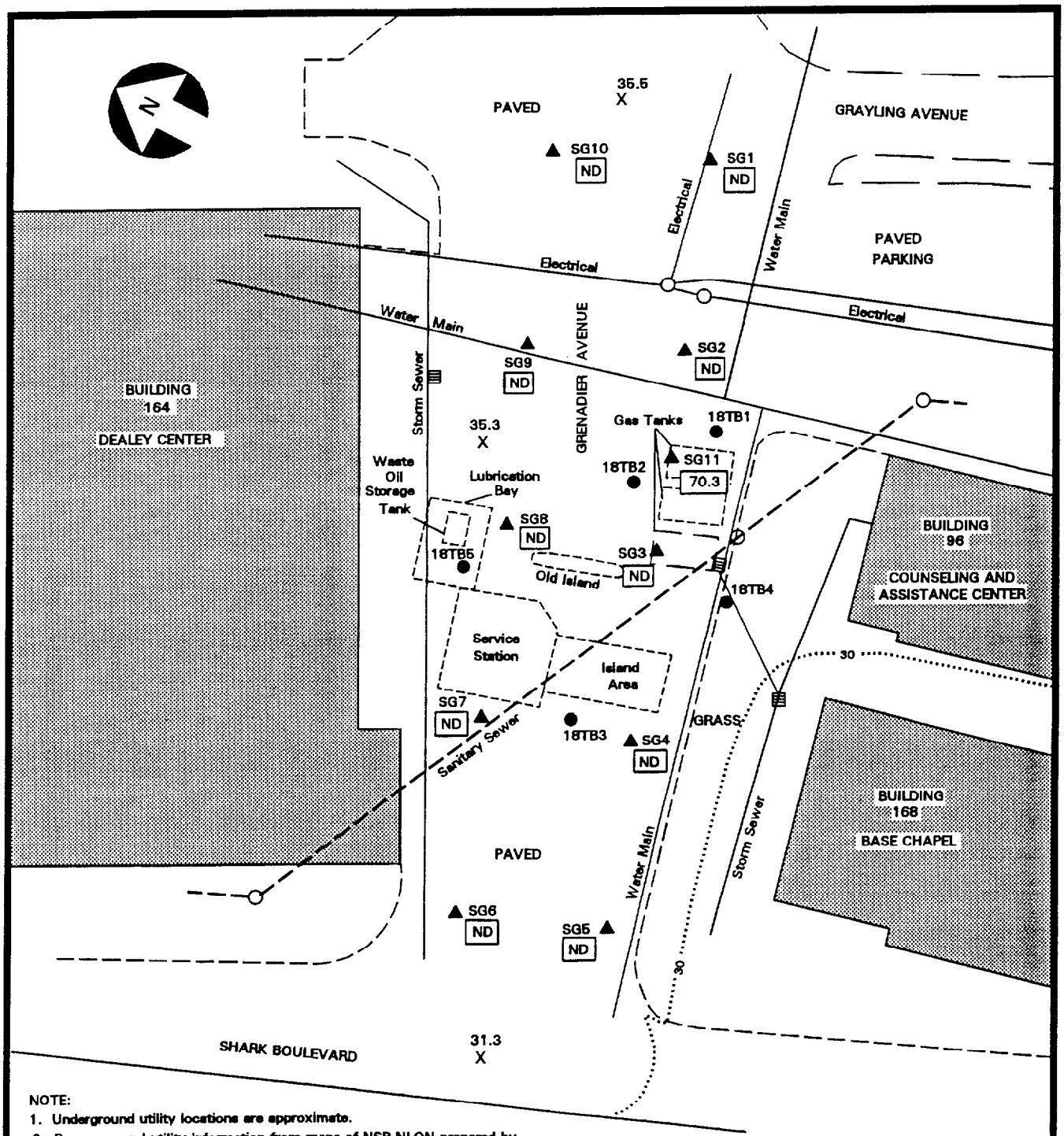
Subsurface soil analytical results are summarized in Table 4-19. Only sample 18TB2 (12-14' depth) located adjacent to the gas tank location, contained VOCs. Trichloroethene (2 ppb) and benzene (1 ppb) were detected at or below TBC values. Field measured organic vapor readings above background were detected at all boring soil samples except 18TB4. Visual evidence of soil contamination was only observed in 18TB3, where a small area of stained soil was noted. It is noted that none of the borings encountered the ground water table where petroleum hydrocarbons can accumulate.

Soil samples 18TB1, 3 and 4 contained arsenic based on TCLP analysis at concentrations in excess of TBC values. Metals more commonly associated with service stations (cadmium and



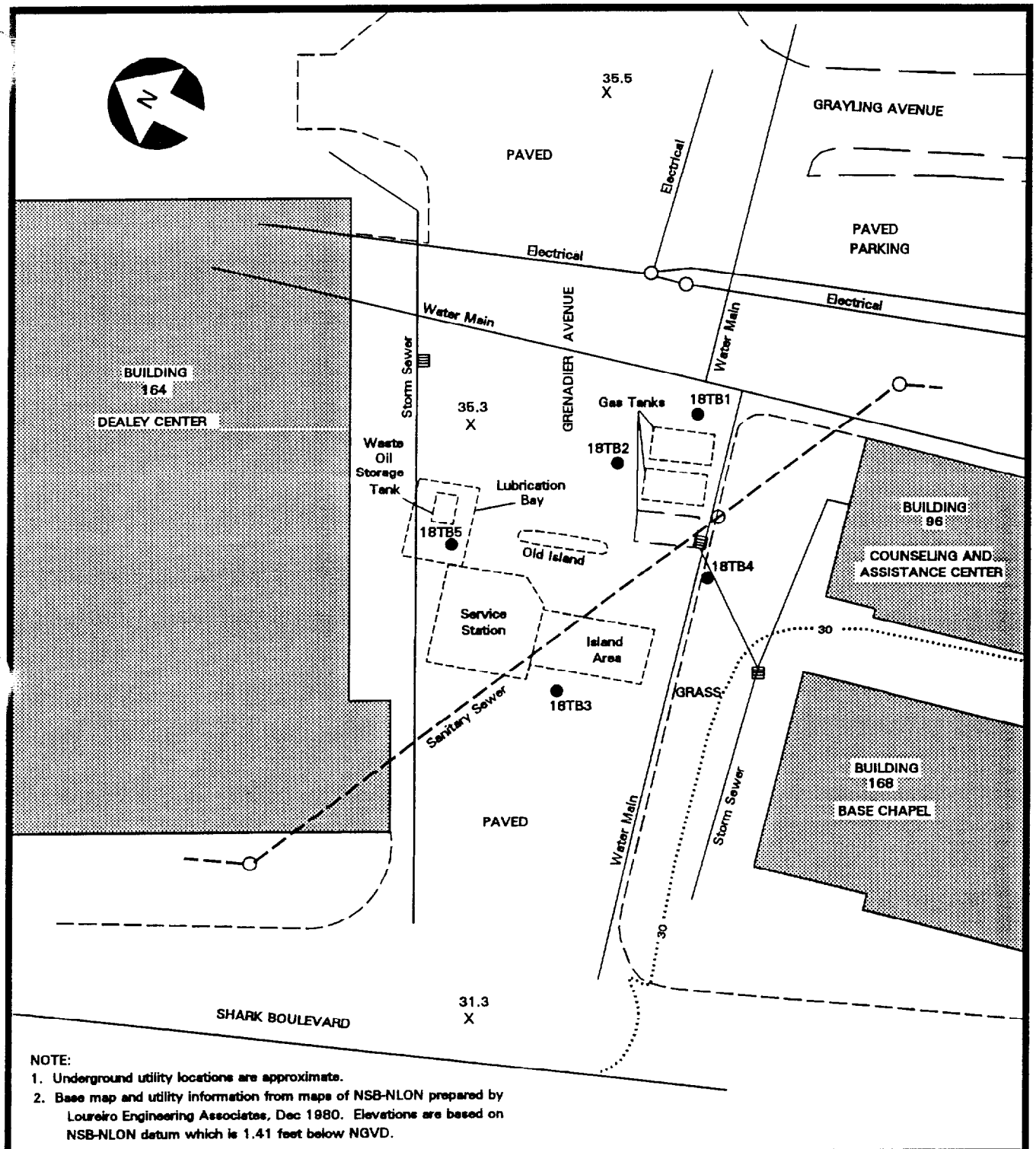
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 4-11 GRID SURVEY POINTS FORMER GASOLINE STATION
	···95··· - Existing Grade – – – – - Former Structure ○ - Manhole ● TB1 - Test Boring ▲ SG1 - Soil Gas Point ——— - Survey Grid and Designation 1A	▒ - Building 78.2 X - Spot Grade ▤ - Catch Basin Approximate Scale 0 20 40'	ATLANTIC ENVIRONMENTAL SERVICES, INC



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 4-12 SOIL GAS CONCENTRATIONS FORMER GASOLINE STATION
	···95··· - Existing Grade ---- - Former Structure ○ - Manhole ● TB1 - Test Boring ▲ SG1 - Soil Gas Point ND - Concentration (volt seconds)	▒ - Building 78.2 X - Spot Grade ▤ - Catch Basin Approximate Scale 0 20 40'	ATLANTIC ENVIRONMENTAL SERVICES, INC



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 4-13 FIELD SAMPLING PLAN FORMER GASOLINE STATION
	···96··· - Existing Grade ---- - Former Structure ▤ - Catch Basin ○ - Manhole ● TB1 - Test Boring	▒ - Building 78.2 X - Spot Grade Approximate Scale 0 20 40'	ATLANTIC ENVIRONMENTAL SERVICES, INC

TABLE 4-19
FORMER GASOLINE STATION
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS AND INORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	18TB1 8-10	18TB2 12-14	18TB3 14-16	18TB4 16-18	18TB5 10-12
TCL VOLATILE ORGANICS (ppb)							
Trichloroethene	5		ND	2 J	ND	ND	ND
Benzene	1		ND	1 J	ND	ND	ND
Total Volatile Organics				3			
TAL INORGANICS (ppm)							
PARAMETER	**BACKGROUND**						
Aluminum	272000		3970	4560	3390	3390	3950
Antimony	2.95		ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		6.2	1.5 B	1.1 B	1.9 B	2.8
Barium	1600		23 BJ	32.1 BJ	23.5 BJ	23 BJ	18.9 BJ
Beryllium	3.52		ND	ND	ND	ND	ND
Cadmium	7		1.1 J	1.1 J	0.87 BJ	1 BJ	0.95 BJ
Calcium	32300		608 BJ	770 BJ	887 BJ	684 BJ	1340 J
Chromium	223		6.7	6.7	5.9	7.8	7
Cobalt	39		3.6 B	3.9 B	2.5 B	2.8 B	3.8 B
Copper	102		6.8 J	10.2 J	7.4 J	6.3 J	6.6 J
Iron	115000		5080 J	5480	4610	4920	4990
Lead	53.2		3.3 J	6.1 J	2 J	1.6 J	1.7 J
Magnesium	26500		1310	1320	1070	1290	1410
Manganese	3790		113 J	105 J	192 J	83.1 J	107 J
Mercury	0.51		ND	ND	ND	ND	ND
Nickel	76.7		5.3 B	5.4 B	6.4 B	5 B	5.2 B
Potassium	12000		842 B	913 B	880 B	1050	789 B
Selenium	1.79		ND	ND	ND	ND	ND
Silver	5		ND	ND	ND	ND	ND
Sodium	51800		108 BJ	142 BJ	124 BJ	101 BJ	146 BJ
Thallium	5		ND	ND	ND	ND	ND
Vanadium	271		8.3 B	9.1 B	6.9 B	7.5 B	8.6 B
Zinc	178		12 J	17.9 J	11.8 J	12.6 J	12.9 J
Boron	109		ND	ND	ND	ND	ND
Cyanide	--		ND J	ND J	ND J	ND J	ND J
TCLP METALS (ppm)							
Arsenic	0.05		0.16	ND	0.12	0.11	ND
Barium	1		0.18	0.3	0.25	0.16	0.15
Cadmium	0.01		ND	ND	ND	ND	ND
Chromium	0.05		0.027	0.015	0.023	0.017	0.01
Lead	0.05		ND	ND	ND	ND	ND
Mercury	0.002		ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND
Silver	0.05		0.021 J	ND R	ND R	ND R	ND R

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discusses in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected for volatile organics, semi-volatile organics, or pesticides/PCBs are listed above, all others were not detected.

lead) were not detected by TCLP analysis and were present at low concentrations by metals mass analysis. No metals exceeded established background levels, based on mass weight analysis, including arsenic, which was present at relatively low levels consistent with arsenic concentrations at other sites. Therefore, the arsenic TCLP values are not considered significant.

The presence of low levels of VOCs in one soil sample in combination with field measured organic vapor readings in four of five soil samples indicates that some small releases of petroleum have occurred at the former gasoline station site. However, no constituents were detected in the subsurface soil above TBC values.

4.11 Area A

The results of the investigation of Area A are discussed in three sections; Area A Landfill, Wetland and OBDA/Downstream Watercourses.

The Step II investigations of Area A consist of a radiation, geophysical, and soil gas survey within the former landfill only. Test borings, ground water monitoring wells, and soil, surface water and ground water sampling and analysis were conducted throughout Area A. Also, offsite residential wells in the vicinity of Area A were also sampled and analyzed as part of the evaluation.

4.11.1 Area A Landfill

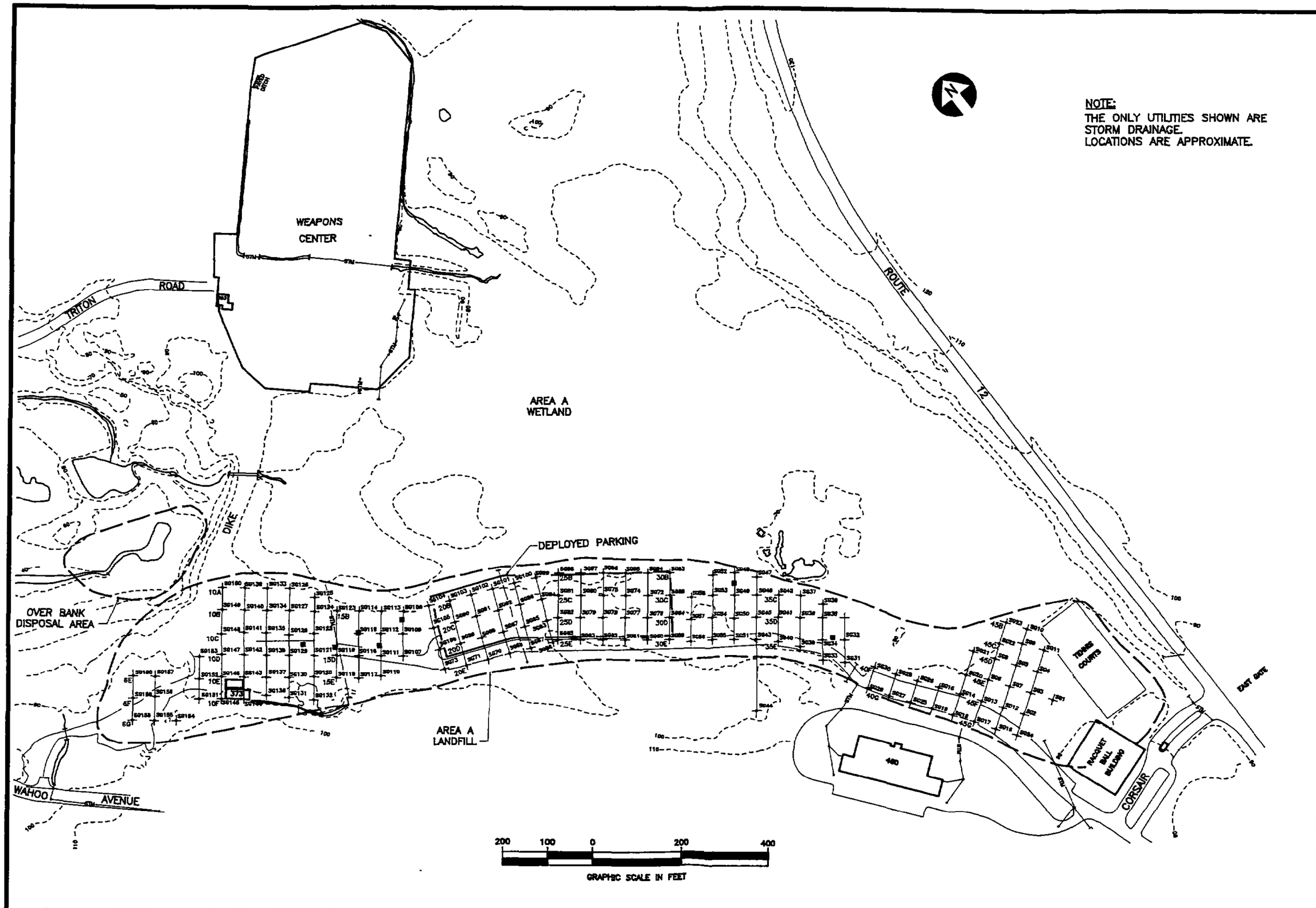
4.11.1.1 Radiation

The following is a summary of the radiation survey results. The Radiological Assessment Report is provided as a separate bound report. Grid survey points for the radiation, geophysical and soil gas surveys are shown on Figure 4-14.

Out of 1,272 measurements taken in the Area A Landfill, fifteen survey points were found to have gamma readings equal to or greater than 20 μR/hr. These points were investigated further to determine the origin of the radiation in excess of background.

Location 8.5-E showed 21 μR/hr at waist level and 19 μR/hr in contact with the ground. These levels were traced to a natural rock outcrop in that area. Most rock in New England contains some traces of naturally-occurring uranium, radium, and thorium; finding individual rocks or rock formations with detectable amounts of radiation is not at all unusual and is not indicative of any radioactive contamination.

The following 12 survey points were all located in the section of the landfill containing sandbags piled on wooden pallets near the west side of landfill adjacent to the dike: 11.5-A/B, 11.5-B, 11.5-B/C, 11.5-C, 12-A/B, 12-B, 12-B/C, 12.5-B, 13.5-B, 13.5-B/C, 13.5-C, and 14-B/C. The readings at these points ranged from 14 μR/hr (location 12.5-B at waist level) to 30 μR/hr (11.5-B/C on contact with the ground).



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

FIGURE 4-14
GRID SURVEY POINTS
AREA A LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC

LEGEND

- GRID LINE
- GRID POINT
- SOIL GAS SAMPLE NO
- POTENTIAL BURIED METAL OBJECTS
- EXISTING CONTOUR
- BUILDING NUMBER
- WATERCOURSE
- STORM SEWER

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

0017208Z

When technicians returned to perform follow-up surveys at these locations, the sandbags within an approximately 40 foot diameter around survey points 11.5-B/C had been removed. Gamma readings at this point were 15 μR/hr contact with the ground, in sharp contrast to the previously-recorded 30 μR/hr. This indicates that the slightly elevated readings in this area are caused by the sandbags (sand, like rock, may contain trace amounts of naturally-occurring radioactive materials). To further test this theory, a gamma measurement of 24 μR/hr was taken on the ground at location 12-B/C (within the sandbag area). The sandbags were then removed from an approximately five foot diameter around this survey point. This reduced the radiation level to 19 μR/hr. This is further evidence that the slightly elevated gamma readings were caused by the sandbags. No gross beta or alpha radiation in excess of background levels was detected.

Four samples of sand (from locations 11.5-B/C, 12-B/C, 13.5-B/C, and 14-B/C) were collected for analysis. The analysis results indicate that there is some small amount of radioactive material in the sand, probably naturally-occurring. The four samples were then combined and sent to the N.D.L. Organization, Inc. for a more precise analysis. This analysis consisted of a gross alpha count, a gamma spectrum analysis for isotope identification, and a determination of specific activity. The analysis showed that only naturally occurring radionuclides were present; no contamination was indicated.

The other locations within the sandbag area showing slightly elevated gamma levels (and the areas around them) were re-surveyed, and no specific "hot" area could be located; the entire sandbag area showed a tendency towards slightly elevated readings. Based on all of the measurements described above, we conclude that the sandbags themselves are the source of the nominally higher gamma levels, and not any man-made contamination or buried radioactive materials.

Location 13.5-F showed 19 μR/hr at waist level and 28 μR/hr on contact with the ground. This measurement was taken near a pile of cut granite which was determined to be the source of the elevated readings. Gamma measurements taken from within the rock pile showed 55 μR/hr; after removing the rocks from an area approximately 16 inches in diameter from that location, the center showed only 25 μR/hr, a reduction of 30 μR/hr. Gross beta measurements from within the rock pile showed 120 cpm; the area where the rocks were removed showed only 80 cpm (background). Granite is especially notorious for containing naturally-occurring radioactive materials. We are therefore confident that the elevated levels in this location are emanating from the rock pile and not from any buried radioactive material.

Location 27-E/F showed 20 μR/hr at waist level and 19 μR/hr in contact with the ground. This measurement, however, was taken at the base of a very large rock outcropping, and was apparently caused by naturally occurring radioactive materials within the rock.

4.11.1.2 Geophysics

A combination of GPR, magnetometry, and EM terrain conductivity were accomplished at the Area A Landfill. Grid survey points are shown on Figure 4-14. The complete geophysical report is provided as a separate bound report.

GPR Results

GPR data collection at Area A was limited to locations where the GPR antenna could access the ground surface. Regions excluded from the GPR survey include the sandbag storage piles and locations cluttered with surface metal objects. Most GPR data from Area A is characterized by numerous mottled reflectors commonly indicative of fill materials.

Continuous GPR reflectors noted near Lines 40 through 46 may represent the bottom of relatively clean fill which appears to be underlain by landfill materials. The thickest sections of the inferred "clean" fill is near Line C.5, Station 46.5 and Line 45.5, Station D.5. Note that C.5 indicates one-half distance between C and D, and similarly for 46.5.

Numerous individual objects were noted on the GPR recordings. Two objects are particularly large and located near Line E, Station 25.9 (approximately five feet deep) and Line 33, Station B.8 (approximately seven to eight feet deep).

Magnetic and EM Conductivity Results

The region west of Line 13.5 exhibits little magnetic variation, indicating that no significant ferrous objects are buried there. This region is therefore likely to be outside the disposal limits.

Buried metal objects may be located east of Line 13.5, as indicated by numerous magnetic variations. The most significant magnetic anomalies are listed below in decreasing order of priority: 1) 20 feet south of survey point 17C, 2) 5 feet north of survey point 15D, 3) at Line 13.5, 10 feet south of Station C, and 4) 25 feet south of survey point 18B.

A lack of EM conductivity anomalies were recorded at the northwest corner of the survey area, similar to the magnetic data discussed above. High conductivity values (up to approximately 300 mmhos/m) in the eastern portion of the survey area may be due to either salt or landfilled materials. EM data indicates anomalies located at Line 13.5, 10 feet south of Station C and at survey point 16C.

Both magnetic and EM conductivity data show a northwest anomaly trend located east of the deployed parking area (15 feet east of survey point 37E).

EM conductivity values throughout the easternmost portion of Area A Landfill (adjacent to Racquetball Center) are not as high as observed in other portions of Area A (up to 80 mmhos/m), but could still represent limited landfilling.

4.11.1.3 Soil Gas

A total of 160 soil gas points were analyzed as shown on Figure 4-14.

Trace to low levels of 1,1-dichloroethene, trichloroethene, and tetrachloroethene were noted in scattered soil gas points across the site. Chlorinated solvents were found in a few

scattered soil samples but at low levels. Low levels of some solvent compounds were detected in ground water at 2LMW13D as subsequently discussed.

Thirty-two (32) moderate to high soil gas results were recorded, containing many unknowns with occasional associated benzene, toluene, and xylenes. All of these chromatograms were similar and suggest a petroleum product. The fact that most of these points were located within the deployed parking area raises the question of whether the contamination is the result of leaks from the many parked cars in this unpaved area. Petroleum hydrocarbons, primarily xylenes, were detected in soils at 2LTB2, 2LMW17S, and 2LMW18S, as subsequently discussed. These are in the general vicinity of many of the elevated soil gas measurements.

Figure 4-15 depicts relative concentrations of soil gas VOC concentration for the site. Complete soil gas data tables for this site are provided in Appendix A.

4.11.1.4 Subsurface and Surface Soil

Twelve subsurface soil samples were collected from eight test boring/monitoring well locations at this site. Two surface soil samples were also collected and analyzed. The goal of the soil sampling program was to assess the extent of soil contamination within the landfill. No previous testing was conducted within the landfill area. Sample locations are shown on Figure 4-16 and Plate 4-1. The site analytical program for the soil samples is summarized in Section 2.0, Table 2-7.

As discussed in Section 3.0, landfill materials were encountered during drilling generally to an average depth of 10-12 feet, which was in most cases underlain by dredge sediments associated with the Area A wetland. Landfill materials encountered were small amounts of glass, brick, wood, plastic, and ash, intermixed with sand and gravel material used as cover.

Surface soil analytical results are summarized in Tables 4-20 (organics) and 4-21 (inorganics). Subsurface soil analytical results are summarized in Tables 4-22 (organics) and 4-23 (inorganics). Figures 4-17 and 4-18 provide bar graphs of total VOC/SVO and pesticide/PCB concentrations in soil, respectively. The bar graphs are oriented generally from the west side to the east side of the former landfill to illustrate spatial distribution of chemical concentrations. Sample point 2WMW3S was included with the landfill bar graph due to its location within the eastern limits of the former landfill. Soil sample 2WMW3S (16-18 feet) was collected from the underlying wetland dredge sediments, all others were collected from landfill materials. Samples collected below the 6-8 foot depth are generally at or below the water table.

Volatile Organics

VOC concentrations in the subsurface soil within Area A landfill are generally low. No TBC values for VOCs in soil samples were exceeded. The highest VOC concentrations in subsurface soils were detected at 2LTB2 (2-8') where xylene was detected at 690 ppb. This sample location corresponds with an elevated soil gas reading detected at this location. Xylene was also detected at 2LMW17S (4-8') at 229 ppb and at 2LMW18 (2-6') at 180 ppb. Both these locations are in the deployed parking area. In general, no substantially elevated organic vapor

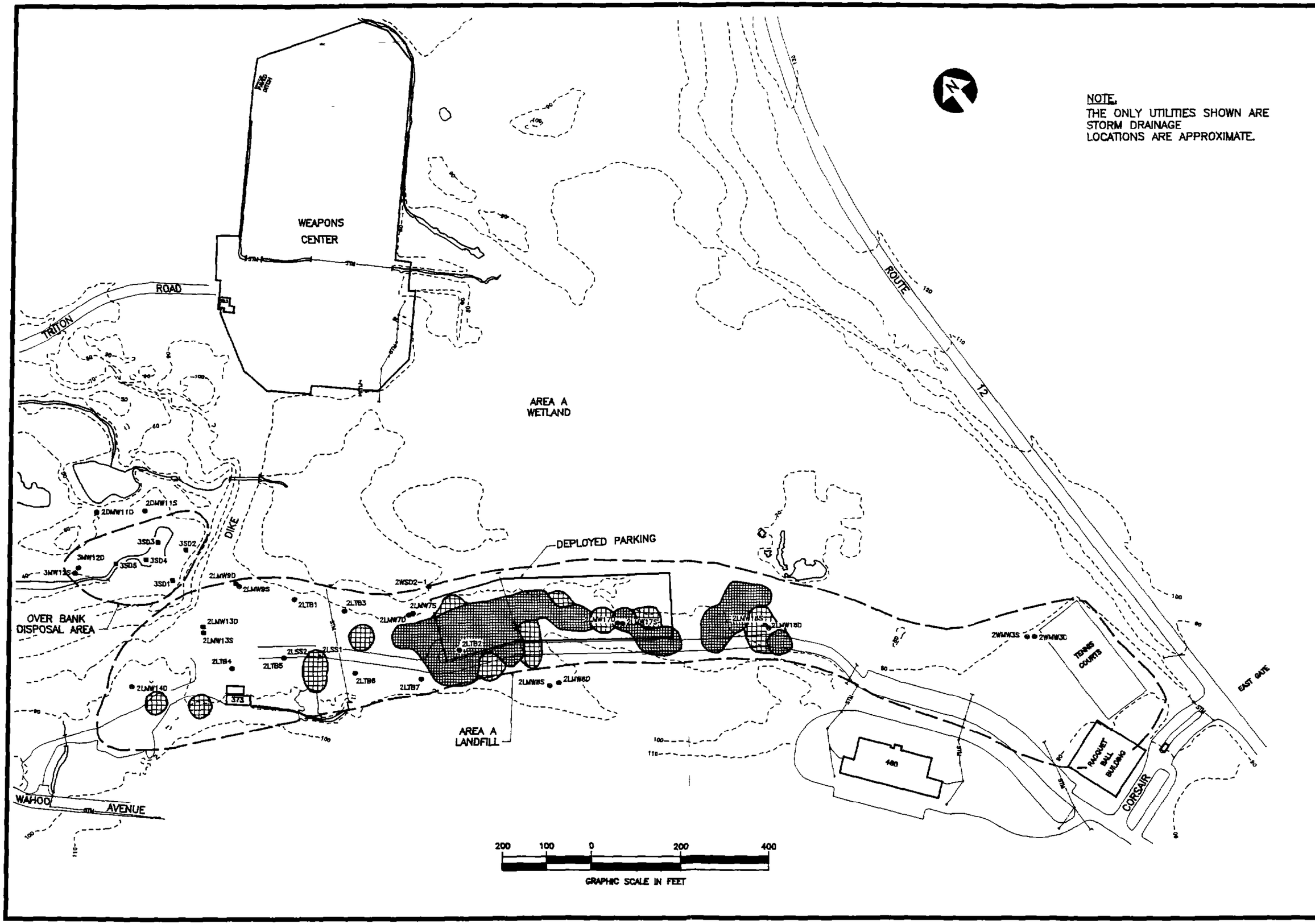


FIGURE 4-15
SOIL GAS CONCENTRATIONS
AREA A LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC.

LEGEND

- EXISTING CONTOUR
- BUILDING NUMBER
- WATERCOURSE
- STORM SEWER

SOIL GAS CONCENTRATIONS
- HIGH
- MODERATE

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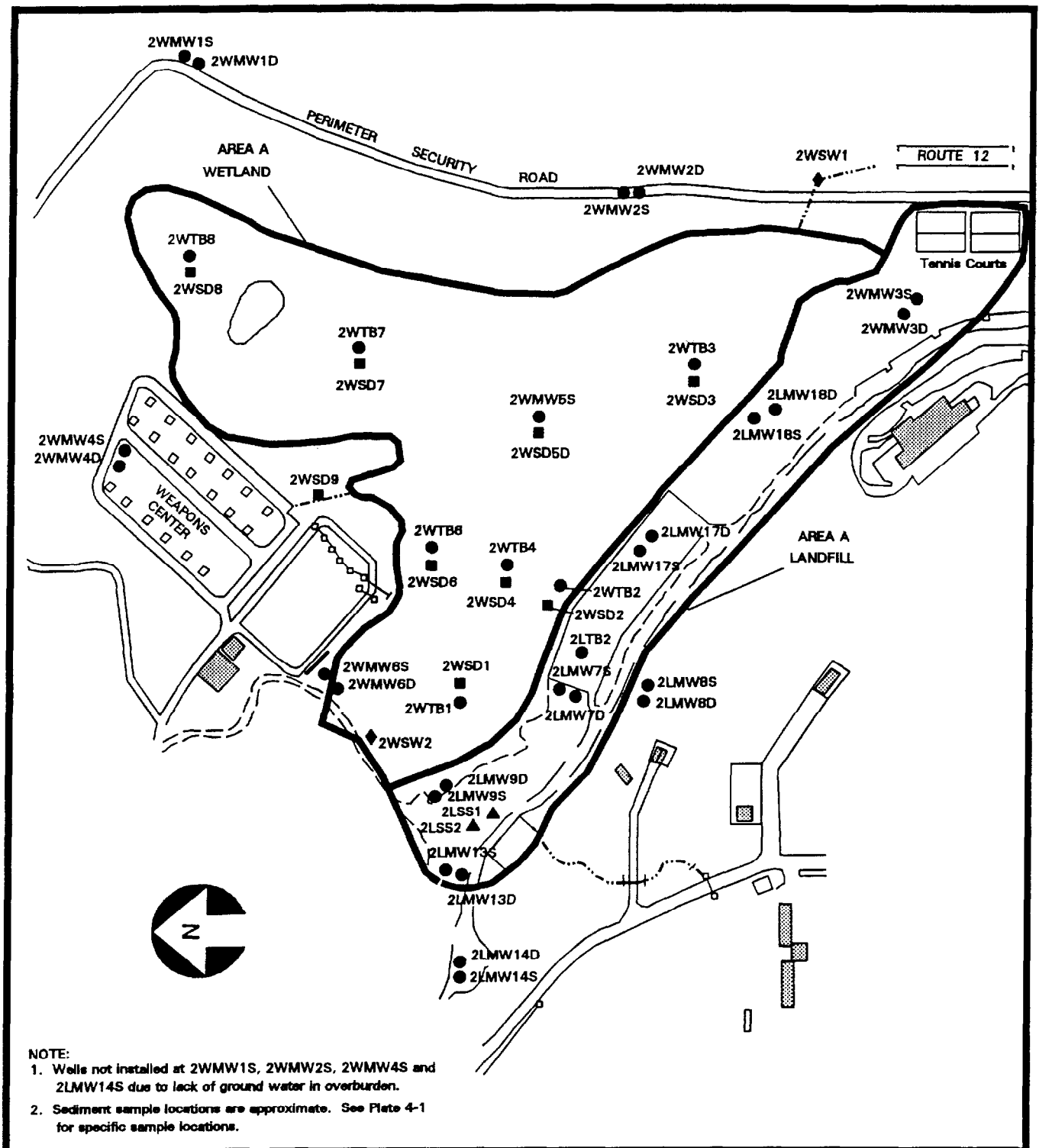


NOTE:
1. Wells not installed at 2WMW1S, 2WMW2S, 2WMW4S and 2LMW14S due to lack of ground water in overburden.
2. Sediment sample locations are approximate. See Plate 4-1 for specific sample locations.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ● TB1 - Test Boring ● MW1 - Monitoring Well ■ SD1 - Sediment Sample ▲ SS1 - Surface Soil Sample ◆ SW1 - Surface Water Sample ▒ - Building -·-·-·- - Watercourse Approximate Scale 0 200'	FIGURE 4-16 FIELD SAMPLING PLAN AREA A LANDFILL AND WETLAND ATLANTIC ENVIRONMENTAL SERVICES, INC

TABLE 4–20
AREA A LANDFILL
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2LSS1	2LSS2
TCL VOLATILE ORGANICS (ppb)				
Methylene Chloride	25		ND	3 J
2–Butanone	1000		ND	2 J
Trichloroethene	5		ND	2 J
Tetrachloroethene	5		ND	4 J
Chlorobenzene	--		4500	43 J
Ethylbenzene	--		14000	2 J
Xylene (total)	--		75000 Y	4 JY
Total Volatile Organics			93500	60
TCL SEMI–VOLATILE ORGANICS (ppb)				
Noncarcinogenic PAH				
Phenanthrene	--		66 J	ND
Fluoranthene	--		160 J	ND
Pyrene	--		110 J	1100 J
Total Noncarcinogenic PAH			336	1100
Probable Carcinogenic PAH				
Benzo(a)anthracene	--		130 J	ND
Chrysene	--		160 J	ND
Banzo(b)fluoranthene	--		220 J	ND
Benzo(k)fluoranthene	--		96 JY	ND
Total Probable Carcinogenic PAH			606	
TCL PESTCIDES/PCBs (ppb)				
44'DDT	500		71 XJ	2300 DJ
Endrin Ketone	--		ND	570 D
Aroclor 1260	10000		350 XJ	12000 DX
TCLP PESTCIDES (ppb)				
TCLP Pesticides	--		ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.

2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.

3) ppb indicates a concentration of parts per billion; ppm is parts per million.

4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–21
AREA A LANDFILL
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACKGROUND	SAMPLE ID:	2LSS1	2LSS2
TAL INORGANICS (ppm)				
Aluminum	272000		6160	5910
Antimony	2.95		ND R	ND R
Arsenic	31.5		2 B	1.1 B
Barium	1600		56.4	53.7
Beryllium	3.52		1.5 J	0.53 BJ
Cadmium	7		4.4	3.9
Calcium	32300		1900	1610
Chromium	223		21.2	15.6
Cobalt	39		8.1 B	5.6 B
Copper	102		120	56.7 J
Iron	115000		12800	11800
Lead	53.2		85.7	36.2
Magnesium	26500		2160	1990
Manganese	3790		151	136
Mercury	0.51		ND	ND
Nickel	76.7		29.8	26.7
Potassium	12000		935 BJ	1050 BJ
Selenium	1.79		0.47 BJ	0.36 BJ
Silver	5		ND	ND
Sodium	51800		204 J	170 BJ
Thallium	5		ND BJ	ND
Vanadium	271		19.7	23.9
Zinc	178		299	128
Boron	109		ND	ND
Cyanide	– –		ND	ND
TCLP METALS (ppm)				
PARAMETER	TBC			
Arsenic	0.05		ND	ND
Barium	1		0.37 J	0.27 J
Cadmium	0.01		0.037	0.0077
Chromium	0.05		ND	ND
Lead	0.05		ND	ND
Mercury	0.002		ND	ND
Selenium	0.01		0.006 J	0.002 J
Silver	0.05		ND R	ND R

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Sections 4.2 and 4.3 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

TABLE 4–22
AREA A LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2LMW7S	2LMW8S	2LMW9S	2LMW9S	2LMW13S	2LMW13S	2LMW14S	2LMW17S	2LMW17S	2LMW18S	2LMW18S	2LTB2
		DEPTH (ft):	7–10	6–10	0–4	2–8	2–4	6–8	5–7	0–2	4–8	0–2	2–6	2–8
TCL VOLATILE ORGANICS (ppb)														
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1 J	ND
Acetone	--		ND	ND	ND	ND	96 B	70 B	ND	ND	ND	ND	58 B	250 J
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5 J	ND
Trichloroethene	5		ND	ND	ND	ND	ND	ND	2 J	ND	ND	ND	ND	ND
1,1,2–Trichloroethane	--		ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND	ND
4–Methyl–2–Pentanone	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	12	ND
1,1,2,2 Tetrachloroethane	--		ND	ND	ND	ND	ND	ND	22	ND	ND	ND	ND	ND
Toluene	1000		ND	11 BJ	ND	ND	ND	ND	ND	ND	ND	ND	ND	6 J
Ethylbenzene	--		ND	ND	ND	ND	ND	ND	ND	ND	29	ND	15	68 J
Xylene (total)	--		ND	ND	ND	ND	ND	ND	ND	4 J	200 Y	ND	180 Y	690 JY
Total Volatile Organics				11			96	70	35	4	229		271	1014
TCL SEMI–VOLATILE ORGANICS (ppb)														
Noncarcinogenic PAH														
Naphthalene	--		ND	120 J	ND	ND	ND	ND	ND	ND	ND	ND	360 J	ND
2–Methylnaphthalene	--		ND	53 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	1300 J
Acenaphthene	--		ND	50 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	--		ND	130 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	--		140 J	680	390 J	380 J	ND	ND	ND	ND	ND	76 J	780 J	860 J
Anthracene	--		ND	260 J	ND	ND	ND	ND	ND	ND	ND	ND	230 J	ND
Fluoranthene	--		170 J	780	670 J	600 J	ND	ND	ND	49 J	ND	120 J	940 J	ND
Pyrene	--		200 J	550	970 J	680 J	ND	ND	ND	57 J	ND	140 J	820 J	ND
Total Noncarcinogenic PAH			510	2623	2030	1660				106		336	3130	2160
Probable Carcinogenic PAH														
Benzo(a)anthracene	--		99 J	290 J	570 J	490 J	ND	ND	ND	ND	ND	97 J	370 J	ND
Chrysene	--		100 J	380 J	460 J	460 J	ND	ND	ND	37 J	ND	120 J	350 J	ND
Benzo(b)fluoranthene	--		70 JY	260 JY	ND	280 JY	ND	ND	ND	ND	ND	130 JY	ND	ND
Benzo(k)fluoranthene	--		120 JY	210 JY	ND	560 JY	ND	ND	ND	57 JY	ND	84 JY	ND	ND
Benzo(a)pyrene	--		ND	250 J	ND	ND	ND	ND	ND	46 J	ND	ND	310 J	ND
Benzo(g,h,i)perylene	--		ND	ND	ND	ND	ND	ND	ND	44 J	ND	ND	ND	ND
Total Probable Carcinogenic PAH			389	1390	1030	1790				184		431	1030	

TABLE 4–22 (continued)
AREA A LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2LMW7S	2LMW8S	2LMW9S	2LMW9S	2LMW13S	2LMW13S	2LMW14S	2LMW17S	2LMW17S	2LMW18S	2LMW18S	2LTB2
		DEPTH (ft):	7–10	6–10	0–4	2–8	2–4	6–8	5–7	0–2	4–8	0–2	2–6	2–8
Phthalates														
bis(2–ethylhexyl)phthalate	--		ND	990	ND	1900 B	ND	ND	78 J	ND	ND	390	1500 J	ND
Di–n–butylphthalate	--		76 J	ND	ND	ND	ND	ND	ND	61 J	ND	ND	ND	ND
Other Semi–Volatile Organics														
Dibenzofuran	--		ND	83 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)														
4,4'–DDE	--		16 JX	ND	ND	ND	ND	ND	ND	ND	ND	ND	24 XJ	ND
4,4'–DDD	--		190 X	190 XJ	ND	ND	ND	ND	ND	ND	ND	ND	24 XJ	ND
4,4'–DDT	500		47 JX	ND	ND	ND	ND	ND	ND	ND	ND	21 XJ	83 XJ	ND
TCLP PESTICIDES (ppb)														
TCLP Pesticides	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

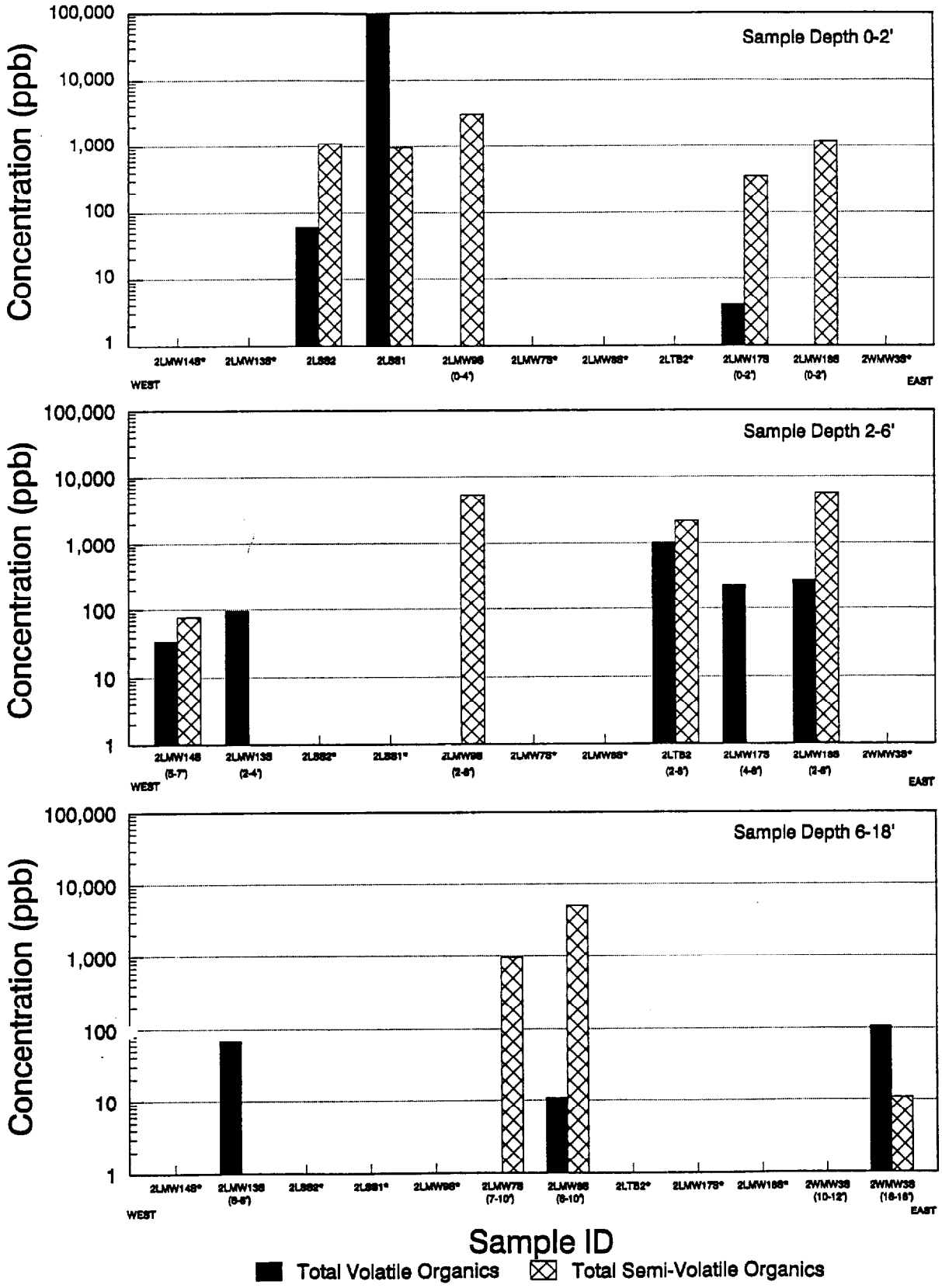
1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4-23
AREA A LANDFILL
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	2LMW7S 7-10	2LMW8S 6-10	2LMW9S 0-4	2LMW9S 2-8	2LMW13S 2-4	2LMW13S 6-8	2LMW14S 5-7	2LMW17S 0-2	2LMW17S 4-8	2LMW18S 0-2	2LMW18S 2-6	2LTB2 2-8
TAL INORGANICS (ppm)														
Aluminum	272000		4450	9680 J	7020	6470	12700	15100	13300 J	8710	6740	6670	7790	7470
Antimony	2.95		ND J	ND R	ND	ND J	ND J	ND J	ND R	ND J	ND J	ND J	ND J	ND J
Arsenic	31.5		1.2 B	8 J	2.2	1.9 B	3.9	3.3	4.6 J	1.8 B	2.7	3.7 J	1.9 JB	4.5
Barium	1600		25.4 B	42.5 JB	62.3	47.2	43.5 B	47.2 B	18.4 JB	57.5	32.8 B	49	116	75.4
Beryllium	3.52		0.25 B	0.53 JB	3	1.2	0.54 B	0.62 B	0.54 JB	0.42 B	0.46 B	0.65 B	3.9	0.4 B
Cadmium	7		2.3	12.1 J	4.5	4.3	4.3	4.9	3.7 J	3.3	6.9	2.7	6.2	3.5
Calcium	32300		2140	5800 J	1990	1650	1170 J	1410 J	856 JB	1320	971 B	1690 J	3680 J	1750
Chromium	223		8.8 J	40.2 J	15.7 J	19.6 J	19.8 J	22.7 J	18.9 J	14.4 J	17.3 J	16.2	31.2	17.5 J
Cobalt	39		4.3 B	8.5 JB	23.8	14.9	6.8 B	7.2 B	5.7 JB	6.5 B	ND	6.6 B	20.5	5.9 B
Copper	102		14.1 J	30 J	378	210	15.8 J	18.2 J	12.4 J	31.2 J	45.5 J	103 J	507 J	69.5 J
Iron	115000		8370	49700 J	15200	12300	12600	13700	11500 J	10900	8260	9890 J	20000 J	12500
Lead	53.2		7.6 J	32.9 J	118 J	114 J	5.9 J	5.5 J	6.8 J	18.1 J	25.3 J	95.8 J	277 J	170 J
Magnesium	26500		2550	5020 J	2970	2660	3410	3900	2460 J	3440	1740	2250 J	2310 J	2980
Manganese	3790		109 J	332 J	228	241 J	133 J	157 J	74 J	144 J	101 J	132 J	288 J	149 J
Mercury	0.51		ND	ND	ND	ND	ND	ND	ND	ND	3.6	ND	0.47	ND
Nickel	76.7		9.6 J	24.9 J	76.2 J	44.6 J	13.2 J	14.2 J	12.4 J	15.6 J	12.4 J	36.3 J	159 J	15.4 J
Potassium	12000		902 JB	2370 J	1120 J	782 JB	1420 J	1340 J	549 JB	1770 J	861 JB	1250	1230 B	2150 J
Selenium	1.79		ND	0.77 JB	ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND
Silver	5		ND J	ND R	ND	ND J	3.1 J	ND	ND R	ND J	ND J	ND	ND	ND J
Sodium	51800		220 JB	600 JB	306 JB	273 JB	115 JB	152 JB	110 JB	210 JB	211 JB	108 JB	427 JB	268 JB
Thallium	5		ND	ND J	ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND
Vanadium	271		16.2	30.6 J	19.6	17.4	28.3	33	24.9 J	24.4	13.9	36.2	24.5	20.7
Zinc	178		30 J	229 J	1480 J	902 J	45.5 J	50 J	27.5 J	75.6 J	93.8 J	349 J	2640 J	149 J
Boron	109		41	1882	45 J	52	ND	56 J	50	43	45	50	130	44
Cyanide	--		ND	ND J	ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND
TCLP METALS (ppm)														
PARAMETER	**TBC**													
Arsenic	0.05		0.21 J	0.008	ND	0.3 J	0.2	0.19	0.004	0.18 J	0.19 J	0.19 J	ND	0.26 J
Barium	1		0.3 J	0.14 J	0.29 J	0.32 J	0.23	0.22	0.16 J	0.35 J	0.34 J	0.25	0.3	0.34 J
Cadmium	0.01		0.005 J	ND	0.019 J	0.034 J	ND	ND	ND	0.0089 J	0.065 J	ND	0.018	0.031 J
Chromium	0.05		ND	0.012 J	ND	0.035 J	ND	ND	ND	0.01 J	0.014 J	ND	ND	0.029 J
Lead	0.05		ND	0.007 J	0.17 J	0.84 J	ND	ND	0.004 J	ND	ND	0.22 J	0.3 J	0.56 J
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		0.1 J	ND	ND	0.23 J	0.11 J	0.12 J	0.003	ND	ND	ND	ND	0.14 J
Silver	0.05		ND	0.01 J	ND	0.042 J	ND J	ND J	0.01 J	ND	ND	ND J	ND J	0.011 J

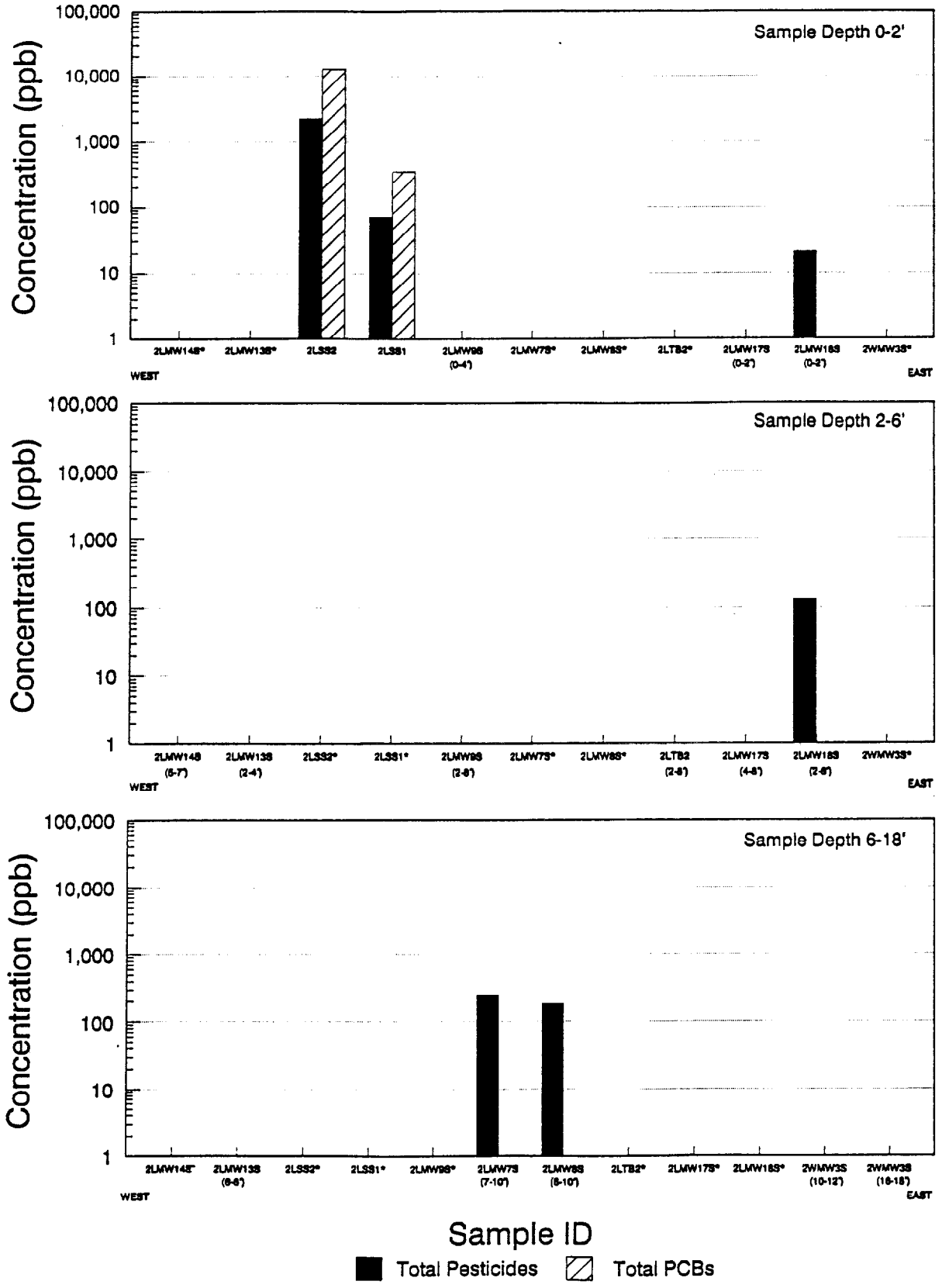
NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation.



* indicates no sample collected at this interval

FIGURE 4-17 - AREA A LANDFILL - SOIL VOC AND SVO ANALYTICAL DATA



* Indicates no sample collected at this interval

FIGURE 4-18 - AREA A LANDFILL - SOIL PESTICIDE AND PCB ANALYTICAL DATA

readings or soil staining was noted during drilling. Heavy oil staining was noted at 2LMW8S (6-10'), however, only toluene was detected at 11 ppb.

Surface soil sample 2LSS1 contained elevated levels of petroleum hydrocarbons (93,500 ppb total VOCs). Parameters detected included chlorobenzene, ethylbenzene, and xylene. This sample was collected downslope from a stained area on the pavement.

SVOs, principally PAHs, were detected at relatively low levels in some of the landfill subsurface soil samples. PAHs were not detected at sample locations 2LMW13S and 2LMW14S. The lack of PAHs and VOCs at these locations (far west end of landfill) suggest that this may be outside of the limit of the landfill, however, the boring logs do indicate fill at these locations. SVOs were present at slightly lower levels at the 0-2 feet interval, in comparison with deeper reporting intervals (Figure 4-17).

The results of the SVOs analyses at Area A landfill are significantly lower than at the DRMO and Goss Cove former landfill sites. The organic results, in general, do not indicate significant disposal of organic chemicals within the Area A landfill.

PCBs/Pesticides

Total PCB/pesticide results are shown for the various reporting intervals on Figure 4-18.

No PCBs were detected in the subsurface soils within Area A landfill. Surface soil samples 2LSS1 and 2LSS2 contained PCB Arochlor 1260 at 350 ppb and 12,000 ppb, respectively. The concentration at 2LSS2 is above the TBC concentration of 10,000 ppb. These soil samples were collected adjacent to the concrete storage pad where drum storage, PCB transformers, and electric switches were once stored. This prior use appears to be the cause of the elevated PCB levels. The potential extent of the PCBs in this area could not be defined based on the two surface soil sample locations.

Pesticides were detected at three subsurface sample locations (2LMW7S, 2LMW8S, and 2LMW18S) at Area A landfill. DDT and its derivatives, which were detected at these locations are relatively low concentrations and are below TBC values. The pesticides were detected at various sample depths. It is unclear if the source of the pesticides were the result of disposal in the landfill, or due to past applications. If associated with past applications, which has been documented within Area A, the presence at deeper depth within the landfill could be related to application at various times during the landfill operation.

The pesticide DDT (71 ppb) was present at surface soil sample 2LSS1 and DDT (2300 ppb) and endrine ketone (570 ppb) at 2LSS2. The DDT level at 2LSS2 is above the TBC value of 500 ppb.

No pesticides were detected by TCLP analysis procedures in any subsurface or surface soil sample, indicating the leachability is low.

Inorganics

Out of the 12 subsurface samples analyzed for by TCLP analysis procedures, ten contained one or more metals exceeding TBC values. Metals exceeding TBC values included arsenic, cadmium, lead, and selenium. TCLP hazardous waste characteristic values were not exceeded for any samples.

Some inorganic constituents exceeded established background levels based on mass weight analysis. These included beryllium (2LMW18S), cadmium (2LMW8S), lead (2LMW9S, 2LMW18S and 2LTB2) and mercury (2LMW17S). Other metals exceeding background levels included copper, nickel and boron. The majority of these elevated metals are likely related to a past landfill disposal.

The arsenic TCLP results are not considered significant when compared to the mass weight analysis, which did not exceed background. Based on the dilution used for the TCLP analysis, it appears that almost all arsenic is leaching from the samples and, in some cases, in excess of the amount indicated by mass weight analysis. Similar conditions exist for the cadmium and selenium TCLP results. The lead TCLP and mass weight analysis results have a higher degree of correlation.

In general, the lead and cadmium values are not indicative of the existence of a significant source such as reported historical battery acid disposal in this area. Levels of cadmium, and particularly lead, were much higher at the Former Acid Storage and Disposal Site and DRMO, where battery acid storage tanks existed. Also, test borings 2LTB1 through 2LTB7 were drilled in the western portion of the landfill to screen for past reported battery acid disposal. pH values for soil samples were determined at boring locations and were generally neutral; only samples from 2LTB2 and 2LTB7 have pH values less than 6.0 (5.5 to 6.0). However, as subsequently discussed, cadmium is present above drinking water standards in ground water below the landfill.

4.11.2 Area A Wetland

4.11.2.1 Subsurface Soil and Sediments

Thirty-three subsurface soil samples were collected from 12 test boring/monitoring well locations at the wetland site. Nine sediment samples were also collected and analyzed. The goal of the sampling and analysis program was to assess the extent of soil and sediment contamination. Previous analysis of wetlands sediments indicated the presence of VOCs, SVOs, pesticides, and metals. Sample locations are shown on Figure 4-16 and Plate 4-1. The site analytical program is summarized in Section 2.0, Tables 2-6 (soils) and 2-9 (sediments).

Subsurface soil analytical results are summarized in Tables 4-24 (organics) and 4-25 (inorganics). Sediment analytical results are summarized in Table 4-26 (organics) and 4-27 (inorganics). Figures 4-19 and 4-20 provide bar graphs of total VOC/SVO and pesticide/PCB concentrations in soil and sediments at various sample intervals. Sediment results are included within the 0-2 foot interval. All soil/sediment samples collected within the limits of the wetland

TABLE 4-24
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2WMW2S	2WMW3S	2WMW3S	2WMW4S	2WMW5S	2WMW5S	2WMW5S	2WMW5S	2WMW6S	2WTB1	2WTB1
		DEPTH (ft):	0-2	10-12	16-18	0-2	0-2	4-6	10-12	13	2-4	8-10	10-12
TCL VOLATILE ORGANICS (ppb)													
Methylene Chloride	25		ND	ND	ND	ND	ND J	2 J	ND	ND	ND	ND	ND
Acetone	--		ND	ND	70	ND	ND J	130	300 J	230	74	78 B	93 B
Carbon Disulfide	--		ND	ND	37	ND	ND J	23 X	32 X	4 J	15	13 J	17 J
2-Butanone	1000		ND	ND	ND	ND	ND J	ND	71 J	40	ND	ND	ND
Trichloroethene	5		ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		ND	ND	ND	ND	3 J	ND	ND	ND	3 J	ND	ND
Benzene	1		ND	ND	ND	ND	ND J	ND	ND	3 JX	ND	ND	ND
Total Volatile Organics					107		3	155	403	277	92	91	110
TCL SEMI-VOLATILE ORGANICS (ppb)													
Noncarcinogenic PAH													
Acenapthylene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	--		120	ND	ND	ND	130 J	ND	ND	ND	ND	ND	ND
Anthracene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	--		160	ND	3 J	ND	180 J	90 J	120 J	ND	460 J	ND	ND
Pyrene	--		150	ND	8 J	ND	320 J	83 J	120 J	ND	360 J	ND	69 J
Total Noncarcinogenic PAH			430		11		630	173	240		820		69
Probable Carcinogenic PAH													
Benzo(a)anthracene	--		83 J	ND	ND	ND	160 J	120 J	ND	ND	370 J	ND	ND
Chrysene	--		110 J	ND	ND	ND	230 J	60 J	ND	ND	330 J	ND	ND
Benzo(b)fluoranthene	--		74 JY	ND	ND	ND	180 JY	110 JY	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	--		71 JY	ND	ND	ND	120 JY	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	--		81 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Probable Carcinogenic PAH			419				690	290			700		
Phthalates													
bis(2-ethylhexyl)phthalate	--		ND	ND	ND	35 J	790	ND	290 J	1500	ND	120 J	130 J
Other Semi-Volatile Organics													
Benzoic Acid	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)													
4,4'DDE	--		ND	ND	ND	ND	ND	ND	ND	ND J	ND J	ND J	ND
4,4'DDD	--		ND	ND	ND	ND	ND	ND	ND	ND J	ND J	ND J	ND
4,4'DDT	500		ND	ND	ND	ND	ND	ND	ND	ND J	ND J	ND J	ND
PCB Aroclor-1260	10000		ND	ND	ND	50 JX	ND	ND	ND	ND J	ND J	ND J	ND
TCLP PESTICIDES (ppb)													
TCLP Pesticides	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4-24 (continued)
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2WTB1	2WTB1	2WTB2	2WTB2	2WTB2	2WTB2	2WTB2	2WTB3	2WTB3	2WTB3	2WTB3
		DEPTH (ft):	15-17	20-22	0-2	4-6	10-12	15-17	20-22	4-6	10-12	15-17	20-22
TCL VOLATILE ORGANICS (ppb)													
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	--		27 B	66 J	ND	89 B	71 B	ND	98 B	ND	350 BE	ND	ND
Carbon Disulfide	--		37 J	25 J	ND	42	32	4 J	33	23	15	16	9
2-Butanone	1000		ND	ND	ND	ND	16 J	10 J	20 J	ND	17 BJ	12 JX	ND
Trichloroethene	5		ND	12 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics			64	103		131	119	14	151	23	382	28	9
TCL SEMI-VOLATILE ORGANICS (ppb)													
Noncarcinogenic PAH													
Acenapthylene	--		ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND	ND
Phenanthrene	--		ND	85 J	ND	ND	ND J	69 J	ND	85 J	120 J	ND	67 J
Anthracene	--		ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND	ND
Fluoranthene	--		81 J	170 J	460 J	ND	ND J	110 J	72 J	130 J	170 J	68 J	120 J
Pyrene	--		120 J	270 J	380 BJ	70 BJ	ND J	130 BJ	84 BJ	250 J	370 J	99 J	190 J
Total Noncarcinogenic PAH			201	525	840	70		309	156	465	660	167	377
Probable Carcinogenic PAH													
Benzo(a)anthracene	--		ND	130 J	400 J	ND	ND J	83 J	64 J	120 J	170 J	ND	ND
Chrysene	--		ND	140 J	ND	ND	ND J	81 J	62 J	150 J	220 J	ND	ND
Benzo(b)fluoranthene	--		ND	110 JY	ND	ND	ND J	90 JY	ND	ND	190 JY	ND	ND
Benzo(k)fluoranthene	--		ND	130 JY	ND	ND	ND J	89 JY	80 JY	ND	130 JY	ND	ND
Benzo(a)pyrene	--		ND	ND	ND	ND	ND J	ND	ND	ND	180 J	ND	ND
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND	ND
Total Probable Carcinogenic PAH				510	400			343	206	270	890		
Phthalates													
bis(2-ethylhexyl)phthalate	--		180 J	ND	ND	ND	130 J	130 BJ	1700 B	510 J	280 J	210 J	ND
Other Semi-Volatile Organics													
Benzoic Acid	--		ND	ND	ND	ND	ND J	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)													
4,4'DDE	--		ND J	ND J	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'DDD	--		ND J	ND J	ND	ND	ND	ND	ND	ND	ND	ND	ND
4,4'DDT	500		ND J	ND J	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB Aroclor-1260	10000		ND J	ND J	370 JX	ND	ND	ND	ND	ND	ND	ND	ND
TCLP PESTICIDES (ppb)													
TCLP Pesticides			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4-24 (continued)
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	2WTB4 0-2	2WTB6 0-2	2WTB6 4-6	2WTB6 15-17	2WTB6 20-22	2WTB7 0-2	2WTB7 4-6	2WTB7 10-12	2WTB8 1-3	2WTB8 6-8	2WTB8 10-12
TCL VOLATILE ORGANICS (ppb)													
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	ND	4 J	ND	ND
Acetone	--		ND	540 BE	310 B	50 B	63	ND	320 EJ	ND	850 E	50	56 B
Carbon Disulfide	--		ND	6 J	6 J	10 J	27	ND	2 J	ND	8 J	15	14
2-Butanone	1000		ND	87 B	ND	13 JX	ND	ND	70 J	ND	310	ND	14 BJ
Trichloroethene	5		4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		ND	ND	ND	ND	ND	ND	ND	ND	7 J	ND	ND
Benzene	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics			4	633	316	73	90		392		1172	65	84
TCL SEMI-VOLATILE ORGANICS (ppb)													
Noncarcinogenic PAH													
Acenapthylene	--		77 J	ND	ND	ND	ND	ND	ND	ND	120 J	ND	ND
Phenanthrene	--		270 J	160 J	ND	76 J	ND	ND	62 J	ND	340 J	ND	ND
Anthracene	--		52 J	ND	ND	ND	ND	ND	ND	ND	79 J	ND	ND
Fluoranthene	--		310 J	300 J	ND	150 J	87 J	72 J	100 J	ND	600 J	110 J	120 J
Pyrene	--		460 J	270 J	60 J	180 BJ	84 BJ	98 J	140 J	ND	570 J	120 J	160 J
Total Noncarcinogenic PAH			1169	730	60	406	171	170	302		1709	230	280
Probable Carcinogenic PAH													
Benzo(a)anthracene	--		220 J	200 J	ND	120 J	67 J	ND	ND	ND	370 J	ND	ND
Chrysene	--		320 J	250 J	ND	110 J	81 J	ND	110 J	ND	600 J	ND	ND
Benzo(b)fluoranthene	--		220 JY	210 JY	ND	93 JY	ND	ND	140 JY	ND	550 JY	ND	ND
Benzo(k)fluoranthene	--		310 JY	250 JY	ND	170 JY	96 JY	ND	67 JY	ND	390 JY	ND	ND
Benzo(a)pyrene	--		230 J	190 J	ND	150 J	ND	ND	ND	ND	390 J	ND	ND
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND	ND	ND	ND	270 J	ND	ND
Total Probable Carcinogenic PAH			1300	1100		643	244		317		2570		
Phthalates													
bis(2-ethylhexyl)phthalate	--		280 J	350 J	100 J	ND	73 BJ	ND	ND	ND	1300	130 J	500 J
Other Semi-Volatile Organics													
Benzoic Acid	--		160 J	130 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)													
4,4'DDE	--		32 XJ	ND J	ND J	ND	ND	ND	ND	ND	ND	ND	ND
4,4'DDD	--		ND J	69 XJ	ND J	ND	ND	ND	ND	ND	ND	ND	ND
4,4'DDT	500		ND J	ND R	ND J	ND	ND	ND	ND	ND	ND	ND	ND
PCB Aroclor-1260	10000		ND J	ND J	ND J	ND	ND	ND	ND	ND	ND	ND	ND
TCLP PESTICIDES (ppb)													
TCLP Pesticides			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–25
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	2WMW2S 0–2	2WMW3S 10–12	2WMW3S 16–18	2WMW4S 0–2	2WMW5S 0–2	2WMW5S 4–6	2WMW5S 10–12	2WMW5S 13	2WMW6S 2–4	2WTB1 8–10	2WTB1 10–12
TAL INORGANICS (ppm)													
Aluminum	272000		13000	8300	16300	4810	11200 J	11700 J	14300 J	10500 J	14100	14500 J	12600 J
Antimony	2.95		ND J	ND J	ND	ND R	ND	ND	ND	ND	ND R	ND	ND
Arsenic	31.5		2.5	2.5	7.8	0.77 B	7 J	6.4 J	7.6 J	2.3 JB	7.7 J	6.8	9.1
Barium	1600		53.3	58.4	49.3 B	27.4 B	45.7 B	37.9 B	48.4 B	31.4 JB	45.6 BJ	43.7 B	40.8 B
Beryllium	3.52		0.55 B	0.4 B	0.92 B	ND	1.2 JB	1.6 JB	1.9 J	1.2 JB	0.57 BJ	0.52 BJ	0.5 BJ
Cadmium	7		6.9	4.1	8.5	1.2	4.7	5.4	6.6	2.7	4.5 J	ND	ND
Calcium	32300		1170 J	1630 J	3500 J	758 BJ	1230 JB	4180 J	3680 J	1190 JB	1450 BJ	5740	12900
Chromium	223		20.5 J	15.9 J	37.9 J	5.9 J	57.1	34.6	56.5	22.7	51 J	41.8	39
Cobalt	39		8.5 B	7 B	9.7 B	4.5 B	7.3 B	9.4 B	12.2 B	10.3 B	7 BJ	10.9 B	10.6 B
Copper	102		26.1 J	20.4 J	17.8 J	6.7 J	38.5	15.7	36	11.6	31.1 J	18.3 J	19.5 J
Iron	115000		14200	11400	26800	6540	21500	21600	26100	10800	28000 J	26800	26100
Lead	53.2		16.3 J	4.8 J	10.3 J	3.6 J	38.5	12	34.4 J	7	298	13.2 J	13.6 J
Magnesium	26500		4170	3560	7430	1660 J	5520	7370	7670	2910 J	5070	7740	7380
Manganese	3790		195 J	190 J	311	121	160 J	287	365	202	176 J	312 J	305 J
Mercury	0.51		ND	ND	ND	ND	0.22	ND	0.19	ND	0.41 J	ND	ND
Nickel	76.7		25.3 J	15.8 J	31.3 J	4.4 B	14.7	21	26.9	8.8 B	16.1 J	22.1	19.8
Potassium	12000		2130 J	2670 J	4280 J	1170	3180	3360	3670	1400	3010	4050	3830
Selenium	1.79		ND	ND	ND	ND J	0.7 B	ND	ND	ND	0.7 BJ	0.86 B	ND
Silver	5		ND	ND	ND	ND J	ND	ND	ND	ND	ND R	ND	ND
Sodium	51800		118 JB	252 JB	5260	152 BJ	957 JB	4470 J	3090 J	1340 J	169 BJ	4750	4410
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		33.2	21	43.3	9.8 B	48.9 J	50.1 J	59.7 J	30.5 J	42.4	39.9 J	37.6 J
Zinc	178		125 J	37.7 J	99.8 J	19.6 J	54.6 J	60.6 J	93.9 J	38.5 J	59.7 J	71 J	70.3 J
Boron	109		71	ND	2600	ND	530 J	2200	2600	250	703	2720	2820
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)													
PARAMETER	**TBC**												
Arsenic	0.05		0.22	0.21	0.23	ND	ND	0.0087	0.0024	ND	ND	0.0099	0.0096
Barium	1		0.36	0.33	0.078	0.083	ND	0.051	0.12	0.093	ND	0.12	0.12
Cadmium	0.01		0.0063	ND	ND	ND	ND	ND	ND	0.016	ND	ND	ND
Chromium	0.05		ND	ND	ND	ND	0.04 J	0.038 J	0.038 J	0.063 J	ND	0.05 J	0.047 J
Lead	0.05		ND	ND	ND	ND	ND	0.0024 J	ND	0.0056 J	1.5	ND	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		0.16 J	ND	0.16 J	ND	0.0036 J	0.0045 J	0.0043 J	0.0051 J	ND	ND	ND
Silver	0.05		0.0092 J	ND J	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4-25 (continued)
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	2WTB1 15-17	2WTB1 20-22	2WTB2 0-2	2WTB2 4-6	2WTB2 10-12	2WTB2 15-17	2WTB2 20-22	2WTB3 4-6	2WTB3 10-12	2WTB3 15-17	2WTB3 20-22
TAL INORGANICS (ppm)													
Aluminum	272000		13100 J	10600 J	14100 J	13800 J	14100 J	11800 J	11800 J	16600 J	20600 J	16800 J	12500 J
Antimony	2.95		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	31.5		7.9	6.1	6.7 J	7.1 J	ND	6.8 J	6.3 B	10.3 J	3.9 J	6.3 J	11.5 J
Barium	1600		40 B	35.9 B	52.1 B	43.3 B	44.1 B	40.4 B	37.7 B	47.9 B	44.7 B	50.9 B	39.3 B
Beryllium	3.52		0.44 JB	0.36 BJ	1.8 J	1.9 J	1.9 J	1.6 BJ	1.6	1.8 JB	1.5 JB	1.7 JB	1.5 JB
Cadmium	7		ND	ND	6.9	6.5	6.4	5.5 J	5.5	6.5 J	6.1 J	6.6 J	5.4 J
Calcium	32300		6540	5000	3300 J	4620	5090	5660	4900	4550	3620	5050	6790
Chromium	223		38.6	38.9	41.2	40.9	39.3	39.5	36.7	60.6	59.5	43	40.1
Cobalt	39		10 B	8.6 B	11.1 B	10.4 B	10.8 B	9.8 B	8.7 B	10 B	9.4 B	10.5 B	8.8 B
Copper	102		17 J	22 J	20.2	19.1	15.8	20.9	17.7	39.9	36.8	21.1	29.9
Iron	115000		24500	21400	27200	24500	25800	22300	21700	24600	21000	24400	20500
Lead	53.2		14.7 J	18.3 J	11.2 J	11.8 J	10.2	14.3 J	12.9	15.3 J	33.7	15.8 J	17.2 J
Magnesium	26500		7470	6600	7230	8660	8970	7790	7850	8520	7620	8580	7470
Manganese	3790		286 J	241 J	306	327	343	282	283	316	262	333	264
Mercury	0.51		ND	ND	ND	ND	ND	ND	ND	1.1	0.23 J	ND	ND
Nickel	76.7		19.9	10.3 B	25.9	26	25.2	21.6	21.5	28.6	24.3	26.3	32.1
Potassium	12000		3860	3340	3530	4010	4150	3520	3490	3850 J	3690 J	4490	3320 J
Selenium	1.79		0.78 B	0.83 B	ND	0.81 B	0.75 B	ND	ND	ND	ND	ND	ND
Silver	5		ND	ND	ND	4	ND	ND	ND	ND	31.8	3.1 B	ND
Sodium	51800		7380	7530	2040 J	6700 J	9970 J	8540 J	8520 J	8920	9690	9390	9210
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		36.7 J	33.3 J	57.9 J	54.7 J	58.7 J	50.3 J	51.1 J	56.8 J	49.8 J	57.5 J	46.3 J
Zinc	178		61.6 J	62.1 J	75.5 J	70.7 J	69.8 J	66.7 J	65.3 J	95.9 J	91.8 J	67.8 J	66.8 J
Boron	109		2460	2240	1600	2400	2700	2100	2000	2600	2300	2300	2200
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)													
PARAMETER	TBC												
Arsenic	0.05		0.012	0.0081	ND	ND	0.0064	0.01	0.012	0.22 J	0.35 J	0.41 J	0.26 J
Barium	1		0.13	0.097	0.67 J	0.14	0.12	0.14	0.13	ND	ND	0.046	ND
Cadmium	0.01		0.014 J	ND	0.023	0.015	0.014	0.015	0.014	ND	ND	ND	0.01
Chromium	0.05		0.049 J	0.043 J	0.075 J	0.077 J	0.045 J	0.079 J	0.066 J	ND	ND	ND	ND
Lead	0.05		ND	ND	ND	ND	0.0022 J	0.0099 J	ND	ND J	ND J	ND J	ND J
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	0.0006	0.00031	ND	ND
Selenium	0.01		ND	ND	0.0093 J	ND	0.0043 J	0.0056 J	ND	ND	0.15 J	0.23 J	0.17 J
Silver	0.05		ND	ND	ND	0.068	ND	ND	ND	0.13 J	0.38 J	0.011 J	0.0081 J

TABLE 4–25 (continued)
AREA A WETLANDS
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	2WTB4 0–2	2WTB6 0–2	2WTB6 4–6	2WTB6 15–17	2WTB6 20–22	2WTB7 0–2	2WTB7 4–6	2WTB7 10–12	2WTB8 1–3	2WTB8 6–8	2WTB8 10–12
TAL INORGANICS (ppm)													
Aluminum	272000		15300 J	16800 J	12500 J	12000 J	10500 J	13900 J	14700 J	11900 J	17900 J	13300 J	26000 J
Antimony	2.95		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	31.5		8.7	8.4	8.5	7.1 J	6.7 J	7.2 J	5.9 J	7.8 J	6.8 J	5.2 J	2.2 J
Barium	1600		61.3	60.7 B	39.2 B	41.5 B	37.3 B	49.3 B	43 B	38.7 B	93.8	42.4 B	78.8
Beryllium	3.52		ND	0.73 JB	0.44 JB	1.7 JB	1.6 JB	1.5 JB	1.6 JB	1.7 JB	1.8 JB	1.7 JB	1.9 J
Cadmium	7		ND	1.9 JB	ND	5.9 J	5	4.5	5.3	5.3	6.7 J	5.7 J	3.3 J
Calcium	32300		1250 B	1660 B	4980	4820	6380	1590 JB	4380	6930	2360	6290	2130
Chromium	223		89	101	37.7	44.9	37.8	72.7	43.7	35.3	102	43.7	39.7
Cobalt	39		8.5 B	9.4 B	10.5 B	8.8 B	9 B	7.6 B	9 B	9 B	9.2 B	10 B	ND
Copper	102		47.6 J	64.1 J	16.7 J	25.9	21.2	35.4	24	15.4	55	24.5	10.2
Iron	115000		30800	27100	24600	21600	20800	20200	21900	23600	27900	23100	8200
Lead	53.2		128 J	44 J	15.7 J	22.5	16.6	49.5 J	21.3	13.3	83.7	22.4	16 J
Magnesium	26500		6130	6540	7210	7860	7550	6580	7690	7750	7840	7660	3400 J
Manganese	3790		188 J	202 J	288 J	276	271	189	267	310	233	300	142
Mercury	0.51		0.69 J	ND	ND	ND	ND	0.38	ND	ND	0.67 J	ND	ND
Nickel	76.7		16.7	20.2	20	22.6	20.7	16.8	21	21.2	26.9	23.5	13.7
Potassium	12000		4320	3680	3730	3590	3320	2680	3390	3470	4040 J	3410 J	2120 J
Selenium	1.79		1.2 B	1.5 B	0.75 B	0.79 B	0.74 B	ND	ND	ND	0.93 BJ	ND	0.72 JB
Silver	5		ND	ND	ND	3.7	ND	ND	ND	ND	4.5	6.6	ND
Sodium	51800		232 JB	1570 JB	6240	9010 J	8810 J	1310 BJ	5650 J	4920 J	3150	5250	2380 J
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		50.5 J	52 J	36 J	51.7 J	49.4 J	56.9 J	53 J	54 J	75 J	53.9 J	41.8 J
Zinc	178		60.8 J	74.9 J	64.8 J	69.6 J	61.5 J	59.5 J	66.2 J	61.7 J	62.9 J	71.5 J	44.8 J
Boron	109		672	563 J	2440	2000	2100	170 J	1700	2400	330	2200	160
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)													
PARAMETER	TBC												
Arsenic	0.05		ND	0.006	0.009	ND	0.012	ND	0.007	0.005	0.17 J	0.23 J	0.21 J
Barium	1		0.075 J	0.12	0.11	0.12	0.14	0.13 J	0.043	0.044	0.21	0.24	0.052
Cadmium	0.01		ND	0.016 J	0.014 J	0.016	0.015	0.015	0.014	0.016	ND	ND	0.008
Chromium	0.05		0.047 J	0.054 J	0.053 J	0.065 J	0.075 J	0.043 J	0.039 J	0.04 J	ND	ND	ND
Lead	0.05		ND	0.018 J	ND	ND	ND	ND	0.017 J	0.019 J	ND J	ND J	ND J
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	0.004 J	0.006 J	0.005 J	ND	ND	0.13 J
Silver	0.05		ND	0.07 J	ND	0.067	ND	ND	ND	ND	ND J	0.092 J	0.11 J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Sections 4.2 and 4.3 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

TABLE 4–26
AREA A WETLANDS
SUMMARY OF SEDIMENT ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2WSD1	2WSD2	2WSD3	2WSD4	2WSD5	2WSD6	2WSD7	2WSD8	2WSD9
TCL VOLATILE ORGANICS (ppb)											
Methylene Chloride	25		ND	ND	ND	10 J	3 J	10 J	ND	2 J	5 J
Acetone	--		210	130	230	ND	ND	240	720	190	ND
Carbon Disulfide	--		11	16	18 J	ND	ND	9 J	ND	15	ND
2-Butanone	1000		140 J	100	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5		ND	ND	ND	11 J	3 J	ND	ND	ND	6 J
Tetrachloroethene	5		ND	ND	ND	16 J	4 J	10 J	ND	ND	11 J
Total Volatile Organics			361	246	248	37	10	269	720	207	22
TCL SEMI-VOLATILE ORGANICS (ppb)											
Noncarcinogenic PAH											
Fluorene	--		ND	ND	ND	ND	ND	ND	ND	ND	1000 J
Phenanthrene	--		ND	ND	ND	ND	ND	ND	ND	440 J	36000
Anthracene	--		ND	ND	ND	ND	ND	ND	ND	ND	2400 J
Fluoranthene	--		970 J	ND	390 J	410 J	ND	ND	470 J	1300 J	80000
Pyrene	--		1300 J	ND	670 J	460 J	ND	470 J	610 J	1500 J	42000 J
Total Noncarcinogenic PAH			2270		1060	870		470	1080	3240	161400
Probable Carcinogenic PAH											
Benzo(a)anthracene	--		670 J	ND	ND	ND	ND	ND	ND	ND	27000
Chrysene	--		630 J	ND	ND	ND	ND	ND	ND	610 J	42000
Benzo(b)fluoranthene	--		380 JY	ND	ND	ND	ND	ND	ND	420 JY	55000 Y
Benzo(k)fluoranthene	--		480 JY	ND	ND	ND	ND	ND	ND	670 JY	45000 Y
Benzo(a)pyrene	--		ND	ND	ND	ND	ND	ND	ND	ND	35000
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND	ND	ND	ND	23000
Benzo(g,h,i)perylene	--		ND	ND	ND	ND	ND	ND	ND	ND	23000
Total Probable Carcinogenic PAH			2160							1700	250000
Other Semi-Volitile Organics											
Benzoic Acid	--		ND	ND	ND	ND	ND	ND	780 J	ND	ND
Dibenzofuran	--		ND	ND	ND	ND	ND	ND	ND	ND	1000 J
TCL PESTICIDES/PCBs (ppb)											
44'DDE	--		36 XJ	40 XJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J
44'DDD	--		140 XJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J
44'DDT	500		ND J	ND J	57 XJ	ND J	ND J	ND J	ND J	ND J	ND J
TCLP PESTICIDES (ppb)											
TCLP Pesticides	--		ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–27
AREA A WETLANDS
SUMMARY OF SEDIMENT ANALYTICAL DATA (INORGANICS)

PARAMETER	BACKGROUND	SAMPLE ID:	2WSD1	2WSD2	2WSD3	2WSD4	2WSD5	2WSD6	2WSD7	2WSD8	2WSD9
TAL INORGANICS (ppm)											
Aluminum	272000		18900	22200	18800	16600	14200	19300	17800	18300	20800
Antimony	2.95		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		9.2 J	9.5 J	9.5 J	10 J	8.5 J	10.5 J	13.9 J	8.1 J	11.8 J
Barium	1600		55.6 B	64.6 B	56.6 B	56 B	53.6 B	59.9 B	59.7 B	64 B	72.8 B
Beryllium	3.52		0.91 B	1.1 B	0.88 B	0.44 B	0.39 B	0.81 B	0.51 B	0.84 B	0.85 B
Cadmium	7		4.2	4.8	5.3	3.8	3.7	3.5	3.5	5	6.1
Calcium	32300		4670	4930	4220	1480 B	1090 BJ	2090	1830 B	6800	2160
Chromium	223		57.1	48.9	92.6	73.9	71.7	93.5	69.3	95.7	63.7
Cobalt	39		10.8 B	11.9 B	11.1 B	7.3 B	6.8 B	8.4 B	7.6 B	10.2 B	8.6 B
Copper	102		33 J	30.5 J	69.5 J	44.8 J	52.2 J	51.3 J	34.6 J	71.5	39.6 J
Iron	115000		28100	31700	29700	26700	28300	22900	24100	25500	44000
Lead	53.2		51	21.3 J	46.1	56.8	48.1	69	37.8	69.2	241 J
Magnesium	26500		7630	7870	7990	5950	5550	6700	6060	7300	5880
Manganese	3790		352	365	341	193	166	210	193	278	357
Mercury	0.51		ND J	ND J	0.31 J	0.25 J	0.35 J	0.32 J	0.42 J	0.48 J	0.24 J
Nickel	76.7		26	28.2	27	17.8	16.7	19.9	17.6	24.2	21.2
Potassium	12000		4390	4920	4280	4560	4160	3980	3790	4070	3310
Selenium	1.79		0.89 B	1.6 B	1.3 B	0.79 B	0.98 B	1.1 B	1.6 B	1.2 B	1.3 B
Silver	5		ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J
Sodium	51800		3510	3290	6090	383 BJ	291 BJ	1150 BJ	464 BJ	6650	321 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		44.5	49.3	45.5	45.4	44.6	49.3	44.8	41	55.9
Zinc	178		90.6	126	127	63.2 J	58.1 J	57.6 J	51.5 J	124	109
Boron	109		4100	4000	4400	1200	1300	730	450	3600	490
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	3.2
TCLP METALS (ppm)											
PARAMETER	**TBC**										
Arsenic	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1		0.059	0.039	0.025	ND	ND	0.027	0.029	0.053	0.14
Cadmium	0.01		0.0023	0.0036	ND	0.0029	ND	ND	0.0036	ND	0.011
Chromium	0.05		0.007	0.035	0.0073	0.01	0.0073	0.013	0.01	0.019	0.01
Lead	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND	0.11	ND
Silver	0.05		0.007 J	0.012 J	ND R	ND R	0.0081 J	ND R	0.016 J	0.013 J	ND R

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Sections 4.2 and 4.3 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

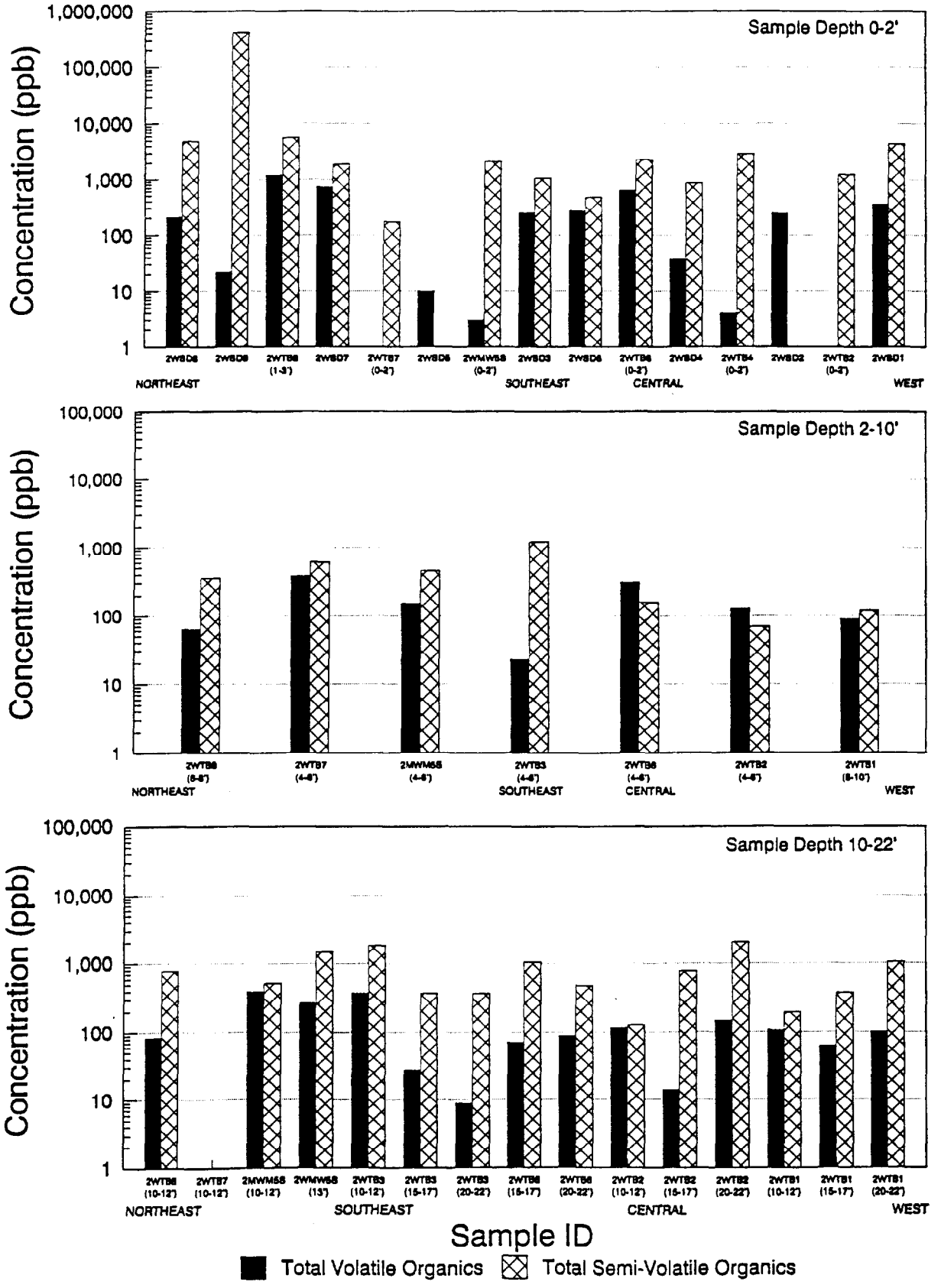


FIGURE 4-19 - AREA A WETLAND - SOIL VOC AND SVO ANALYTICAL DATA

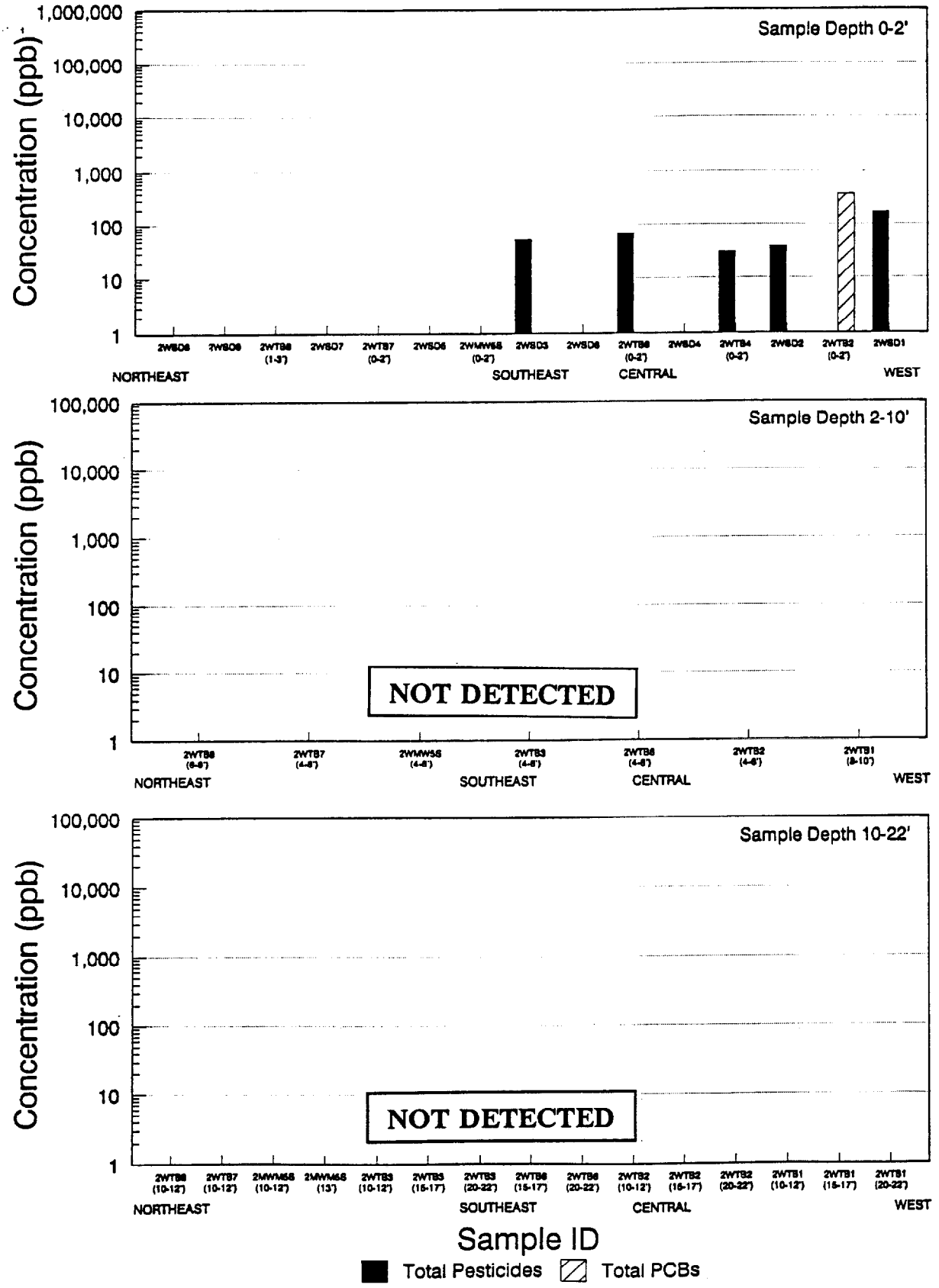


FIGURE 4-20 - AREA A WETLAND - SOIL PESTICIDE AND PCB ANALYTICAL DATA

were at or below the ground water table. The depth of the dredge sediment is fully described in Section 3.0, but generally are 10-15 feet at the northeast portion, extending deeper along the south near the landfill to 25-35 feet. All samples for analysis were collected from the dredged sediment materials.

Volatile Organics

VOC concentrations in the subsurface soil and sediment within Area A wetland are in the low to moderate range. Inspection of the bar graphs for the various sample reporting intervals indicates VOCs are generally spatially distributed throughout the wetland area and generally present at uniform concentrations with depth. This is consistent with the origin of the sediments from the Thames River dredge materials deposited in the wetland. Selected VOCs detected include methylene chloride (7 of 42 sample locations), trichloroethene (5 of 42), 2-butanone (methyl ethyl ketone 14 of 42), tetrachloroethene (7 of 42), and benzene (1 of 42). VOC TBCs exceeded included 2WMW5S (benzene), 2WTB1 (trichloroethene), 2WTB8 (tetrachloroethene), 2WSD4 (trichloroethene, tetrachloroethene), 2WSD6 (tetrachloroethene) and 2WSD9 (trichloroethene, tetrachloroethene).

The source of the VOCs in the wetlands subsurface soils (2WTB1 (20-22') and 2WMW5S (13')) would appear to be associated with sediments originally contained from the Thames River, and/or absorption of ground water chemicals onto the sediments.

The source of the VOCs in the sediments could be from several sources including that mentioned above, runoff from the Weapons Center (2WSD9 and 2WSD6), and general urban runoff. The samples collected near the landfill (2WSD1, 2WSD2) did not contain any VOCs above TBC values.

Semi-Volatile Organics

SVOs, principally PAHs, were detected at generally low levels in most of the wetland sediment and subsurface samples. Overall SVO concentrations were slightly higher in the 0-2 and 10-22 feet reporting intervals, although this may be attributable to the smaller number of samples collected in the 2-10 foot interval. The highest concentration of SVOs was detected at 2WSD9 (412,400 ppb). This sample was collected within a drainage swale at the stormwater discharge location of the Weapons Center. The Verification Study (Wehran, 1988) sediment sampling of another storm water culvert discharge location near the Weapons Center also indicated the presence of PAHs. Sediment samples recently collected from the Thames River also contain low levels of PAHs (Navy, 1991).

PCBs/Pesticides

PCBs (Arochlor 1260) were detected at only two sample locations, 2WTB2 (0-2') and 2WMW4S (0-2'), at respective concentrations of 370 ppb and 50 ppb, below the TBC value. The source of the PCBs at 2WTB2 appears related to transport of contaminated surface soils from Area A landfill. Sample 2WMW4S was collected from the Weapons Center.

Pesticides (DDT and residual compounds) were detected at five sample locations in the 0-2 foot reporting interval. Based on detection in the 0-2 foot interval, these appear to be related to past reported surface application of pesticides at the wetland area. As subsequently discussed, the pesticide detections were less frequent and the concentrations much less than for the samples from the Area A watercourses. This may be related to the potential for higher concentration of pesticides present at locations not sampled (pesticide bricks were reportedly applied at point locations), and/or due to compositing of the samples. This may be supported by previous sediment sampling (Wehran, 1988) conducted in the wetland reported in Section 1.0. A sample location within the wetland near its outlet and at an upgradient location (east side), contained DDT in the 17,000 ppb range. Alternatively, it could indicate a more substantial application of pesticides in the downstream watercourse area.

Figure 4-21 illustrates concentrations of pesticides in the surface soil and sediments in Area A.

Inorganics

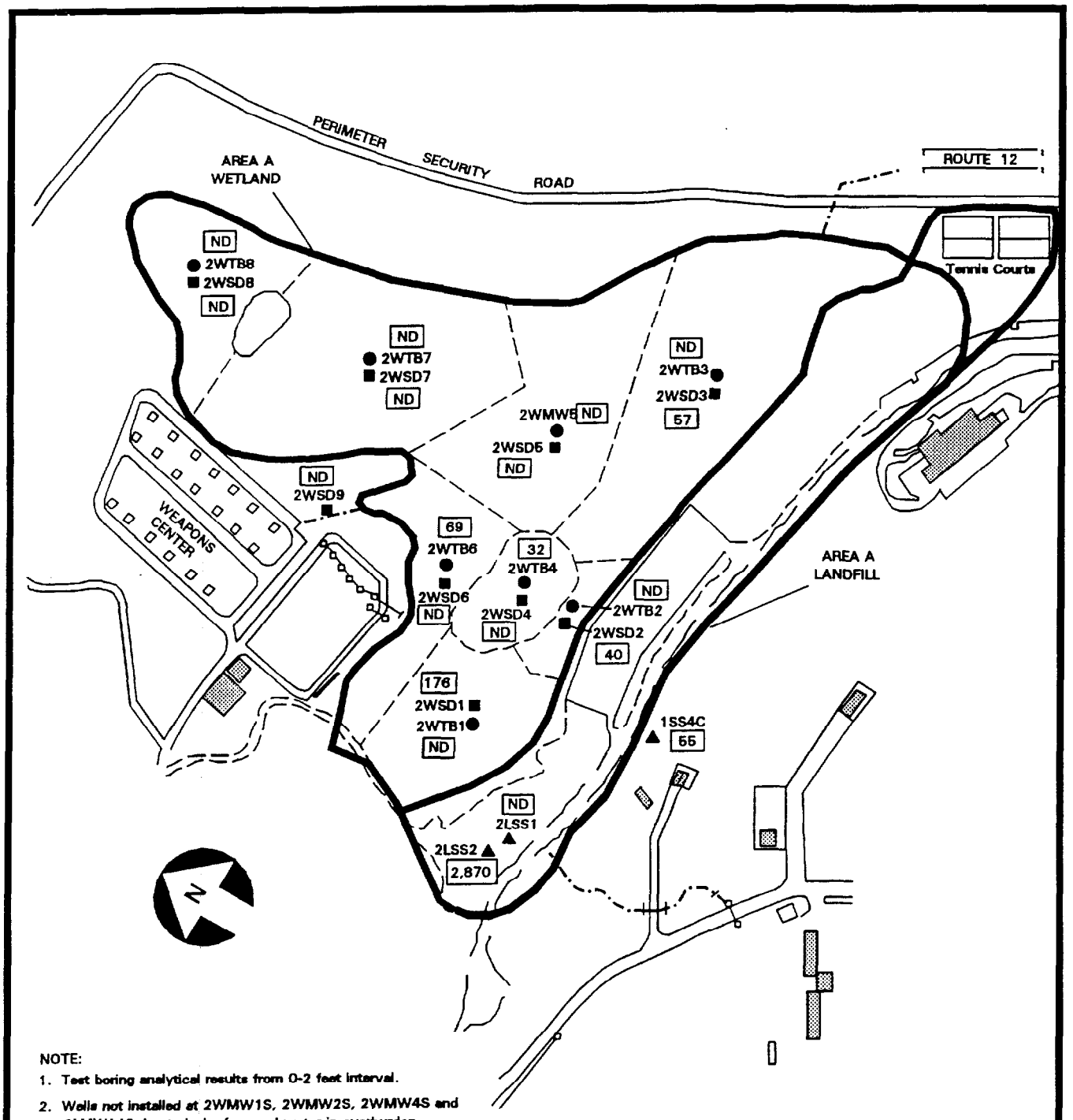
In general, metal concentrations within the wetland subsurface soil and sediment samples were low. A total of 35 soil and sediment samples were collected within the wetland proper, with the remainder collected at adjacent locations. Several samples contained slightly elevated levels of lead (7), mercury (3), cadmium (1), and silver (2). Boron was consistently above established background levels, but this is attributable to the origin of the sediments from the Thames River; salt water contains high concentrations of boron.

Several samples exceeded TBC values based on TCLP extraction analysis. These included arsenic, cadmium, chromium, lead, selenium, and silver. Only two samples (2WMW6S-lead, 2WTB3-silver) had metal values which exceeded both established background concentrations and TBC values based on TCLP analysis. Sample 2WMW6S (2-4') is located adjacent to the Weapons Center, and the lead concentrations were high. Cyanide was detected at 2WSD9 (3.2 ppm), at the drainage outlet from the Weapons Center. The previous verification study also reported a cyanide value of 2.53 ppm, at another surface water discharge location from the Weapons Center. These detections of cyanide, and the elevated PAHs at 2WSD9, suggest a possible source of contaminants at the Weapons Center. The elevated levels of cyanide and PAHs suggest that spent Otto fuel may be the cause of this contamination, however, the specific source is unknown.

4.11.3 Area A Downstream/OBDA

4.11.3.1 Subsurface Soil

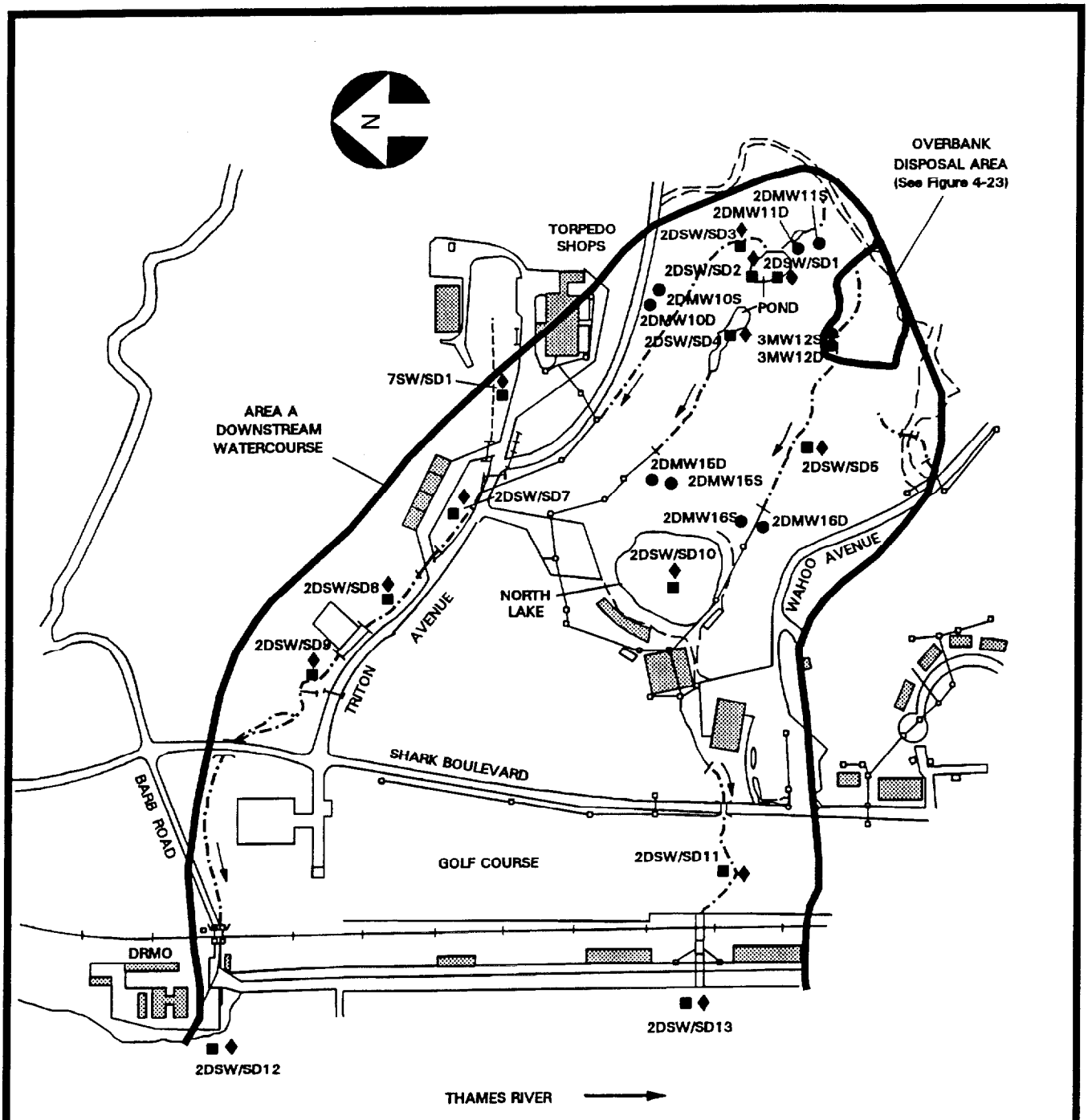
Sample locations are shown on Figure 4-22 and Plate 4-1. Five subsurface soil samples were collected from five monitoring well locations. The soil sampling was conducted at well locations which were in wooded undeveloped areas where no past disposal was reported or apparent. The exception was 3MW12S, which was located adjacent to the wetland at the Over Bank Disposal Area, where past disposal is evident, as previously discussed. The site subsurface analytical program is summarized in Section 2.0, Table 2-7.



NOTE:

1. Test boring analytical results from 0-2 feet interval.
2. Wells not installed at 2WMW1S, 2WMW2S, 2WMW4S and 2LMW14S due to lack of ground water in overburden.
3. Sediment sample locations are approximate. See Plate 4-1 for specific sample locations.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ● TB1 - Test Boring ■ SD1 - Sediment Sample ▲ SS1 - Surface Soil Sample 57 - Total Pesticides (ppb) ND - Indicates Not Detected - Building - Watercourse Approximate Scale 0 200'	FIGURE 4-21 TOTAL PESTICIDES SEDIMENT AND SURFACE SOILS AREA A LANDFILL AND WETLAND ATLANTIC ENVIRONMENTAL SERVICES, INC



NOTE:
1. Wells not installed at 2DMW10S and 2DMW15S due to lack of ground water in overburden.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ● MW1 - Monitoring Well ■ SD1 - Sediment Sample ♦ SW1 - Surface Water Sample	▒ - Building —·—·— - Watercourse Approximate Scale 0 200'	FIGURE 4-22 FIELD SAMPLING PLAN AREA A DOWNSTREAM WATERCOURSE ATLANTIC ENVIRONMENTAL SERVICES, INC

Subsurface soil analytical results are summarized in Tables 4-28 (organics) and 4-29 (inorganics).

Volatile Organics

No VOCs were detected at 2DMW11S and 2DMW16S. Trichloroethene (24 ppb) and tetrachloroethene (58 ppb) were detected at 2DMW15S, both of which are above TBC values of 5 ppb. Low levels of toluene and 1,1-dichloroethene were also detected. The compound 2-butanone (methyl ethyl ketone) was detected at 2DMW12S (0-3'), which is adjacent to the OBDA site. This compound was also detected at consistent concentrations at several sediment samples within OBDA.

The source of the solvents detected at 2DMW15S, located near North Lake, is unknown. One possibility is an unconfirmed report from a retired Navy employee who stated that there was a past disposal area in this general vicinity. This could not be confirmed based on reviews of aerial photographs and discussions with other Navy personnel.

Semi-Volatile Organics

No SVO compounds were detected at 2DMW10S, 2DMW11S, 2DMW15S, or 2DMW16S, except for low levels of phthalates at 2DMW11S. Low levels of SVOs (413 ppb), principally PAHs, were present at 3MW12S (0-3'). The detection of SVOs at 3MW12S (0-3') correlates with SVOs detected in the sediment samples at OBDA, which are subsequently discussed.

PCBs/Pesticides

No PCBs were detected in the subsurface sample points. Pesticides, DDT and its derivatives, were detected at 3MW12S (0-3')(112 ppb) and 2DMW16S (102 ppb). The detection of pesticides at these locations appears related to past pesticide application in Area A; the presence at the 2-4' interval at 2DMW16 may indicate that this area (next to North Lake) was regraded at one time.

Inorganics

Arsenic and selenium were detected above TBC values based on TCLP analysis at 2DMW11S and 3MW12S, both of which are adjacent to OBDA. These values appear anomalous when compared to concentrations by mass analysis which were well below background levels for arsenic and for selenium, which was not detected. The arsenic TCLP results did not correlate with the mass weight analyses when the dilution constant is considered. Lead exceeded TBC values for sample 2DMW16S. Comparison with mass weight analysis indicated that the lead concentrations were below background concentrations.

TABLE 4–28
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	2DMW10S 3–5	2DMW11S 2–4	3MW12S 0–3	2DMW15S 2–4	2DMW16S 2–4
TCL VOLATILE ORGANICS (ppb)							
Acetone	--		ND	ND	ND	79 J	ND
Carbon Disulfide	--		ND	ND	ND	7 J	ND
1,1–Dichloroethene	--		ND	ND	ND	16 BJ	ND
2–Butanone	1000		ND	ND	32	ND	ND
Trichloroethene	5		6 J	ND	ND	24 J	ND
Tetrachloroethene	5		ND	ND	ND	58 J	ND
Toluene	1000		ND	ND	ND	100 J	ND
Total Volatile Organics			6		32	284	
TCL SEMI–VOLATILE ORGANICS (ppb)							
Noncarcinogenic PAH							
Fluoranthene	--		ND	ND	67 J	ND	ND
Pyrene	--		ND	ND	54 J	ND	ND
Total Noncarcinogenic PAH					121		
Probable Carcinogenic PAH							
Benzo(k)fluoranthene	--		ND	ND	50 JY	ND	ND
Total Probable Carcinogenic PAH					50		
Phthalates							
bis(2–ethylhexyl)phthalate	--		ND	140 J	160 JX	ND	ND
Other Semi–Volatile Organics							
Benzoic Acid	--		ND	ND	82 J	ND	ND
TCL PESTICIDES/PCBs (ppb)							
4,4'DDE	--		ND	ND	27 X	ND	28 JX
4,4'DDD	--		ND	ND	61 JX	ND	ND
4,4'DDT	500		ND	ND	24 JX	ND	74 JX
TCLP PESTICIDES (ppb)							
TCLP Pesticides	--		NA	NA	ND	NA	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected for volatile organics and semi–volatile organics are listed above, all others were not detected.

TABLE 4–29
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	2DMW10S 3–5	2DMW11S 2–4	3MW12S 0–3	2DMW15S 2–4	2DMW16S 2–4
TAL INORGANICS (ppm)							
Aluminum	272000		15500	17000 J	14000 J	26200	4080
Antimony	2.95		ND R	ND	ND	ND R	ND R
Arsenic	31.5		2.5	2.2 JB	2.6 JB	3.1	0.58 B
Barium	16000		58.7	31.4 B	70.6	56	23.1 B
Beryllium	3.52		0.42 B	0.75 JB	0.52 JB	0.72 B	ND
Cadmium	7		1.8	5 J	5.1 J	2.4	ND
Calcium	32300		978 JB	865 JB	2590 J	706 JB	534 JB
Chromium	223		23.6 J	21.9	27.9	28.6 J	6.5 J
Cobalt	39		8.3 B	6.1 B	ND	13.4	ND
Copper	102		22.6 J	12.2 J	11.8 J	14.3 J	11.9 J
Iron	115000		19800	16100	12000	22600	7220
Lead	53.2		5.1 J	15.1 J	17.8 J	7.5 J	28.1 J
Magnesium	26500		4420	2880	3510	3920	1300
Manganese	3790		283 J	94.6 J	255 J	232 J	105 J
Mercury	0.51		ND J	ND	ND	ND J	ND J
Nickel	76.7		11.3	14.3	16.4	13.4	4.4 B
Potassium	12000		2340	323 JB	884 JB	724 B	1010 B
Selenium	1.79		ND	ND	ND	ND	ND
Silver	5		ND	ND	ND	ND	ND
Sodium	51800		141 JB	318 JB	630 JB	102 JB	92.2 JB
Thallium	5		ND	ND	ND	ND	ND
Vanadium	271		38.1	31.5 J	31.3 J	49.1	15.3
Zinc	178		47.2 J	82.1 J	83.8 J	39 J	27.2 J
Boron	109		47	ND	300	46	41
Cyanide	--		ND	ND	ND	ND	ND
TCLP METALS (ppm)							
PARAMETER	**TBC**						
Arsenic	0.05		ND	0.21 J	0.19 J	ND	ND
Barium	1		0.21	0.35	0.25	0.34	0.19
Cadmium	0.01		ND	ND	ND	ND	ND
Chromium	0.05		ND	ND	ND	ND	ND
Lead	0.05		ND	ND J	ND J	ND	0.1
Mercury	0.002		ND	ND	ND	ND	ND
Selenium	0.01		ND	0.13 J	0.13 J	ND	ND
Silver	0.05		0.0084 J	ND J	ND J	ND J	ND J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

4.11.3.2 Sediments

Twenty-three sediment samples were collected for analysis from the OBDA wetland, and the Area A downstream watercourses and associated ponds. Sediment sample locations are indicated on Figures 4-22 and 4-23 (OBDA), and Plate 4-1. The samples were collected from 18 sample locations; they included five sample locations at OBDA from which two sediment samples were collected at each location (0-6", 12-18"). The purpose of the sediment sampling and analysis programs was to assess the extent of sediment contamination (principally pesticides) within this area, due to past application and sediment transport from potential source areas. Previous analysis of sediments in this area indicated the presence of pesticides and metals. The site analytical program for sediments is summarized in Section 2.0, Table 2-9. The sediment sample from the Torpedo Shop (7SD1) is included in the discussion in this section because it is part of the downstream watercourses system.

Sediment analytical results are summarized in Tables 4-30 (organics) and 4-31 (inorganics).

Volatile Organics

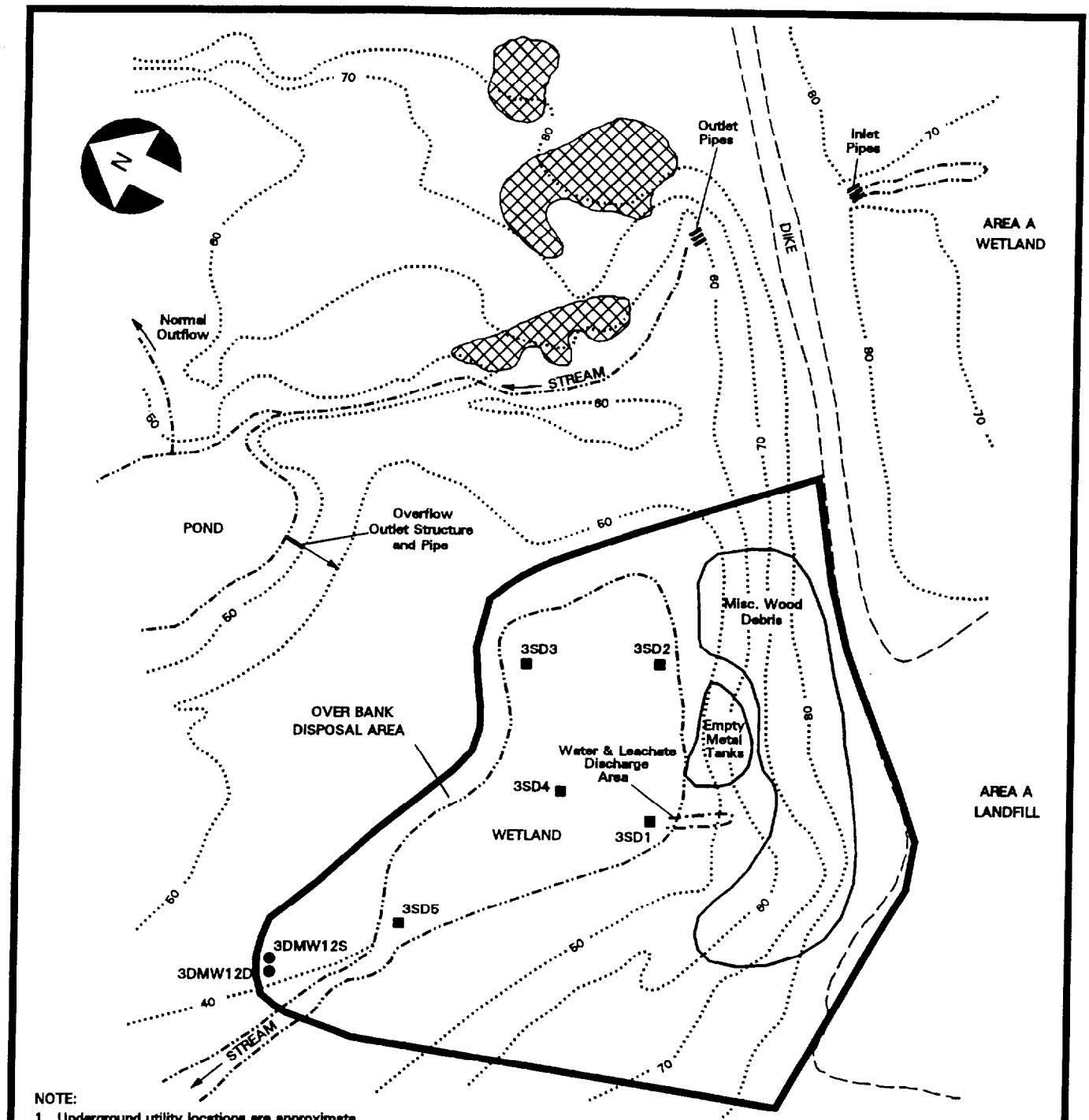
No VOCs were detected above TBC values for samples collected from the downstream watercourse sediments. At sample locations 2DSD2 and 2DSD3, low levels of VOCs (methylene chloride, trichloroethene) were detected; these sample points are closest to the outlet of the Area A wetland discharge culverts. This indicates some limited migration of VOCs via sediment transport from Area A wetland. Within OBDA, all sediment samples contained low levels of VOCs, but below TBC values. VOCs detected include methylene chloride, 2-butanone (methyl ethyl ketone), tetrachloroethene, toluene, ethylbenzene, and xylene. This indicates that some past releases of solvents and petroleum hydrocarbons occurred at the OBDA site.

Semi-Volatile Organics

Low to moderate levels of SVOs were detected in most sediment samples. No PAHs were detected in the samples (2DSD1,2,3) directly downstream of the wetland discharge culvert. Nitroaniline was detected at 3100 ppb at 2DSD2. This compound is associated with dyes. PAHs were present in sediment samples on the north side of Triton Road, including 7SD1 at the Torpedo Shop. PAHs were also present in some samples from OBDA and in the stream discharging from this wetland extending to the Thames River. The highest level of SVOs were detected at 2DSD11, collected adjacent to Shark Boulevard, which may be associated with road runoff.

Pesticides/PCBs

The only detection of PCBs was at 2DSD12, which is at the outlet of the downstream watercourse, at the Thames River, adjacent to DRMO. Based on the elevated levels of PCBs at the DRMO site, it appears likely that this is associated with the DRMO site and not Area A. This is further discussed in Section 4.12.



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

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 4-23 FIELD SAMPLING PLAN OVER BANK DISPOSAL AREA
	··· 95 ··· - Existing Grade - Exposed Bedrock ● MW1 - Monitoring Well ■ SD1 - Sediment Sample	- Building - Watercourse Approximate Scale 0 20 40'	ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4-30
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2DSD1	2DSD2	2DSD3	2DSD4	2DSD5	2DSD7	2DSD8
TCL VOLATILE ORGANICS (ppb)									
Methylene Chloride	25		ND	5 J	3 J	ND	ND J	ND	ND
Carbon Disulfide	--		ND	4 J	ND	ND	5 J	2 J	ND
Trichloroethene	5		ND	3 J	ND	ND	ND	ND	ND
Total Volatile Organics				12	3		5	2	
TCL SEMI-VOLATILE ORGANICS (ppb)									
Noncarcinogenic PAH									
Acenaphthylene	--		ND	ND	ND	ND	ND	ND	ND
Acenaphthene	--		ND	ND	ND	ND	ND	ND	ND
Fluorene	--		ND	ND	ND	ND	ND	ND	ND
Phenanthrene	--		ND	ND	ND	130 J	210 J	980 J	ND
Anthracene	--		ND	ND	ND	ND	ND	ND	ND
Fluoranthene	--		ND	ND	ND	97 J	280 J	1000 J	ND
Pyrene	--		ND	ND	ND	190 J	380 J	810 J	1200 J
Total Noncarcinogenic PAH						417	870	2790	1200
Probable Carcinogenic PAH									
Benzo(a)anthracene	--		ND	ND	ND	ND	130 J	ND	ND
Chrysene	--		ND	ND	ND	ND	170 J	ND	1200 J
Benzo(b)fluoranthene	--		ND	ND	ND	ND	140 JY	ND	ND
Benzo(k)fluoranthene	--		ND	ND	ND	ND	110 JY	ND	ND
Benzo(a)pyrene	--		ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	--		ND	ND	ND	ND	ND	ND	ND
Total Probable Carcinogenic PAH							550		1200
Other Semi-Volatile Organics									
Benzoic Acid	--		ND	ND	ND	160 J	ND	ND	ND
4-Chloroaniline	--		ND	ND	ND	ND	ND	510 J	ND
2-Nitroaniline	--		ND	3100 J	ND	ND	ND	ND	ND
Dibenzofuran	--		ND	ND	ND	ND	ND	ND	ND
4,6-Dinitro-2-Methylphenol	--		ND	6200 J	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)									
44'DDE	--		6300 XJ	3100 XJ	1500 XJ	28000 DJ	17 JX	170 JX	350 XDJ
44'DDD	--		23000 XJ	90000 XDJ	18000 XDJ	1700000 DJ	1000 JX	3300 DJ	14000 XDJ
44'DDT	500		ND	1400 XDJ	60 XDJ	240000 DJ	29 JX	1400 DJ	610 DJ
Aroclor - 1260	10000		ND	ND	ND	ND	ND	ND	ND
TCLP PESTICIDES (ppb)									
TCLP Pesticides	--		ND	ND	ND	ND	ND	ND	ND

TABLE 4-30 (continued)
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	2DSD9	2DSD10	2DSD11	2DSD12	2DSD13	7SD1
TCL VOLATILE ORGANICS (ppb)								
Methylene Chloride	25		ND	ND	ND	ND	ND J	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND
Trichloroethene	5		ND	ND	ND	ND	ND	ND
Total Volatile Organics								
TCL SEMI-VOLATILE ORGANICS (ppb)								
Noncarcinogenic PAH								
Acenaphthylene	--		ND	ND	150 J	71 J	65 J	ND
Acenaphthene	--		ND	ND	41 JX	ND	ND	ND
Fluorene	--		ND	ND	130 J	ND	51 J	ND
Phenanthrene	--		160 J	ND	1600 J	270 J	500 J	140 J
Anthracene	--		ND	ND	160 J	68 J	91 J	ND
Fluoranthene	--		340 J	68 J	1300 J	590 J	750	210 J
Pyrene	--		560	64 J	4700 J	2700 J	640	200 J
Total Noncarcinogenic PAH			1060	132	8081	3699	2097	550
Probable Carcinogenic PAH								
Benzo(a)anthracene	--		230 J	ND	780 J	700 J	430	84 J
Chrysene	--		220 J	ND	950 J	540 J	420	110 J
Benzo(b)fluoranthene	--		340 JY	47 J	520 Y	500 Y	320 JY	ND
Benzo(k)fluoranthene	--		110 JY	ND	300 JY	170 JY	320 JY	ND
Benzo(a)pyrene	--		180 J	ND	640 J	410 J	310 J	ND
Indeno(1,2,3-cd)pyrene	--		ND	ND	1200 J	750 J	110 J	ND
Benzo(g,h,i)perylene	--		ND	ND	1200 J	730 J	ND	ND
Total Probable Carcinogenic PAH			1080	47	5590	3800	1910	194
Other Semi-Volatile Organics								
Benzoic Acid	--		ND	ND	46	91 J	ND	ND
4-Chloroaniline	--		ND	ND	ND	ND	ND	ND
2-Nitroaniline	--		ND	ND	ND	ND	ND	ND
Dibenzofuran	--		ND	ND	ND	ND	ND	ND
4,6-Dinitro-2-Methylphenol	--		ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)								
44'DDE	--		ND	ND	120 J	ND	ND	ND
44'DDD	--		12000 D	ND	ND	ND	ND	ND
44'DDT	500		7000 DJ	ND	ND	68 J	120 XJ	ND
Aroclor - 1260	10000		ND	ND	ND	280 XJ	ND	ND
TCLP PESTICIDES (ppb)								
TCLP Pesticides	--		ND	ND	ND	ND	ND	NA

TABLE 4-30 (continued)
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (in):	3SD1 0-6	3SD1 12-18	3SD2 0-6	3SD2 12-18	3SD3 0-6	3SD3 12-18	3SD4 0-6	3SD4 12-18	3SD5 0-6	3SD5 12-18
TCL VOLATILE ORGANICS (ppb)												
Methylene Chloride	25		2 J	ND	ND	ND J	ND	ND	ND	ND	ND	ND
Acetone	--		ND	ND	ND	ND	150	210	310	140	54	130
Carbon Disulfide	--		ND	ND	ND	ND	3 J	4 J	ND	ND	2 J	11 J
2-Butanone	1000		ND	6 J	4 J	6 J	32	51	66	33	13 J	24
Tetrachloroethene	5		ND	ND	ND	ND	ND	ND	ND	ND	4 J	ND
Toluene	1000		ND	ND	ND	ND	ND	ND	4 J	ND	ND	ND
Ethylbenzene	--		ND	ND	ND	ND	2 J	ND	ND	ND	ND	ND
Xylene (total)	--		ND	ND	ND	ND	3 JY	ND	ND	ND	ND	ND
Total Volatile Organics			2	6	4	6	190	265	380	173	73	165
TCL SEMI-VOLATILE ORGANICS (ppb)												
Noncarcinogenic PAH												
Naphthalene	--		80 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	--		140 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	--		180 J	ND	ND	ND	ND	ND	ND	ND	ND	200 J
Phenanthrene	--		1300 J	ND	ND	ND	ND	ND	ND	ND	ND	1600 J
Anthracene	--		330 J	ND	ND	ND	ND	ND	ND	ND	ND	390 J
Fluoranthene	--		1400	110 J	73 J	ND	ND	ND	1300 J	970 J	ND	1500 J
Pyrene	--		1400 J	140 J	170 J	ND	ND	ND	1300 J	1100 J	ND	1300 J
Total Noncarcinogenic PAH			4830	250	243				2600	2070		4990
Probable Carcinogenic PAH												
Benzo(a)anthracene	--		850 J	ND	45 J	ND	ND	ND	ND	ND	ND	720 J
Chrysene	--		700 J	ND	75 J	ND	ND	ND	ND	ND	ND	720 J
Benzo(b)fluoranthene	--		750 JY	ND	86 J	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	--		290 JY	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	--		520 J	ND	ND	ND	ND	ND	ND	ND	ND	590 J
Indeno(1,2,3-cd)pyrene	--		360 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	--		260 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Probable Carcinogenic PAH			3730		206							2030
Other Semi-Volatile Organics												
4-Methylphenol	--		120 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibenzofuran	--		100 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTCIDES/PCBs (ppb)												
4,4' DDE	--		87 JX	60 JX	ND	ND	15000 JX	3000 JX	410 JX	4800 JX	11000 X	1500 X
4,4' DDD	--		89 J	140 JX	190 JX	59 JX	300000 X	73000 X	3200 JX	84000 X	99000 X	11000 X
4,4' DDT	500		57 J	69 JX	85 JX	ND	37000 X	3800 JX	3300 JX	12000 X	1100 JX	270 JX
TCLP PESTICIDES (ppb)												
TCLP Pesticides	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) pph indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–31
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (INORGANICS)

PARAMETER	BACKGROUND	SAMPLE ID:	2DSD1	2DSD2	2DSD3	2DSD4	2DSD5	2DSD7	2DSD8
TAL INORGANICS (ppm)									
Aluminum	272000		32100	33100	11500	11500	9910 J	9460	15300
Antimony	2.95		ND R	ND R	ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		5 B	7.5	4	ND	4.2	3.2 B	3.8
Barium	1600		82 B	128 B	53.7 B	61.4 B	43.1 B	48.4 B	60.5 B
Beryllium	3.52		4.1	5.4	1.6 B	ND	0.58 B	1.5 B	1.5 B
Cadmium	7		13.8 J	12.3 J	4.2 J	4 BJ	3 J	6.1 J	4.3 J
Calcium	32300		1780 B	2550 B	1290 BJ	5840 B	2480	1530 BJ	2160
Chromium	223		48.9	48.7	13.8	12.8 B	17.9	21.3	23.9
Cobalt	39		9.6 B	8.9 B	5.6 B	ND	6.8 B	5.7 B	9.3 B
Copper	102		94.3	78.7	21.1 J	21.7 BJ	14 J	30.9 J	45.7
Iron	115000		18900	62400	25600	17100	17500	33200	20300
Lead	53.2		51.5 J	50 J	18.7 J	55.3 J	22.1 J	64.2 J	27.4 J
Magnesium	26500		2980 B	2610 B	1900 B	1300 B	2680	1540 B	3790
Manganese	3790		137	222	129	311	411	145	236
Mercury	0.51		ND	ND	ND	ND	ND	0.26 J	0.15 J
Nickel	76.7		26.5	27.9	10.1 B	25.2 B	8.4 B	10.6 B	19.1
Potassium	12000		1610 B	1380 B	910 B	ND	1570 B	729 B	2080
Selenium	1.79		ND J	ND J	ND J	3 BJ	0.65 BJ	ND J	ND J
Silver	5		ND	ND	ND	ND	ND	7.8	ND
Sodium	51800		815 BJ	642 BJ	208 BJ	2220 BJ	527 BJ	432 BJ	249 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND
Vanadium	271		46.7	41.2	20.8	40.1 B	22.3	17.9 B	42.8
Zinc	178		617	291	73 J	85.4 J	44.1 J	118	135
Boron	109		870	660	320	4100	1700	530	840
Cyanide	--		ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)									
PARAMETER	**TBC**								
Arsenic	0.05		ND	ND	ND	ND	ND	ND	ND
Barium	1		0.17	0.47	0.23	0.091	0.15	0.21	0.19
Cadmium	0.01		0.036 J	0.022 J	0.009 J	ND J	0.012 J	0.034 J	0.0084 J
Chromium	0.05		ND	ND	ND	ND	ND	ND	ND
Lead	0.05		ND J	0.11 J	ND J	ND J	ND J	0.12 J	ND J
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND
Silver	0.05		ND J	ND J	ND J	ND J	ND J	ND J	ND J

TABLE 4–31 (continued)
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (INORGANICS)

PARAMETER	BACKGROUND	SAMPLE ID:	2DSD9	2DSD10	2DSD11	2DSD12	2DSD13	7SD1
TAL INORGANICS (ppm)								
Aluminum	272000		5100	8830	1710	4060	3030	11900
Antimony	2.95		ND R	ND R	ND R	ND R	ND J	ND J
Arsenic	31.5		1.1 B	4.5 J	1.1 B	0.83 B	1.1 B	5.6
Barium	1600		33.3 B	41.9 B	13.9 B	16.1 B	27.3 B	45.6 B
Beryllium	3.52		0.46 B	0.36 B	ND	ND	ND	0.49 BJ
Cadmium	7		1.2 BJ	1.7 J	1.4 J	1.8 J	1.7 J	2.4 J
Calcium	32300		912 BJ	1150 BJ	573 BJ	2060	842 BJ	2300
Chromium	223		8.3	12.5	6	6.4	4.1 J	15
Cobalt	39		4 B	5.5 B	3.2 B	3.7 B	4.1 B	5.3 BJ
Copper	102		13.9 J	36.5 J	16 J	13.1 J	8.8 J	16.4 J
Iron	115000		8960	9930	8560	9300	8000	11600
Lead	53.2		13.8 J	13.1 J	38.2 J	10.9 J	8.7 J	13.5 J
Magnesium	26500		1750	2350	877 B	3200	1880	2980
Manganese	3790		149	177	191	102	657	147
Mercury	0.51		ND	ND	ND	ND	ND	ND
Nickel	76.7		6.9 B	8.6 B	4.1 B	6.5 B	4.6 BJ	9.5 BJ
Potassium	12000		1320 B	1310	394 B	1090 B	486 BJ	767 BJ
Selenium	1.79		ND J	ND J	ND J	ND J	ND	0.28 B
Silver	5		ND	ND	ND	ND	ND	ND
Sodium	51800		182 BJ	375 BJ	230 BJ	3500	214 BJ	76 BJ
Thallium	5		ND	ND	ND	ND	ND	ND
Vanadium	271		14.2	21.4	9.7 B	23.3	10.1 B	24.9
Zinc	178		44.4 J	37.7 J	44.2 J	41.9 J	41 J	56.5 J
Boron	109		ND	63	60	650	60	67
Cyanide	--		ND	ND	ND	ND	ND J	ND J
TCLP METALS (ppm)								
PARAMETER	**TBC**							
Arsenic	0.05		ND	ND	ND	ND	ND	NA
Barium	1		0.22	0.16	0.36	0.069	0.31	NA
Cadmium	0.01		0.0035 J	ND J	0.0038 J	0.015 J	0.0021 J	NA
Chromium	0.05		ND	ND	ND	ND	ND	NA
Lead	0.05		ND J	0.1 J	0.16 J	0.14 J	ND J	NA
Mercury	0.002		ND	ND	ND	ND	ND	NA
Selenium	0.01		ND	ND	ND	ND	ND	NA
Silver	0.05		0.032 J	0.0078 J	ND J	0.037 J	ND J	NA

TABLE 4–31 (continued)
AREA A DOWNSTREAM AND OBDA
SUMMARY OF SEDIMENT ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (in):	3SD1 0–6	3SD1 12–18	3SD2 0–6	3SD2 12–18	3SD3 0–6	3SD3 12–18	3SD4 0–6	3SD4 12–18	3SD5 0–6	3SD5 12–18
TAL INORGANICS (ppm)												
Aluminum	272000		4820	4660	4190	8050	18800	15100	13000	14400	14400	17400
Antimony	2.95		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		5.6	3.6	19.7	1.9 B	6.1 B	6.8	39.9	10.2	7.7	6.6
Barium	1600		40.3 B	41.9 B	102	27.2 B	59.3 B	54.3 B	154 B	60.3 B	60.3 B	57.9 B
Beryllium	3.52		1.2 BJ	0.37 BJ	0.74 BJ	0.52 BJ	1.2 BJ	1.2 BJ	1.8 BJ	0.81 BJ	0.68 BJ	0.75 BJ
Cadmium	7		3.8	3.2	23.6	1.2 B	11.1	5.7	30.1	6.7	3.8	4.5
Calcium	32300		1900	1640	1840 B	1390	3760 B	2940	5720	4510	2780	5390
Chromium	223		13.6	13.5	30	11.6	21	34.6	21.1	35.6	38.4	43.4
Cobalt	39		6.2 B	9.2 B	26.6	3.7 B	22.5 B	11 B	10.8 B	11.2 B	11 B	11 B
Copper	102		33.2 J	29.7 J	118	10.6 J	20.7 BJ	19 J	105	26.1 J	20.6 J	19.7 J
Iron	115000		25400	15700	133000	8430	76800	37800	195000	47100	25400	27600
Lead	53.2		87.7	73.9	223	5 J	30.8	18	189	32.6 J	17.9	14.5 J
Magnesium	26500		2170	2950	9640	2410	3200 B	6120	3460 B	6000	6070	6710
Manganese	3790		166	118	382	104	342	377	1020	537	339	433
Mercury	0.51		ND J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	76.7		13	14.6	44.6	6.8 B	18.9 B	19.8	25.1 B	22.3	21.4	22.9
Potassium	12000		739 BJ	534 BJ	644 BJ	593 BJ	ND	2850 J	535 BJ	2560 J	2680 J	3620 J
Selenium	1.79		0.83 BJ	0.33 BJ	1.1 BJ	ND	1.5 BJ	0.7 BJ	3.2 BJ	2.5 J	1.4 BJ	1.3 BJ
Silver	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	51800		210 BJ	200 BJ	1360 BJ	534 BJ	2070 BJ	1240 BJ	793 BJ	863 BJ	870 BJ	1160 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		15	15.4	57.5	18.6	48.8	36.7	64.9	37.5	35.8	40.9
Zinc	178		145	155	2720	18.2 J	93.9	63.5 J	416	95.3	65.9 J	65.9 J
Boron	109		660	720	8300	ND	6200	3500	400	2900	2200	2600
Cyanide	--		ND	ND	3.4	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)												
PARAMETER	**TBC**											
Arsenic	0.05		0.16 J	0.13 J	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1		0.29 J	0.12 J	0.28 J	0.18 J	0.086 J	0.088 J	0.38 J	0.21 J	0.2 J	0.041 J
Cadmium	0.01		0.0082	0.005	0.0066	ND	0.013	0.0097	0.045	0.031	0.0086	ND
Chromium	0.05		ND	ND	ND	ND	0.05	ND	ND	ND	ND	ND
Lead	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0023
Selenium	0.01		0.006 J	0.0039 J	0.0026 J	ND	0.0029 J	ND	ND	ND	0.006 J	ND
Silver	0.05		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	0.0083 J	ND R

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Sections 4.2 and 4.3 for further explanation). Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

Pesticides, DDT and its derivative compounds, were detected at moderate to high concentrations within the Area A downstream watercourses and ponds. The TBC value, which is based upon the tolerance level for DDT residues in fresh fruit, was exceeded at ten of the 23 sample locations. Total pesticide concentrations are illustrated in Figure 4-24. The highest concentrations were detected in the two ponds below the Area A dike, and within the OBDA sediments. Lower concentrations downstream of these areas and extending to the Thames River are likely attributable to sediment transport from the higher concentration areas. The data indicate that some ongoing migrations of pesticides, due to sediment transport, to the Thames River is occurring from the pond source areas.

Inorganics

Several metals were detected above established background levels. These occurred in samples closest to the Area A wetland area. They included beryllium, cadmium, lead, selenium, zinc and boron. The following samples exceeded both established background levels and TBC values based on TCLP analysis; 2DSD1-cadmium, 2DSD2-cadmium, and 2DSD7-lead. Further downstream samples (2DSD9-2DSD13) contained generally low concentrations of metals. Cadmium was not detected above background levels in the Area A wetland sediments, therefore, the cadmium source does not appear to be related to sediment transport from the wetland.

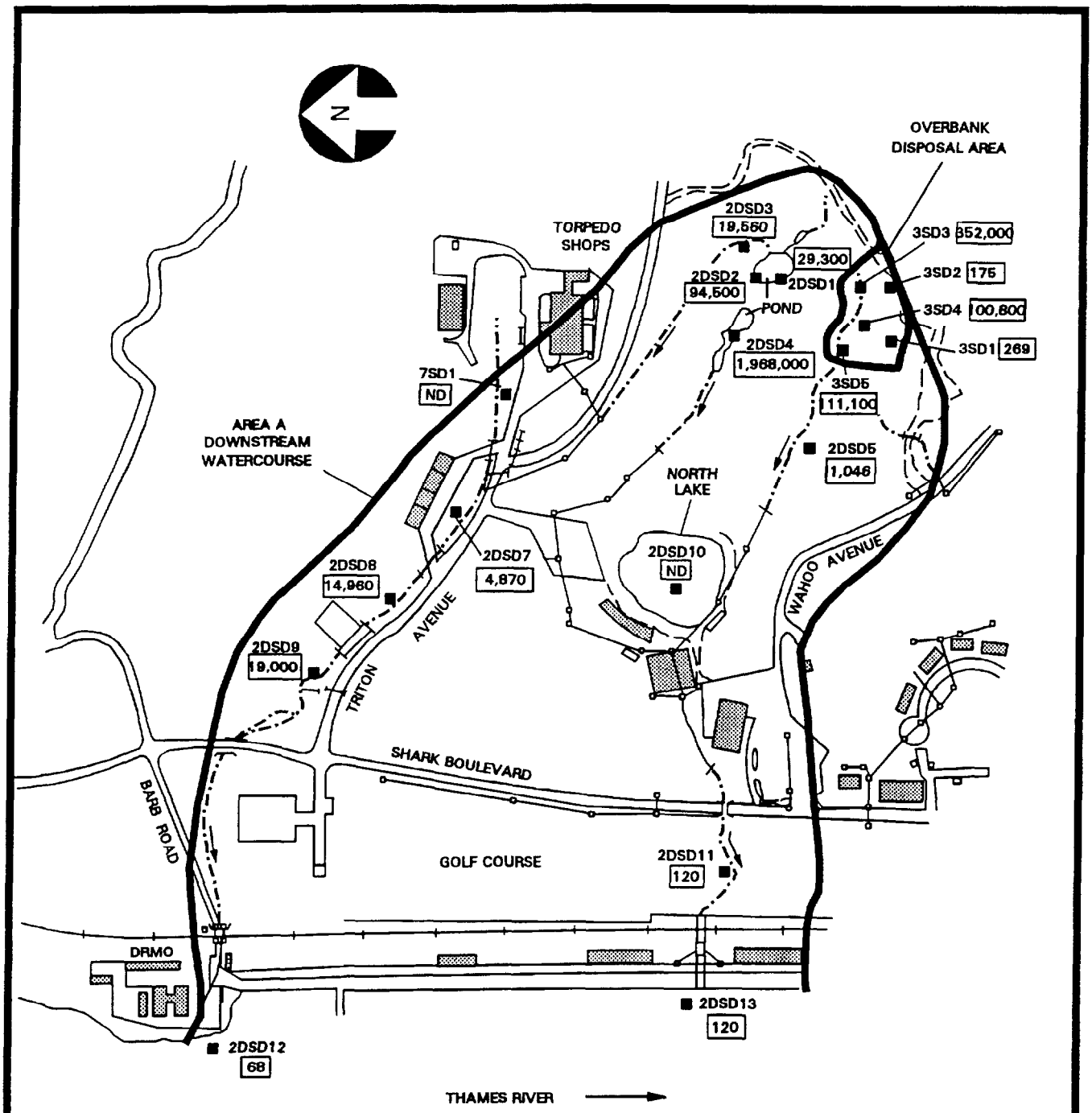
Ten sediment samples were collected from the OBDA area. Sediment samples contained metals above established background levels for cadmium (3), iron (2), lead (4), selenium (2), and zinc (2). Cadmium results based on TCLP analysis correlated with mass weight analysis for two samples. No lead was detected from TLCP analysis. The elevated iron concentration may partially explain the rust colored leachate that is visible in this wetland area. The lead and cadmium which had the highest concentrations of inorganics recorded throughout Area A, may suggest battery/battery acid disposal in this area. Alternately, it could be related to the cadmium present in the ground water at this location, and adsorption onto the sediments as it discharges to OBDA.

4.11.4 Area A Ground Water

Twenty-eight ground water monitoring wells were installed and sampled within Area A, which includes the landfill, wetland, and downstream areas. These well locations are shown on Figures 4-16, 4-22 and Plate 4-1. Eleven were water table overburden wells and 17 wells were installed and screened in the bedrock aquifer. The ground water analytical program is summarized in Section 2.0, Table 2-12. Ground water hydrology for Area A is summarized in Section 3.0.

Ground water analytical results for Area A wetlands and landfill are summarized in Tables 4-32 (organics) and 4-33 (inorganics and radiological). Results for Area A downstream and OBDA are summarized in Tables 4-34 (organics) and 4-35 (inorganics and radiological).

VOCs were detected in only six of 28 monitoring wells within Area A. Of the six, only three locations exceeded TBC/ARAR values for drinking water. VOC ground water concentrations are summarized in Table 4-36 and are also illustrated on Plate 4-2.



NOTE:
1. Wells not installed at 2DMW10S and 2DMW15S due to lack of ground water in overburden.
2. Pesticide totals for OBDA are highest of 0-6" or 12-18" sample intervals.

	LEGEND		
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	■ SD1 - Sediment Sample 68 - Total Pesticides (ppb) ND - Indicates Not Detected	- Building - Watercourse Approximate Scale 0 200'	FIGURE 4-24 TOTAL PESTICIDES - SEDIMENT AREA A DOWNSTREAM WATERCOURSE ATLANTIC ENVIRONMENTAL SERVICES, INC

TABLE 4-32
AREA A WETLANDS AND LANDFILL
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	2LMW7S	2LMW7D	2LMW8S	2LMW8D	2LMW9S	2LMW9D	2LMW13D	2LMW14D	2LMW17S	2LMW17D
TCL VOLATILE ORGANICS (ppb)												
1,2 Dichloroethene	70 ARAR	MCL	ND	ND	ND	ND	ND	ND	1 J	ND	ND	ND
Trichloroethene	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	10	ND	ND	ND
Benzene	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	0.17 TBC	WQC	ND	ND	ND	ND	ND	ND	140	ND	ND	1 J
Chlorobenzene	488 TBC	WQC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	700 ARAR	MCL	ND	ND	2 J	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	10000 ARAR	MCL	ND	ND	2 JY	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics					4				151			1
TCL SEMI-VOLATILE ORGANICS (ppb)												
Noncarcinogenic PAH												
Naphthalene	20	PMCL	ND	ND	3 J	ND	6 J	ND	ND	ND	ND	ND
2-Methylnaphthalene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Noncarcinogenic PAH					3		6					
Phthalates												
bis(2-ethylhexyl)phthalate	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Other Semi-Volatile Organics												
2-Chlorophenol	40 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	600 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	75 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	600 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methylphenol	--		ND	ND	ND	ND	7 J	ND	ND	ND	ND	ND
2,4-Dimethylphenol	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic Acid	--		ND	ND	ND	ND	4 J	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	9 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)												
Aroclor 1254	1 TBC	CTDOHS HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4–32 (continued)
AREA A WETLANDS AND LANDFILL
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	2LMW18S	2LMW18D	2WMW1D	2WMW2D	2WMW3S	2WMW3D	2WMW4D	2WMW5S	2WMW6S	2WMW6D
TCL VOLATILE ORGANICS (ppb)												
1,2 Dichloroethene	70 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	5 ARAR	MCL	10 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2–Tetrachloroethane	0.17 TBC	WQC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	488 TBC	WQC	220	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	700 ARAR	MCL	120	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	10000 ARAR	MCL	840 Y	ND	ND	ND	ND	ND	ND	1 JY	ND	ND
Total Volatile Organics			1190							1		
TCL SEMI–VOLATILE ORGANICS (ppb)												
Noncarcinogenic PAH												
Naphthalene	20	PMCL	15 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
2–Methylnaphthalene	– –		3 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Noncarcinogenic PAH			18									
Phthalates												
bis(2–ethylhexyl)phthalate	– –		4 J	6 J	ND	ND	ND	ND	2 J	ND	ND	13
Other Semi–Volatile Organics												
2–Chlorophenol	40 TBC	USEPA HA	4 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3–Dichlorobenzene	600 TBC	USEPA HA	25 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4–Dichlorobenzene	75 ARAR	MCL	99 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2–Dichlorobenzene	600 TBC	USEPA HA	10 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
4–Methylphenol	– –		15 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
2,4–Dimethylphenol	– –		19 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzoic Acid	– –		ND	ND	ND	ND	ND	12 J	ND	ND	ND	ND
1,2,4–Trichlorobenzene	9 TBC	PMCL	67 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)												
Aroclor 1254	1 TBC	CTDOHS HA	150 X	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.

TABLE 4–33
AREA A WETLANDS AND LANDFILL
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	ARARs/TBC	SAMPLE ID:	2LMW7S	2LMW7D	2LMW8S	2LMW8D	2LMW9S	2LMW9D	2LMW13D	2LMW14D	2LMW17S	2LMW17D
TAL INORGANICS (ppb)												
Aluminum	200 TBC	SMCL	ND	ND	ND	ND	ND	ND	ND	35.8 B	54.3 B	ND
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1000 ARAR	MCL	25 B	57.4 B	33.4 B	ND	112 B	62.9 B	33.4 B	32.9 B	18.5 B	31 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	3.8 BJ	3.8 B	ND	ND	ND	44.8 J	ND	ND	ND
Calcium	--		26000	13900	14100	33400	34700	24400	36100	18200	14300	18300
Chromium	50 ARAR	MCL	11.5 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		5.3 B	ND	ND	ND	ND	ND	ND	ND	ND	ND
Copper	1000 ARAR	MCL	ND	6.1 BJ	7.1 BJ	6.2 BJ	ND	10.5 BJ	ND	15.1 BJ	ND	ND
Iron	300 TBC	SMCL	13600	28100	8360	41.9 BJ	13100	7580	3760 J	28.1 BJ	8620	13200
Lead	15 ARAR	Action Level	8.5 J	ND J	3 B	3.8 B	ND J	ND J	ND	4.4 BJ	7.1 J	ND J
Magnesium	--		36200	4040 B	2440 B	2210 B	4040 B	29300	4510 B	2120 B	2970 B	3210 B
Manganese	50 TBC	SMCL	280	216	544	57.5 J	412	1030	408	595	323	286
Mercury	2 ARAR	MCL	ND J	ND	ND	ND	ND J	ND	ND	ND	ND J	ND
Nickel	100 TBC	PMCL	16.8 BJ	21.1 BJ	ND	ND	22.6 BJ	23.1 BJ	21.7 BJ	ND	17.6 BJ	18.4 BJ
Potassium			16400	3290 B	3560 BJ	1420 BJ	4710 B	11800	1950 B	5830 J	1300 B	960 B
Selenium	10 ARAR	MCL	2.9 B	ND	1 BJ	1 BJ	2.2 B	1.5 B	ND	ND	ND	ND
Silver	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	28000 TBC	Notif. Level	365000	89200	12600	11400	160000	287000	26500	26500	10700	10600
Thallium	1 TBC	PMCL	ND R	ND	ND	ND	ND R	ND	ND	ND	ND R	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	10.5 BJ	11 BJ	13.2 BJ	ND J	14.2 BJ	10.2 BJ	10.8 BJ	18.6 BJ	15.9 BJ	8.7 BJ
Boron	600 TBC	USEPA HA	1200	2100	1200	1200	1100	1300	5400	2500	1700	2300
Cyanide	200 ARAR	MCL	ND J	ND	ND	ND J	ND J	ND	ND	ND J	ND J	ND
RADIOLOGICAL CONSTITUENTS (pCi/L)												
Gross Alpha	5	Screening Level	11	1.3	1.2	0	0.5	14.7	17.9	1.5	3.3	2.9
Gross Beta	50	Screening Level	20.9	6.6	3.7	2.9	6	18.8	24.1	11.6	1.8	4

TABLE 4–33 (continued)
AREA A WETLANDS AND LANDFILL
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	ARARs/TBC	SAMPLE ID:	2LMW18S	2LMW18D	2WMW1D	2WMW2D	2WMW3S	2WMW3D	2WMW4D	2WMW5S	2WMW6S	2WMW6D
TAL INORGANICS (ppb)												
Aluminum	200 TBC	SMCL	51.1 B	ND	ND	139 B	39.6 B	ND	ND	ND	2060	71.7 B
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	4.2 B	ND	ND	ND	7.6 B	ND	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	711	66.3 B	16 B	39 B	396	613	70.1 B	167 B	38 B	26.2 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	1 B	ND
Cadmium	5 ARAR	MCL	29.1	7.2	ND	ND	10.6	7.7 J	ND J	6.4	ND	ND
Calcium	--		54600	21000	9330	7530	67300	72200	28700	52300	18700	40500
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		11.4 B	ND	ND	ND	ND	ND	ND	12.1 B	14.3 B	ND
Copper[7]	1000 ARAR	MCL	ND	5.4 BJ	ND	ND	6.2 BJ	ND	ND	7.9 BJ	ND	5.5 BJ
Iron	300 TBC	SMCL	192000	36800	85.1 BJ	256 J	75400	62600	65.2 BJ	44800	3140	2310
Lead	15 ARAR	Action Level	ND	ND	2.2 BJ	22.4 J	ND	ND J	ND R	ND	2.5 BJ	2 B
Magnesium	--		65900	4340 B	1400 B	1700 B	126000	108000	2850 B	50800	4350 B	8830
Manganese	50 TBC	SMCL	580	863	2.3 B	27.4	3200	3630	31.1	8130	648	673
Mercury	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND J	ND	ND J	ND
Nickel	100 TBC	PMCL	29.5 B	ND	23.4 BJ	20.6 BJ	ND	18.9 BJ	18.6 BJ	ND	39.7 BJ	ND
Potassium			47100	4350 BJ	1120 B	715 B	37100 BJ	26400	1170 B	17300 J	5510	8330 J
Selenium[7]	10 ARAR	MCL	2.9 BJ	ND	ND	ND	2.3 BJ	3.6 B	ND J	2.2 BJ	ND	ND
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND J	ND	ND	ND
Sodium	28000 TBC	Notif. Level	777000	27400	28900	40500	1360000	1140000	9020 J	654000	31200	94700
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND R	ND	ND R	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	600	12 BJ	20.2 J	62.1 J	15.3 BJ	16.1 BJ	15 BJ	12.4 BJ	136	21.1 J
Boron	600 TBC	USEPA HA	1000	2400	1300	1300	970	1500	1400	1600	7500	8100
Cyanide[7]	200 ARAR	MCL	ND	ND	ND J	ND J	ND	ND	ND J	ND	ND J	ND J
RADIOLOGICAL CONSTITUENTS (pCi/L)												
Gross Alpha[7]	5	Screening Level	0	0	0	4.7	0	42.2	10.1	0	2.8	4.6
Gross Beta	50	Screening Level	56.3	3.7	2.5	3.8	40.2	51	4.4	15.8	4.4	12.4

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

TABLE 4–34
AREA A DOWNSTREAM AND OBDA
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	2DMW10D	2DMW11S	2DMW11D	2DMW15D	2DMW16S	2DMW16D	3MW12S	3MW12D
TCL VOLATILE ORGANICS (ppb)										
1,2–Dichloroethene (total)	70 ARAR	MCL	ND	ND	ND	ND	ND	13	ND	ND
Trichloroethene	5 ARAR	MCL	ND	ND	ND	ND	ND	17	ND	ND
1,1,2,2–Tetrachloroethane	0.17 TBC	WQC	ND	ND	ND	ND	ND	7	ND	ND
Total Volatile Organics								37		
TCL SEMI–VOLATILE ORGANICS (ppb)										
Phthalates										
bis(2–ethylhexyl)phthalate	--		4 J	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)										
TCL Pesticides/PCBs	--		ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.

TABLE 4–35
AREA A DOWNSTREAM AND OBDA
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	ARARs/TBC	SAMPLE ID:	2DMW10D	2DMW11S	2DMW11D	2DMW15D	2DMW16S	2DMW16D	3MW12S	3MW12D
TAL INORGANICS (ppb)										
Aluminum	200 TBC	SMCL	ND J	ND	ND	44.5 BJ	ND	ND	ND	ND
Antimony	5 TBC	PMCl	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	39.6 B	29.4 B	104 B	31.6 B	17.1 B	97.1 B	39.2 B	44.4 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND	ND	ND	5.1	ND	16 J
Calcium	--		22300 J	41200	42400	7340	32400	196000	64900	69400
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	14.1 B	16 B
Copper[7]	1000 ARAR	MCL	ND J	5 BJ	ND	ND	ND	6.3 B	ND	ND
Iron	300 TBC	SMCL	287 J	101 J	16900	83.4 BJ	669 J	11600	1580	7090
Lead	15 ARAR	Action Level	ND J	ND	ND J	ND J	ND J	ND J	ND J	ND J
Magnesium	--		8960 J	15600	11400	3400 B	5260	28800	50900	52000
Manganese	50 TBC	SMCL	106 J	1150	2390	49.7	339	2190	6010	6770
Mercury	2 ARAR	MCL	ND	ND J	ND	ND	ND J	ND	ND J	ND
Nickel	100 TBC	PMCL	20.7 BJ	15.2 BJ	19.2 BJ	19.2 BJ	20.5 BJ	33.4 BJ	19.7 BJ	24.2 BJ
Potassium	--		5000	7210	7780	4440 B	2520 B	12600	14300	14900
Selenium[7]	10 ARAR	MCL	ND	ND	ND	ND	ND	1.8 B	ND	2.5 B
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	28000 TBC	Notif. Level	88800	190000	194000	57200	44500	319000	478000	560000
Thallium	1 TBC	PMCL	ND	ND R	ND	ND	ND R	ND	ND R	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	8.1 BJ	6.7 BJ	6.1 BJ	4 BJ	22.8 J	23.3 J	14.4 BJ	10.4 BJ
Boron	600 TBC	USEPA HA	6900 J	7500	1600	3400	2200	11000	11000	11000
Cyanide[7]	200 ARAR	MCL	ND	ND J	ND	ND	ND J	ND J	ND J	ND
RADIOLOGICAL CONSTITUENTS (pCi/L)										
Gross Alpha[7]	5	Screening Level	3.1	18.5	8.9	2.1	0.2	1.5	25.7	29.3
Gross Beta	50	Screening Level	7.5	7.7	18.3	5.6	5.1	32.8	2.8	34.1

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are base on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

TABLE 4-36 AREA A SUMMARY OF VOCS DETECTED IN GROUND WATER		
WELL NO.	**VOCS DETECTED/CONCENTRATION (ppb)**	
LANDFILL		
2LMW18S	Benzene:	10*
	Chlorobenzene:	220
	Ethyl Benzene:	120
	Xylene:	840
2LMW17D	1,1,2,2 Tetrachloroethene:	1
	Ethyl Benzene:	2
2LMW8S	Xylene:	2
	Trichloroethene: 1,2	10*
2LMW13D	dichloroethene: 1,1,2,2	1
	tetrachloroethane:	140
WETLAND		
2WMW5S	Xylene:	1
DOWNSTREAM/OBDA		
2DMW16D	1,2 dichloroethene:	13*
	trichloroethene:	17*
	1,1,2,2 tetrachloroethane:	7
* Indicates drinking water ARAR/TBC value exceeded.		

The solvent trichloroethene was detected above drinking water standards at 2LMW13D (10 ppb) at the west end of the landfill, and 2DMW16D (17 ppb) upgradient of North Lake. This suggests a low concentration plume of solvents within the bedrock aquifer extending from the western portion of the former landfill downgradient to the North Lake area. As discussed in Section 3.0, the ground water **in the bedrock aquifer** does not appear to discharge to North Lake **as there is no significant** vertical head **difference between wells** 2DMW16S&D. **The overburden aquifer which is expected to be discharging into North Lake did not contain any detectable levels of solvents.** The plume appears to be fairly narrow, as no solvents were detected in the Area A downstream wells to the north (2DMW11S&D, 2DMW10D, and 2DMW15D). This is supported by review of the ground water specific conductivity data which is used as a landfill leachate indicator. Solvents were not detected in downgradient well 3MW12D (OBDA), suggesting preferred fracture flow is occurring in the bedrock aquifer. However, this does not correlate with the cadmium data, which indicated elevated levels of cadmium at 2LMW13D and 3MW12D. The downgradient extent of the solvent plume, which is flowing in a westerly direction, is undefined. **Section 8.0 includes recommendations for ground water elevation monitoring to further evaluate the ground water flow regime at North Lake.**

Benzene was detected at 10 ppb, above drinking water standards (5 ppb) at 2LMW18S, which may be related to the parked vehicles in this area; it was not detected in any other well

in Area A.

Overall, the VOC concentrations for those wells where detected are low, given the historical use of Area A as a landfill. Although drinking water ARAR/TBC values are exceeded in three wells, the results do not indicate any significant ongoing release of VOC contaminants. As discussed in Section 4.11.1.3 (Soil Gas) and 4.11.1.4 (Subsurface Soil), low levels of petroleum hydrocarbons and solvents were detected throughout much of the Area A landfill area. This suggests a generally uniform low level area of soil contamination within the landfill, and no substantial source area. The deployed parking area and adjacent area to the east (also used for automobile storage/parking) exhibited the most uniform level of petroleum hydrocarbons, principally xylene and ethylbenzene. Benzene was not detected in any soil samples, but was present in soil gas samples in this area. The deployed parking area is likely the source of benzene detected in one well (2LMW18S) at 10 ppb.

PCB was detected at a concentration of 150 ppb at well 2LMW18S. This concentration far exceeds its solubility of 0.012 ppb. It is also Arochlor 1254 and not 1260, which was found near the concrete pad at Area A landfill. Further sampling of the well would be required for confirmation of the result.

Cadmium was the only inorganic compound which exceeded primary drinking water standards within Area A. **Lead was detected above the 15 ppb action level at 2WMW2D (22.4) ppb.** Cadmium **and lead** concentrations above drinking water standards **or action levels for lead are** also detected **in** residential wells located east of Area A. The residential well sampling results are summarized in the subsequent report section. Cadmium was detected above the 5 ppb drinking water standards at 2WMW3S (10.6 ppb), 2LMW18S (29.1 ppb), 2LMW13D (44.8 ppb), **2LMW18D (7.2 ppb), 2WMW3D (7.7 ppb), 2DMW16D (5.1 ppb), 2WMW5S (6.4 ppb)** and 3MW12D (16 ppb). The source of these elevated levels of cadmium **and lead in Area A** would appear to be related to soils within the landfill and, possibly, OBDA. However, cadmium soil concentrations in the landfill only exceeded established background levels at one sample location (2LMW8S). It is possible that higher concentrations of cadmium exist in the landfill, at locations other than the sample points. Dissolved cadmium levels in Area A ground water may be partially attributable to low pH values for some wells. Values of pH were included as Table 2-10 in Section 2.0. Low pH values may be partially attributable to landfill and wetland dredge spoil material. However, low pH values may also be partially attributable to natural conditions as evidenced by the lowest pH value (5.2) at upgradient background well 2WMW2D. At wells 2LMW3S and 2LMW18S, the upward vertical head gradient should minimize the transport of cadmium from the landfill into the bedrock aquifer. However, at bedrock well 2LMW13D, where there is a strong upward vertical head, the cadmium is present in the bedrock system due to a source, either upgradient within the landfill, or another unknown upgradient source. The former Weapons Center is upgradient of this area along Wahoo Avenue, however, the lack of high levels of cadmium in other nearby bedrock wells (2LMW9D, 2LMW17D, and 2LMW14D) does not strongly support an offsite source, but rather a landfill source.

Cadmium concentrations in Area A monitoring wells are illustrated on Plate 4-2.

Based on ground water flow directions discussed in Section 3.0, overburden ground water flow along the central and eastern portion of the landfill is toward the wetland, and along the western portion of the landfill to the northwest, down the Area A downstream watercourse valley. Therefore, the cadmium ground water contamination appears confined to the landfill and the OBDA area. Cadmium was only detected in well 3MW2D in the OBDA, suggesting a potential confined plume to the northwest although, due to preferred bedrock flow patterns, other wells may not have intercepted the cadmium and, therefore, the cadmium plume is undefined. Bedrock fractures, as discussed in Section 3.0, are oriented along the axis of Area A Downstream, in the direction of ground water flow.

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

Iron and manganese exceeded secondary drinking water standards in many Area A wells. The results for 2WMW1D and 2WMW2D (upgradient wells) and the residential well analytical results (Section 4.10.5) were much lower for iron and manganese, which indicates a source of these inorganics within the Area A landfill material and wetland sediments.

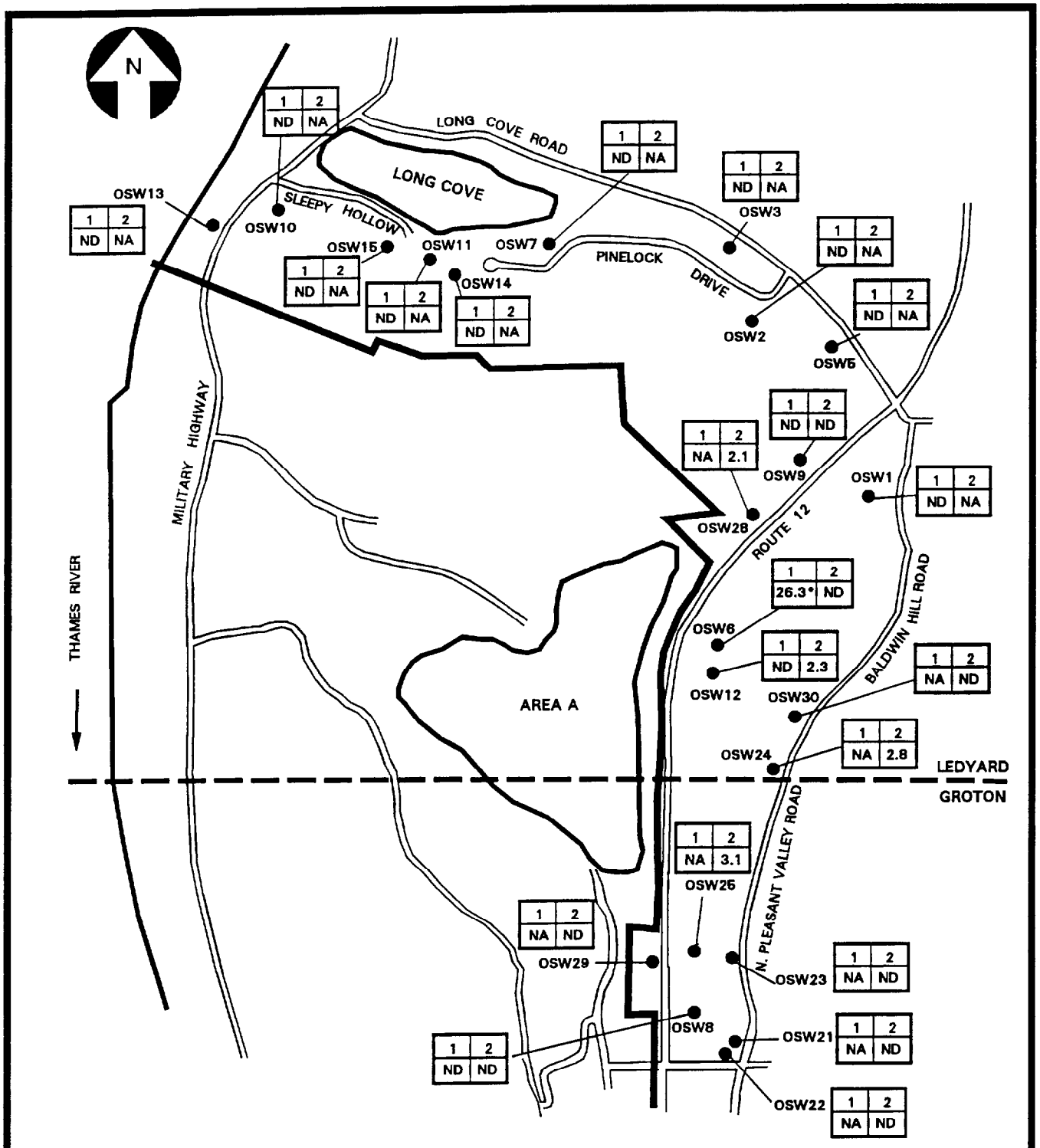
Radiological ARAR or screening parameters were exceeded in nine of the 20 samples. These occurred at 2LMW7S, 2LMW9D, 2WMW3D within the landfill area; 2WMW4D near the Weapons Center; and 2DMW11S, 2DMW11D, 3DMW3S, and 3DMW3D within the Area A downstream area. Gross alpha radiation in four wells, gross beta radiation in one well, and gross alpha and beta radiation in one well were detected. These elevated readings could be the result of naturally occurring radioisotopes which do not meet the gross screening criteria. Further sampling and analysis is required for confirmation.

4.11.5 Residential Well Sampling

A residential well sampling and analysis program was conducted to assess ground water quality in offsite areas near Area A.

The locations of the residential wells are shown on Figure 4-25.

The results of the analysis program (first round) are summarized on Tables 4-37 (organics) and 4-38 (inorganics). The second **and third** rounds **are** summarized on Table 4-39 (organics and inorganics).



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

LEGEND

● - Residential Well
OSW8 - Sampling Number
1 2 / ND NA - Sample Round - Cadmium Concentration (ppb)

NA - Not Analyzed
ND - Not Detected
* - Indicates above drinking water standards

Approximate Scale
0 500 1,000'

FIGURE 4-25
OFFSITE RESIDENTIAL WELL SAMPLE LOCATIONS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 4-37
OFFSITE RESIDENTIAL WELLS (FIRST ROUND)
SUMMARY OF WELL WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs TBC	SAMPLE ID: LOCATION:	OSW1 1488 Rte 12	OSW2 7 Pinelock Dr	OSW3 1053 Long Cove Rd	OSW5 1037 Long Cove Rd	OSW6 1458 Rte 12	OSW7 40 Pinelock Dr	OSW8 1292 Rte 12
TCL VOLATILE ORGANICS (ppb)									
Chloromethane	--		ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	25 ARAR	CTDOHS HA	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	10000 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics									
TCL SEMI-VOLATILE ORGANICS (ppb)									
Phthalates									
bis(2-ethylhexyl) phthalate	--		ND	ND	ND	ND	3 J	ND	ND
TCL PESTICIDES/PCBs (ppb)									
TCL Pesticides/PCBs	--		ND	ND	ND	ND	ND	ND	ND

PARAMETER	ARARs TBC	SAMPLE ID: LOCATION:	OSW9 1477 Rte 12	OSW10 10 Sleepy Hollow	OSW11 18 Sleepy Hollow	OSW12 1444 Rte 12	OSW13 162 Military Hwy	OSW14 48 Pinelock Dr	OSW15 16 Sleepy Hollow
TCL VOLATILE ORGANICS (ppb)									
Chloromethane	--		ND	ND	ND	ND	ND	ND	27 J
Methylene Chloride	25 TBC	CTDOHS HA	ND	ND	ND	ND	ND	ND	4 J
Xylene (total)	10000 ARAR	MCL	ND	ND	ND	ND	ND	ND	2 JY
Total Volatile Organics									33
TCL SEMI-VOLATILE ORGANICS (ppb)									
Phthalates									
bis(2-ethylhexyl) phthalate	--		ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)									
TCL Pesticides/PCBs	--		ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further information. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4-2 or glossary for further information.

TABLE 4–38
OFFSITE RESIDENTIAL WELLS (FIRST ROUND)
SUMMARY OF WELL WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARAR/TBC	SAMPLE ID: LOCATION:	OSW1 1488 Rte 12	OSW2 7 Pinelock Dr	OSW3 1053 Long Cove Rd	OSW5 1037 Long Cove I	OSW6 1458 Rte 12	OSW7 40 Pinelock Dr	OSW8 1292 Rte 12
TAL INORGANICS (ppb)									
Aluminum	200 TBC	SMCL	62.1 BJ	96 BJ	44.3 BJ	51.4 BJ	ND	ND	33.8 BJ
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	43.8 B	ND	43.6 B	30.4 B	ND	ND	38.6 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND J	ND	26.3	ND	ND
Calcium	--		11200	5610	26200	10700	8590	12900	6410
Chromium[7]	15 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND
Copper[7]	1000 ARAR	MCL	30.6	66.3	29.1	388	48.2	87.6	67.5
Iron	300 TBC	SMCL	203	204	198	603	128	128	75.3 B
Lead	15 ARAR	Action Level	ND	8.4	2.4 B	4.6 B	11	ND	8.6
Magnesium	--		1900 B	1040 B	3190 B	1820 B	2200 B	1340 B	1280 B
Manganese	50 TBC	SMCL	11.1 B	14.4 B	244	9.2 B	ND	ND	3.5 B
Mercury	2 ARAR	MCL	ND	0.4	ND	ND	ND	ND	ND
Nickel	100 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Potassium	--		766 B	ND	1720 B	1280 B	ND	ND	1380 B
Selenium[7]	10 ARAR	MCL	ND	ND	ND	2.1 B	ND	ND	ND
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Sodium	28000 TBC	Notif. Level	34600	3720 BJ	32000	10300	11000	4800 B	28600
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	13.3 BJ	12.9 BJ	184	21.3 J	16.7 BJ	13.2 BJ	32.6 J
Boron	600 TBC	USEPA HA	2000	1000	2000	2000	1000	2000	2000
Cyanide	200 ARAR	MCL	ND J	ND J	ND J	ND J	ND J	ND J	ND J

TABLE 4–38 (continued)
OFFSITE RESIDENTIAL WELLS (FIRST ROUND)
SUMMARY OF WELL WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARAR/TBC	SAMPLE ID: LOCATION:	OSW9 1477 Rte 12	OSW10 10 Sleepy Hollow	OSW11 18 Sleepy Hollow	OSW12 1444 Rte 12	OSW13 162 Military Hwy	OSW14 48 Pinelock Dr	OSW15 16 Sleepy Hollow
TAL INORGANICS (ppb)									
Aluminum	200 TBC	SMCL	38.1 BJ	3360	261 J	ND	ND	46.5 BJ	46.5 BJ
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	17.3 B	38.9 B	16.5 B	ND	ND	99 B	ND
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Calcium	--		8190	3200 B	4170 B	9110	25000	23400	3820 B
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND
Copper[7]	1000 ARAR	MCL	271	500	15.4 B	70.4	31.4	27.6	78.2
Iron	300 TBC	SMCL	105	911	53.1 B	743	148	63.3 B	85.3 B
Lead	15 ARAR	Action Level	3.2 B	38.8	ND	4.8 B	7.4	2.4 B	8.4 J
Magnesium	--		1170 B	797 B	1020 B	2300 B	1490 B	1500 B	889 B
Manganese	50 TBC	SMCL	11.2 B	226	15.7	4.5 B	ND	ND	8.6 B
Mercury	2 ARAR	MCL	ND	ND	ND	ND	1.3	ND	ND
Nickel	100 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Potassium	--		ND	ND	ND	ND	ND	ND	ND
Selenium[7]	10 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND
Sodium	28000 TBC	Notif. Level	4210 B	7810	3530 B	11800	15100	5990 J	3330 BJ
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	23.2 J	42 J	33 J	30 J	12.3 BJ	19.3 BJ	17.7 BJ
Boron	600 TBC	USEPA HA	1000	1000	1000	1500	2000	2000	1000
Cyanide	200 ARAR	MCL	ND J	ND J	ND J	ND J	ND J	ND J	ND J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. DTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

TABLE 4-39
OFFSITE RESIDENTIAL WELLS (SECOND AND THIRD ROUND)
SUMMARY OF WELL WATER ANALYTICAL DATA (ORGANICS AND INORGANICS)

PARAMETER	ARAR/TBC	SAMPLE ID:	OSW6		OSW8	OSW9	OSW12		OSW15	OSW21		OSW22
		LOCATION:	1458 Rte 12		1292 Rte 12	1477 Rte 12	1444 Rte 12		16 Sleepy Hollow	1140 N. Pleasant Valley Rd.		1130 N. Pleasant Valley Rd.
			2nd	3rd	2nd	2nd	2nd	3rd	2nd	2nd	3rd	2nd
TCL VOLATILE ORGANICS (ppb)												
TCL Volatile Organics			NA	NA	NA	NA	NA	NA	ND	NA	NA	NA
Total Volatile Organics												
TCL SEMI-VOLATILE ORGANICS (ppb)												
TCL Semi-Volatile Organics			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TCL PESTICIDES/PCBs												
TCL Pesticides/PCBs			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TAL INORGANICS (ppb)												
Aluminum	200 TBC	SMCL	ND J	21.8 B	ND	ND	47.2 B	ND	NA	2040	ND	82 B
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Barium[7]	1000 ARAR	MCL	ND	8.4 B	50.1 B	15.8 B	ND	7 B	NA	42.7 B	20 B	29.8 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND	ND	2.3 B	ND	NA	3.1 B	ND	ND
Calcium	--		6710	6360	6990	6360	6580	6440	NA	7730	8700	8710
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Copper[7]	1000 ARAR	MCL	221	158	283	247	19.5 BJ	27.5 BJ	NA	68.8	19 B	107
Iron	300 TBC	SMCL	88.1 J	46.8 BJ	60.7 BJ	142 J	42.9 BJ	66 B	NA	21800	247 J	67.6 BJ
Lead	15 ARAR	Action Level	16.8 J	8 J	5.9	2.6 B	3.7 B	5.8 J	NA	18.1	7.8 J	8
Magnesium	--		1660 B	1670 B	1310 B	914 B	1750 B	1720 B	NA	2070 B	2080 B	2230 B
Manganese	50 TBC	SMCL	ND J	2.1 B	3.4 B	7.6 B	ND	2.5 B	NA	270	9.1 B	14.3 B
Mercury	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND
Nickel	100 TBC	PMCL	ND	ND	ND	ND	ND	17.5 BJ	NA	ND	5 BJ	ND
Potassium	--		ND	1230 B	1440 BJ	ND	1170 BJ	1010 B	NA	1320 BJ	1960 B	2260 BJ
Selenium[7]	10 ARAR	MCL	ND	ND	ND	1 BJ	ND	ND	NA	1 BJ	ND	ND
Silver[7]	50 ARAR	MCL	ND	5.8 B	ND	ND	ND	ND	NA	ND	ND	ND
Sodium	28000 TBC	Notif. Level	8740	8820	34600	3540 B	8950	9170	NA	10200	8600	16200
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	2.4 B	NA	ND	ND	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	NA	33.1 B	ND	ND
Zinc	5000 TBC	SMCL	22.7 J	25.1	62 J	34.4 J	14.8 BJ	33.6	NA	16.3 BJ	28.2	15.7 J
Boron	600 TBC	USEPA HA	1160	1100	1270	770	1180	1100	NA	1200	1200	1200
Cyanide[7]	200 ARAR	MCL	ND	ND	ND	ND	ND	ND	NA	15.1	ND	ND

TABLE 4-39 (continued)
OFFSITE RESIDENTIAL WELLS (FIRST ROUND)
SUMMARY OF WELL WATER ANALYTICAL DATA (ORGANICS AND INORGANICS)

PARAMETER	ARAR/TBC	SAMPLE ID:	OSW23	OSW24		OSW25		OSW28		OSW29	OSW30	OSW32
		LOCATION:	1198 N. Pleasant Valley Rd.	1298 N. Pleasant Valley Rd.		1320 Rte. 12		1469 Rte. 12		1323 Rte. 12	1319 Baldwin Hill Road	160 Military Highway
			2nd	2nd	3rd	2nd	3rd	2nd	3rd	2nd	2nd	3rd
TCL VOLATILE ORGANICS (ppb)												
TCL Volatile Organics			NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
Total Volatile Organics												
TCL SEMI-VOLATILE ORGANICS (ppb)												
TCL Semi-Volatile Organics			NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
TCL PESTICIDES/PCBs												
TCL Pesticides/PCBs			NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
TAL INORGANICS (ppb)												
Aluminum	200 TBC	SMCL	263	59.1 B	ND	61.6 B	74.2 B	34.1 B	40.1 B	36.8 B	ND	206
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	30.9 B	26.8 B	27.8 B	35.3 B	33.6 B	ND	9.6 B	56.7 B	ND	15.6 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	2.8 B	ND	3.1 B	ND	2.1 B	ND	ND	ND	ND
Calcium	--		5150	6650	8010	8500	7020	3560 B	4400 B	15500	4200 B	6280
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	6 B
Copper[7]	1000 ARAR	MCL	159	57.4	65	25 BJ	108	460	252	135	125	14.6 B
Iron	300 TBC	SMCL	606	68.1 BJ	74.8 BJ	43.5 BJ	46.1 BJ	191 J	94.2 BJ	75 BJ	92.3 BJ	97.3 BJ
Lead	15 ARAR	Action Level	32.2	4.1 B	5.4 J	2.4 BJ	11.7 J	5.6	ND J	5.6	4.1 B	13.4 J
Magnesium	--		1770 B	1480 B	1780 B	1960 B	1640 B	893 B	1090 B	2420 B	1020 B	752 B
Manganese	50 TBC	SMCL	56.7	12.4 B	17.2	134	32	ND	3.3 B	3.1 B	9.9 B	37
Mercury	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	100 TBC	PMCL	ND	ND	ND	ND	8.9 BJ	ND	ND	ND	ND	8.2 BJ
Potassium	--		1520 BJ	1750 BJ	2160 B	2130 BJ	2340 B	621 BJ	1340 B	2140 BJ	ND	474 B
Selenium[7]	10 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	28000 TBC	Notif. Level	11800	28000	24900	9260	11000	11700	8740	11600	19400	8790
Thallium	1 TBC	PMCL	ND	ND	ND	ND	2.4 B	ND	ND	ND	ND	2.6 B
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	30.5 J	44 J	37	19 BJ	64	42.9 J	57.1	37.5 J	18.7 BJ	41.3
Boron	600 TBC	USEPA HA	1300	1080	1300	1850	1800	960	850	1560	960	1300
Cyanide[7]	200 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/- range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4-2 or glossary for further explanation.
7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. DTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

The first round of sampling indicated low levels of chloromethane, methylene chloride, and xylene at OSW15 (16 Sleepy Hollow), but below drinking water standards. This well was resampled for VOCs in the second round and none were detected. The first sampling round indicated the presence of cadmium at OSW6 (1458 Route 12) above primary drinking water standards (5 ppb) at a concentration of 26.3 ppb. **Lead was present above its action level of 15 ppb in wells OSW6 (16.8 ppb, 2nd round), OSW10 (38.8 ppb, 1st round), OSW23 (32.2 ppb, 2nd round), and OSW21 (18.1 ppb, 2nd round). The lead levels measured during the second round in residential wells OSW6 and OSW21 were only slightly above the 15 ppb action level (16.8 ppb and 18.1, respectively) and were below the action level in the subsequent sampling round. The lead levels measured in residential wells OSW10 and OSW23 are higher than levels in Area A ground water and these wells are located in opposite directions from Area A, i.e., OSW10 is northwest of Area A and OSW23 is southeast of Area A, indicating that Area A ground water does not appear to be the source of this contamination. A common cause of lead contamination in residential water supplies is corrosion of lead from pipes, solder, and other plumbing fixtures. The action level is the level that, if exceeded at the tap, would require a public water utility to implement corrosion control procedures and, if necessary, source water treatment and lead service line replacement as necessary to reduce lead concentrations below 15 ppb. The MCL or drinking water standard for lead is 50 ppb, however, EPA has indicated that they plan to lower this level in the future.** Other compounds (iron, manganese, aluminum and sodium) were detected in other wells which exceeded secondary drinking water standards, and are attributable to natural ground water conditions.

Due to the presence of cadmium, the second sampling round was conducted to expand the sampling program to areas east of Area A on Route 12, North Pleasant Valley Road, and Baldwin Hill Road. The second sampling round did not detect any metals above primary drinking water standards. Also, cadmium was not detected at 1458 Route 12, where it was previously present. Cadmium was detected at low levels at five of 13 wells sampled in the 2.1-3.1 ppb range, below the 10 ppb standard. As previously discussed, an assessment of the ground water hydrogeology of this area indicates that the presence of cadmium in the offsite residential wells is not attributable to the detection of cadmium within Area A at NSB-NLON, with the possible exception of well OSW25 to the southeast, which contained cadmium below standards but could be downgradient of Area A Landfill.

The cadmium level within the residential sample area appears to be a natural background concentration in the ground water. Another round of residential well sampling is planned to further confirm the analytical results.

The cadmium concentrations are summarized on Figure 4-25.

Boron was found in all residential wells above the TBC value of 600 ppb, which is based on an EPA health advisory. Concentrations of boron detected ranged from 770 to 2000 ppb. The source of this boron is unknown. Section 8.0 contains a recommendation to determine the source of boron in the residential wells.

4.11.6 Area A Surface Water

Fifteen surface water samples were collected within Area A, which includes the landfill, wetland, downstream areas and Thames River. These samples were collected to assess the surface water quality. Sample locations are shown in Figures 4-16 and 4-22, and Plate 4-1. The site analytical program for surface water sampling is summarized in Section 2.0, Table 2-12.

Surface water analytical results are summarized in Tables 4-40 (organics) and 4-41 (inorganics and radiological).

Low levels of VOCs were detected at sampling points 2DSW5, 2DSW7, 2DSW8, 2DSW12, and 2DSW13. Except for 2DSW8, constituents detected are in petroleum hydrocarbons and could be associated with runoff. Sample 2DSW8 (near Triton Avenue) contained 3 ppb of tetrachlorethene and 2 ppb of styrene. No ARARs or TBCs were exceeded for the VOCs.

No SVOs were detected at any of the sampling locations.

No pesticides or PCBs were detected at any of the sampling points except for 2DSW4, which contained 1.9 ppb of DDD. This sample is in the area where high levels of DDT and related compounds, including DDD, were detected in sediments. It is likely that the origin of DDD in the surface water is from the sediments.

ARARs/TBCs for inorganics were exceeded at several sample locations for cadmium (3 of 15), copper (**15** of 15), iron (11 of 15), lead (**11** of 15), manganese (13 of 15), **zinc (14 of 15),** and mercury (1 of 15). These ARARs are based upon in-stream water quality criteria **and standards** to protect aquatic life and may not be appropriate to the wetlands and small drainage streams. The presence of iron and manganese in surface water may be a result of the low pH and reduced conditions created by the Area A Landfill. The stream beds within Area A Downstream were heavily stained, which supports the elevated iron and manganese levels. Natural surface waters seldom contain concentrations above those measured at NSB-NLON. Some of the iron and manganese may originate from wastes, however, the majority of what is detected in surface water is probably being leached from native soils. Of note are the ARAR exceedances in the Thames River at sample locations 2DSW12 for manganese and iron, and at 2DWS13 for manganese. **These samples were collected approximately ten feet away from the outfalls of the Area A downstream watercourses.** Area A upstream surface water samples also contained elevated levels of iron and manganese, whereas surface water samples in the Thames River at DRMO and Goss Cove did not contain levels above ARARs. The iron standard of 1000 ppb is based upon chronic aquatic toxicity WQC and the manganese standard is based upon WQC for human health risks from fish consumption.

Copper **and zinc were** detected in concentrations above background **in soils at** the Area A Landfill. Copper **and zinc are** found naturally in surface waters, and concentrations above **water quality standards** have been measured at several sampling locations in Connecticut (USGS, 1991) **and in the upgradient sample location (2WSW1).** However, **until an**

TABLE 4–40
AREA A WETLANDS AND DOWNSTREAM
SUMMARY OF SURFACE WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	2DSW1	2DSW2	2DSW3	2DSW4	2DSW5	2DSW7	2DSW8	2DSW9
TCL VOLATILE ORGANICS (ppb)										
Carbon Disulfide	--		ND	ND	ND	ND	3 J	ND	ND	ND
Tetrachloroethene	8.85 ARAR	WQC	ND	ND	ND	ND	ND	ND	3 J	ND
Ethylbenzene	3280 ARAR	WQC	ND	ND	ND	ND	ND	1 J	3 J	ND
Styrene	--		ND	ND	ND	ND	ND	ND	2 J	ND
Xylene (total)	--		ND	ND	ND	ND	ND	ND	6 Y	ND
Total Volatile Organics							3	1	14	
TCL SEMI–VOLATILE ORGANICS (ppb)										
TCL Semi–Volatile Organics	--		ND J	ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)										
44'DDD	0.00084 TBC	WQS	ND	ND	ND	1.9 XJ	ND J	ND	ND	ND

PARAMETER	ARARs/TBC	SAMPLE ID:	2DSW10	2DSW11	2DSW12	2DSW13	2WSW1	2WSW2	7SW1
TCL VOLATILE ORGANICS (ppb)									
Carbon Disulfide	--		ND	ND	2 J	ND	ND	ND	ND
Tetrachloroethene	8.85 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	3280 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND
Styrene	--		ND	ND	ND	ND	ND	ND	ND
Xylene (total)	--		ND	ND	4 JY	2 JY	ND	ND	ND
Total Volatile Organics					6	2			
TCL SEMI–VOLATILE ORGANICS (ppb)									
TCL Semi–Volatile Organics	--		ND	ND	ND	ND	ND	ND	ND
TCL PESTICIDES/PCBs (ppb)									
44'DDD	0.00084 TBC	WQS	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4-41
AREA A WETLANDS AND DOWNSTREAM
SUMMARY OF SURFACE WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	ARARs/TBC	SAMPLE ID:	2DSW1	2DSW2	2DSW3	2DSW4	2DSW5	2DSW7	2DSW8	2DSW9
TAL INORGANICS (ppb)										
Aluminum	--		99 B	104 BJ	87 BJ	159 B	35.3 BJ	71.2 BJ	95.6 BJ	116 BJ
Antimony	1600 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.14 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND	ND
Barium	--		37.9 B	35.6 B	36 B	29.8 B	41.1 B	36.3 B	35 B	35.8 B
Beryllium	0.13 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	0.66 ARAR	WQS	ND	ND	ND	2.1 B	ND	ND	ND	ND
Calcium	--		13600	13000	13200	15000	32000	14200	14000	14300
Chromium	11 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND	ND
Copper	4.8 ARAR	WQS	8.4 BJ	12.6 BJ	9 BJ	9.4 BJ	9.6 BJ	11.7 BJ	10.5 BJ	11.4 BJ
Iron	1000 ARAR	WQC	3040	3250	3490	5670	3170	2890	2660	2980
Lead	1.3 ARAR	WQS	ND	5.6 J	3.6 BJ	ND	2.2 BJ	5.2 J	4.7 BJ	7 J
Magnesium	--		4570 B	4490 B	4510 B	5350	17900	4490 B	4350 B	4430 B
Manganese	100 ARAR	WQC	172	175	179	639	1510	174	166	172
Mercury	0.012 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND	1.5 J
Nickel	88 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND	ND
Potassium	--		8660 J	8040 J	7740 J	5570 J	8470 J	7590 J	7580 J	7880 J
Selenium	5 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.12 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	--		37500	88900	90200	96000	64000	86300	82900	83800
Thallium	6.3 ARAR	WQS	ND	ND J	ND J	ND	ND J	ND J	ND J	ND J
Vanadium	--		ND	ND	ND	ND	ND	ND	ND	ND
Zinc	12.3 ARAR	WQS	13.2 BJ	19.4 BJ	18 BJ	12 BJ	16 BJ	22.4 J	18.4 BJ	19.5 BJ
Boron	--		2200	1600	1600	1600	3300	1800	1700	2000
Cyanide	5.2 ARAR	WQS	ND	ND J	ND J	ND	ND J	ND J	ND J	ND J
RADIOLOGICAL CONSTITUENTS (pCi/L)										
Gross Alpha	--		NA	NA	1.1	NA	1.0	NA	NA	NA
Gross Beta	--		NA	NA	9.8	NA	9.2	NA	NA	NA

TABLE 4-41 (continued)
AREA A WETLANDS AND DOWNSTREAM
SUMMARY OF SURFACE WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICALS)

PARAMETER	ARARs/TBC	SAMPLE ID:	2DSW10	2DSW11	2DSW12	2DSW13	2WSW1	2WSW2	7SW1
TAL INORGANICS (ppb)									
Aluminum	--		148 BJ	71.4 BJ	164 BJ	69.2 BJ	137 B	153 B	356
Antimony	1600 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.14 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND
Barium	--		ND	34.1 B	23.4 B	23.4 B	22.3 B	23.8 B	30.5 B
Beryllium	0.13 ARAR	WQS	ND	ND	ND	ND	ND	ND	ND
Cadmium	0.66 ARAR	WQS	ND	ND	ND	ND	13.7	126 J	ND
Calcium	--		9240	27200	27500	47200	7890	10000	32700
Chromium	11 ARAR	WQC	ND	ND	ND	ND	6.8 B	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND
Copper	4.8 ARAR	WQS	10 BJ	11.4 BJ	9.5 BJ	9.2 BJ	13 BJ	13.2 BJ	16.2 BJ
Iron	1000 ARAR	WQC	711 J	2340	1880	854	293 J	4010 J	558
Lead	1.3 ARAR	WQS	5.2 J	2.8 BJ	ND J	ND J	7.8	2 B	4.4 B
Magnesium	--		1920 B	13600	51600	97300	2070 B	4350 B	2440 B
Manganese	100 ARAR	WQC	136	1030	115 J	589	52 J	136	32.1 J
Mercury	0.012 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND
Nickel	88 ARAR	WQS	ND	ND	ND	ND	ND	7.3 B	ND
Potassium	--		2680 BJ	7040 J	20300	31300	4020 BJ	7990 J	4270 BJ
Selenium	5 ARAR	WQS	ND	ND	ND	1.4 B	ND	ND	1.2 BJ
Silver	0.12 ARAR	WQC	ND	ND	ND	ND	ND	ND	ND
Sodium	--		30200	26000	444000	902000	22100	56700	9150
Thallium	6.3 ARAR	WQS	ND J	ND J	ND J	ND J	ND	ND	ND
Vanadium	--		ND	ND	ND	ND	ND	ND	ND
Zinc	12.3 ARAR	WQS	17.1 B	18 BJ	16.9 BJ	13.9 BJ	22.8 J	19.6 BJ	54.1
Boron	--		1200	3300	9100	16000	1700	2100	2000
Cyanide	5.2 ARAR	WQS	ND J	ND J	ND J	ND J	ND	ND	ND
RADIOLOGICAL CONSTITUENTS (pCi/L)									
Gross Alpha	--		NA	NA	NA	NA	0.4	0.7	NA
Gross Beta	--		NA	NA	NA	NA	1.6	6.9	NA

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/- range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4-2 or glossary for further explanation.

upgradient source can be verified, it is assumed that the elevated concentrations originate from the Area A Landfill.

Cadmium and lead are present above levels normally seen in natural surface waters and are present both in the Area A wetlands and landfill soils and sediments. The presence may be the result of historical disposal activities. However, cadmium and lead were detected in the upgradient sample location (**2WSW1**) above ARARs.

Mercury was only detected in one surface water sample (2DSW9). This location (adjacent to Triton Road) is immediately downgradient of two sediment sampling locations where mercury was found. Although these two sediment mercury concentrations were below background, mercury was not detected in all other sediment samples. There was one occurrence of mercury above background concentrations in Area A Landfill soils. Mercury is rarely found in natural surface waters above 1 ppb. The source of the mercury in sediments is not apparent, however, historical disposal in Area A Landfill is possible. It is more likely that past spillage upgradient of sample locations 2DSD7 and 2DSD8 along Triton Road occurred. It is noted that sediment sample 7SD1, within a runoff swale from the Torpedo Shop, contained no mercury, nor did any other soil or ground water sample at the Torpedo Shop.

All of the radiological results were below ARAR screening values.

4.11.7 Perimeter Security Road Sediment and Surface Water Sampling

A total of three surface and sediment samples each were collected at locations as shown on Figure 4-25. These samples were collected to determine if there has been any offsite migration by sediment or surface water transport at this stream location. The analytical program for offsite sampling is summarized in Section 2.0, Table 2-9 (sediment) and Table 2-12 (surface water).

4.11.7.1 Sediment

Sediment analytical results are summarized in Tables 4-42 (organics) and 4-43 (inorganics).

VOCs were not detected in any of the sediment samples.

PAHs (phenanthrene, fluoranthene and pyrene) were detected at low levels in the three samples. Concentrations decreased as sample locations moved downstream.

Pesticides (DDD and DDE) were detected in the two upstream samples with concentrations decreasing as sample locations moved downstream. These concentrations are probably due to historical pesticide application at NSB-NLON.

Metals were only present above background concentrations at the upstream sample (OSSD3). This sample contained concentrations slightly above background of beryllium, selenium, and boron. There is no known apparent source of these materials.

TABLE 4–42
OFFSITE STREAM
SUMMARY OF SEDIMENT ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	OSSD1	OSSD2	OSSD3
TCL VOLATILE ORGANICS (ppb)					
TCL Volatile Organics			ND	ND	ND
TCL SEMI–VOLATILE ORGANICS (ppb)					
Noncarcinogenic PAH					
Phenanthrene			ND	ND	89 J
Fluoranthene			57 J	80 J	120 J
Pyrene			ND J	ND	120 J
Total Noncarcinogenic PAH			57	80	329
TCL PESTICIDES/PCBs (ppb)					
4,4' DDE	500 TBC		ND	17 JX	ND
4,4' DDD	500 TBC		ND	28 JX	510 X

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Sections 4.2 and 4.3 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further information. NA indicates not analyzed.
5) Only the parameters detected for volatile organics and semi–volatile organics are listed above, all others were not detected.

TABLE 4–43
OFFSITE STREAM
SUMMARY OF SEDIMENT ANALYTICAL DATA (INORGANICS)

PARAMETER	BACKGROUND	SAMPLE ID:	OSSD1	OSSD2	OSSD3
TAL INORGANICS (ppm)					
Aluminum	272000		10200	8640	25400
Antimony	2.95		ND J	ND J	ND J
Arsenic	31.5		1.9 B	2.9 B	2.1 B
Barium	1600		47	61.3 B	218
Beryllium	3.52		0.84 B	1.9	4
Cadmium	7		2.6	3.6	3.7
Calcium	32300		923 B	1280 B	2990
Chromium	223		12.7	12.6	47.2
Cobalt	39		5.4 B	9.4 B	6.9 B
Copper	102		20.8	8.3 B	43.8
Iron	115000		12000	16200	17000
Lead	53.2		52	23.8	21.2
Magnesium	26500		2590	2020	2640
Manganese	3790		309 J	1050 J	704 J
Mercury	0.51		ND	ND	ND
Nickel	76.7		10.7 J	13.2 BJ	19.2 J
Potassium	12000		1330	708 B	1680 B
Selenium	1.79		0.3 B	0.94 B	4.1
Silver	5		ND	ND	ND
Sodium	51800		105 BJ	106 BJ	181 BJ
Thallium	5		ND	ND	ND
Vanadium	271		21.3	37	35.4
Zinc	178		50.3	55.8	54.8
Boron	109		46.3	76.1	259
Cyanide	--		ND	ND	ND

NOTES:

1) Background values are discussed in Section 4.3. Shaded numbers exceed background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

4.11.7.2 Surface Water

Surface water analytical results are presented in Table 4-44 (organics) and 4-45 (inorganics).

Other than 4 ppb of chloromethane in OSSW2, no VOCs were detected. It is of interest to note that chloromethane was noted in the first residential well sampling round at OSW1, however, it was not detected in the second sampling round.

No SVOs, PCBs, or pesticides were detected in surface water samples.

ARARs/TBCs were slightly exceeded for lead at OSSW1, **OSSW2, and OSSW3**, for cadmium at OSSW2, **for zinc at OSSW1 and OSW3** and for manganese at OSSW3. There is no correlation between upstream and downstream concentrations. The ARARs exceeded are based on in-stream water quality criteria **or standards** to protect aquatic life.

4.12 DRMO

The Step II field investigation at this site consisted of radiation, geophysical, and soil gas surveys. Test borings, ground water monitoring wells, and soil, surface water, and ground water sampling and analysis were also conducted.

4.12.1 Radiation

At this site, 372 measurements were made. All were well within what is considered normal background radiation for this region. No measurement in this area exceeded 17 μR/hr. The complete Radiological Assessment Report is provided in a separate bound report.

Grid survey points for radiation, geophysics, and soil gas surveys are shown on Figure 4-26.

4.12.2 Geophysics

GPR, magnetometry, and EM conductivity data were obtained to characterize subsurface conditions at the DRMO area. Extensive surface metal (buildings, objects awaiting auction, utilities) were present at this site, thus limiting the applicability of EM and magnetic methods.

Background magnetic values at this area should be in the vicinity of 55,000 to 56,000 gammas. Values at this site vary considerably from background even in areas relatively free of surface metal. Consequently, buried metal objects are likely throughout large portions of the DRMO area.

Based on a combination of GPR, magnetometry, and EM conductivity data, potential locations of significant buried metal objects are at the following grid points as shown on Figure 4-26: 16A, 19B (10$\pm$ feet south along line B) and 21C.

TABLE 4–44
OFFSITE STREAM
SUMMARY OF SURFACE WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	OSSW1	OSSW2	OSSW3
TCL VOLATILE ORGANICS (ppb)					
Chloromethane			ND	4 J	ND
Total Volatile Organics				4	
TCL SEMI–VOLTILE ORGANICS (ppb)					
TCL Semi–Volatile Organics			ND	ND	ND
TCL PESTICIDES/PCBs (ppb)					
4,4' DDE	0.00059 ARAR		ND	ND	ND

NOTES:

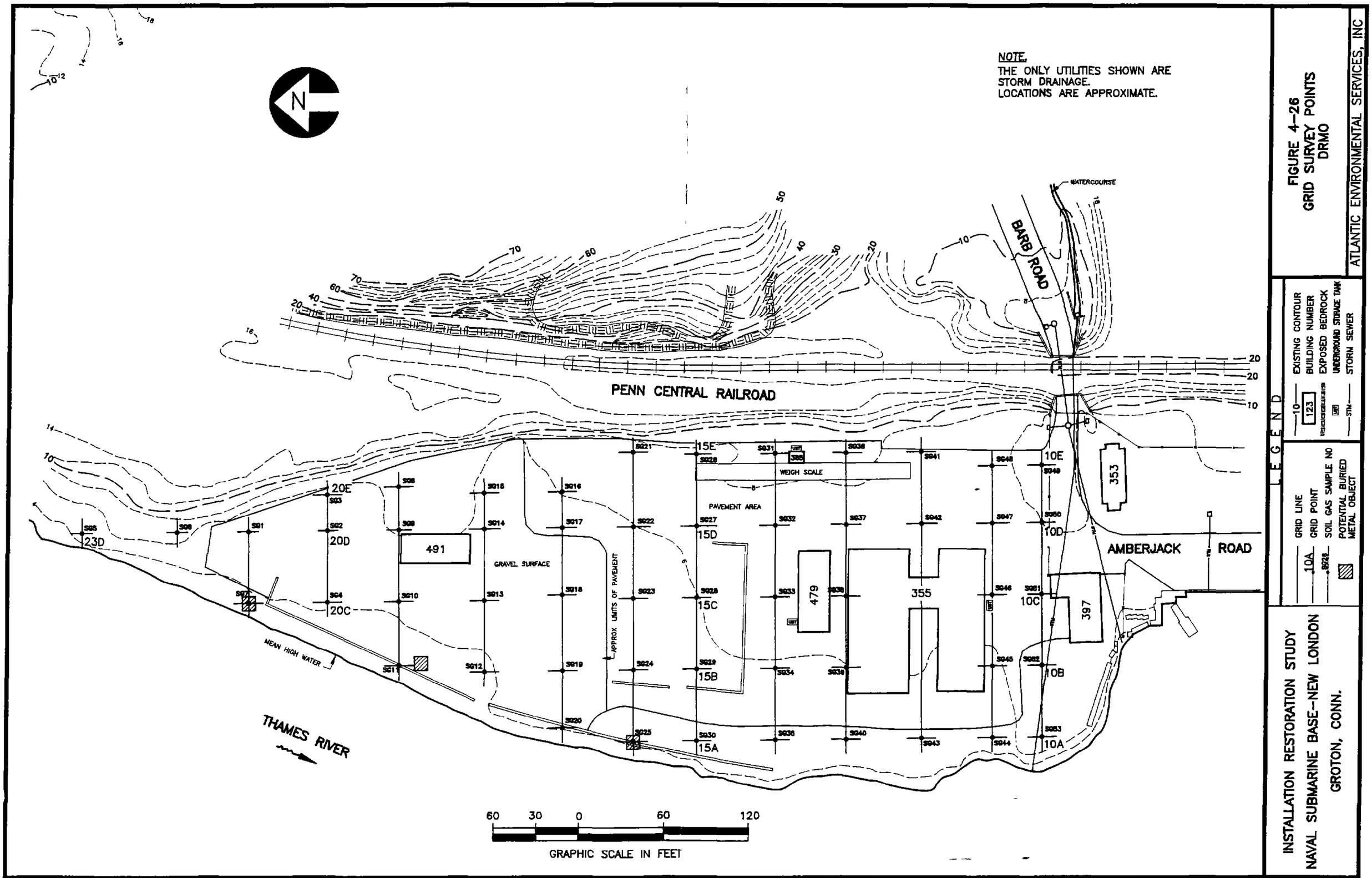
1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–45
OFFSITE STREAM
SUMMARY OF SURFACE WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	OSSW1	OSSW2	OSSW3
TAL INORGANICS (ppb)					
Aluminum	--		688	143 BJ	103 BJ
Antimony	1600 ARAR	WQC	ND	ND	ND
Arsenic	0.14 ARAR	WQS	ND	ND	ND
Barium[7]	--		17 B	19.1 B	20.2 B
Beryllium	0.013 ARAR	WQS	ND	ND	ND
Cadmium	0.66 ARAR	WQS	ND J	3.2 BJ	ND J
Calcium	--		4010 B	4170 B	5080
Chromium[7]	11 ARAR	WQC	ND J	ND J	ND J
Cobalt	--		ND J	ND J	ND J
Copper[7]	4.8 ARAR	WQS	ND J	ND J	ND J
Iron	1000 ARAR	WQC	655	247	618
Lead	1.3 ARAR	WQS	4.4 BJ	3.2 B	2.6 BJ
Magnesium	--		1120 B	1190 B	1430 B
Manganese	100 ARAR	WQC	66.9	95.1	300
Mercury	0.012 ARAR	WQC	ND	ND	ND
Nickel	88 ARAR	WQS	ND J	ND J	ND J
Potassium	--		ND J	601 BJ	861 BJ
Selenium[7]	5 ARAR	WQS	ND	ND	ND
Silver[7]	0.12 ARAR	WQC	ND J	ND J	ND J
Sodium	--		3350 B	3490 B	3410 B
Thallium	6.3 ARAR	WQS	ND	ND	ND
Vanadium	--		ND	ND	ND
Zinc	12.3 ARAR	WQS	17.8 BJ	10.3 BJ	14.6 BJ
Boron	--		1080	1070	1030
Cyanide[7]	5.2 ARAR	WQS	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.


NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE.
LOCATIONS ARE APPROXIMATE.
N
WATERCOURSE
BARB ROAD
PENN CENTRAL RAILROAD
AMBERJACK ROAD
THAMES RIVER
MEAN HIGH WATER
WEIGH SCALE
PAVEMENT AREA
GRAVEL SURFACE
APPROX LIMITS OF PAVEMENT
491
479
355
397
353
23D
20E
20D
20C
15E
15D
15C
15B
15A
10E
10D
10C
10B
10A
60 30 0 60 120
GRAPHIC SCALE IN FEET
FIGURE 4-26
GRID SURVEY POINTS
DRMO
ATLANTIC ENVIRONMENTAL SERVICES, INC
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXPOSED BEDROCK
UNDERGROUND STORAGE TANK
STORM SEWER
GRID LINE
GRID POINT
SOIL GAS SAMPLE NO
POTENTIAL BURIED METAL OBJECT
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

00172102

The complete geophysical report is provided in a separate bound report.

4.12.3 Soil Gas

A total of 53 soil gas samples were analyzed, approximately half of which were under pavement.

High to moderate levels of VOCs were detected at SG23 and SG28. Benzene, toluene and trichloroethene were detected. These results correlate well with the soil analytical data for 6TB4, which was located near SG23. As subsequently reported in this section, high levels of trichloroethene were detected in the soil samples at this location, including other solvents and petroleum hydrocarbons.

Moderate levels of trichloroethene, and trace levels of tetrachlorethene were detected at SG2, located approximately 50 feet north of Building 491. Although no test boring was drilled at this location, other sampling points in the vicinity (6TB6, 6TB7, 6SS1C) did not detect significant concentrations of VOCs.

There was also many trace to low levels of benzene, toluene, and tetrachloroethene scattered about the site.

A review of the soil gas and geophysical data does not suggest that the detection of any significant buried metal objects correlate with any high soil gas measurements.

Figure 4-27 depicts relative concentrations of total soil gas VOC concentration for the site. Complete soil gas data tables for this site are provided in Appendix A.

4.12.4 Subsurface and Surface Soil

Twenty-four soil samples were collected from 12 test boring/monitoring well locations at this site. Four surface soil samples were also collected and analyzed. The goal of the soil sampling program was to further define the extent of soil contamination at this site, as a follow-up to the previous Step I study. Sample locations are shown on Figure 4-28. The site analytical program for the soil samples is summarized in Section 2.0, Table 2-7.

Some evidence of the former landfill was encountered during the drilling, including wood fragments, brick, metal, but predominantly earth fill material. The depth of fill varied from five to 20 feet. Field measured organic vapor (HNu) levels above background were detected in about half of the borings.

Analytical results are summarized for subsurface soils in Tables 4-46 (organics) and 4-47 (inorganics) and for surface soils in Tables 4-48 (organics) and 4-49 (inorganics). Figures 4-29 and 4-30 provide bar graphs of total VOC/SVO, and pesticide/PCB concentrations, respectively, in soil at 0-2 feet, 2-6 feet, and 6-10 feet intervals, respectively. The bar graphs are oriented generally from the north to the south on the site to illustrate spatial distribution of chemical

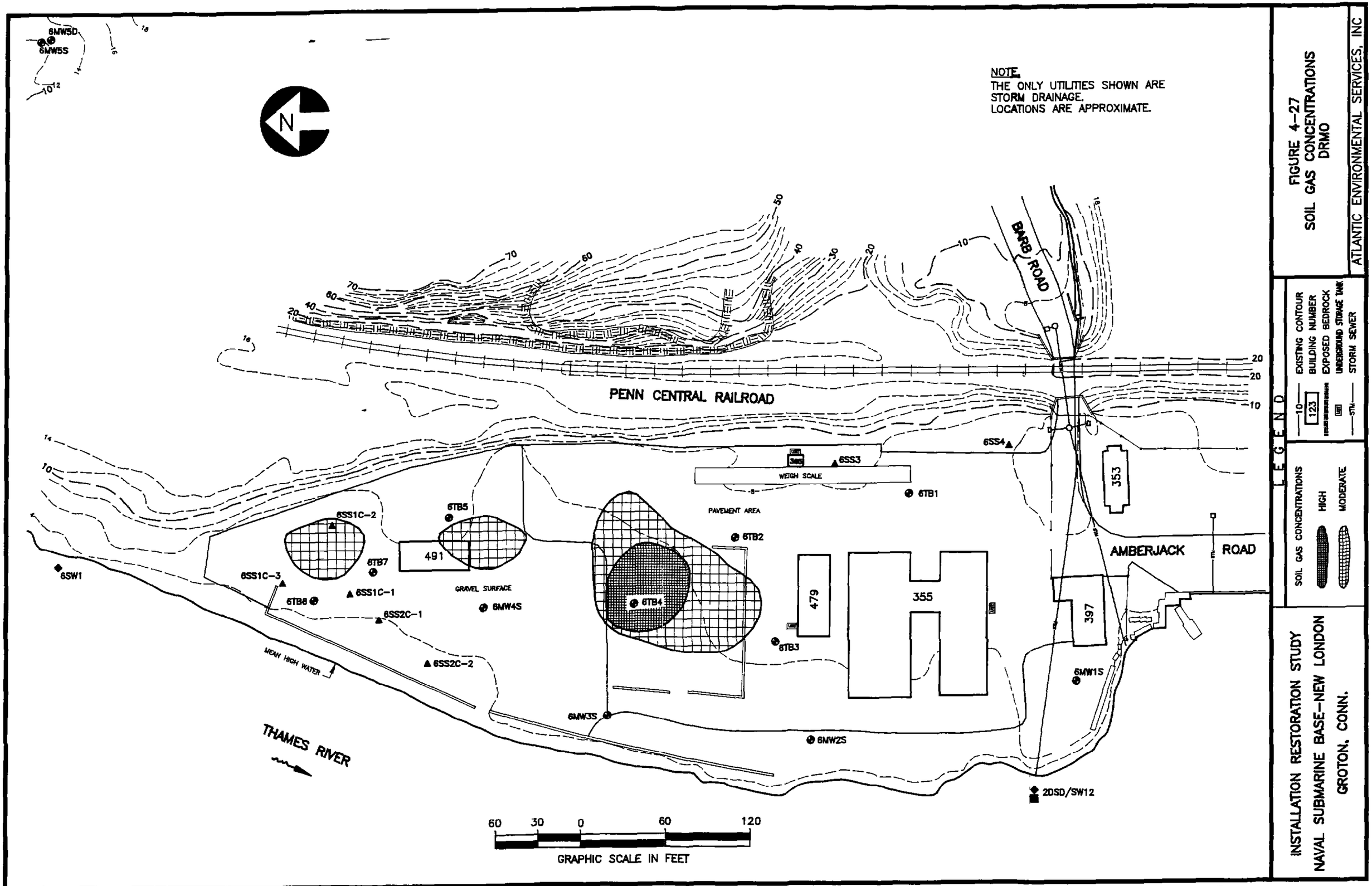
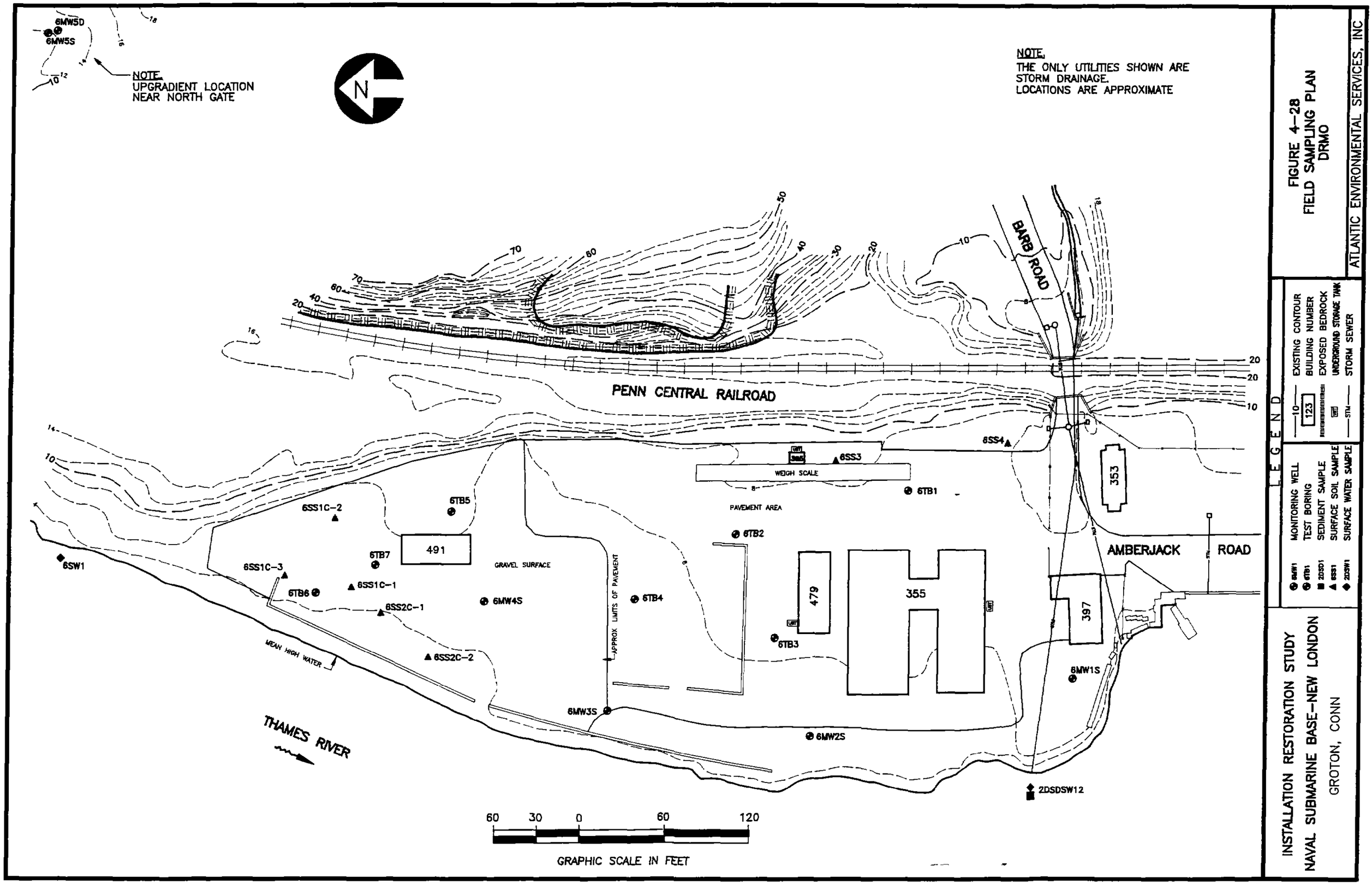


FIGURE 4-27
SOIL GAS CONCENTRATIONS
DRMO

ATLANTIC ENVIRONMENTAL SERVICES, INC

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

00172112


6MW5D
6MW5S
NOTE.
UPGRADIENT LOCATION
NEAR NORTH GATE
N
NOTE.
THE ONLY UTILITIES SHOWN ARE
STORM DRAINAGE.
LOCATIONS ARE APPROXIMATE
BARB ROAD
PENN CENTRAL RAILROAD
6SS4
6SS3
WEIGH SCALE
6TB1
PAVEMENT AREA
6TB2
6TB5
6SS1C-2
6TB7
491
GRAVEL SURFACE
6SW1
6SS1C-3
6TB6
6SS1C-1
6SS2C-1
6MW4S
6TB4
APPROX. LIMITS OF PAVEMENT
MEAN HIGH WATER
6SS2C-2
6TB3
479
355
353
397
AMBERJACK ROAD
6MW1S
6MW3S
6MW2S
THAMES RIVER
2DSDSW12
60 30 0 60 120
GRAPHIC SCALE IN FEET
FIGURE 4-28
FIELD SAMPLING PLAN
DRMO
ATLANTIC ENVIRONMENTAL SERVICES, INC
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXPOSED BEDROCK
UNDERGROUND STORAGE TANK
STORM SEWER
MONITORING WELL
TEST BORING
SEDIMENT SAMPLE
SURFACE SOIL SAMPLE
SURFACE WATER SAMPLE
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN

00172122

TABLE 4–46
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	6MW1S	6MW1S	6MW2S	6MW2S	6MW3S	6MW3S	6MW4S	6MW4S	6MW5S	6MW5S	6TB1	6TB1
		DEPTH (ft):	0–2	4–6	0–2	2–4	0–2	2–4	0–2	2–4	0–2	8–10	0–2	2–4
TCL VOLATILE ORGANICS (ppb)														
Vinyl Chloride	2		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	2 J	ND	ND	1 J	ND
Acetone	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	--		ND	1 J	ND	ND	2 J	ND	2 J	ND	ND	ND	1 J	ND
1,1-Dichloroethane	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethene (total)	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	100		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2 Dichloroethane	1		ND	ND	ND	ND	22	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5		3 J	ND	ND	6	2 J	8	17	ND J	ND	ND	3 J	ND
1,1,2-Trichloroethane	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	1		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		1 J	ND	5 J	10	2 J	ND	4 J	35 J	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1000		ND	1 J	ND	ND	ND	ND	ND	ND	ND	ND	1 J	ND
Ethylbenzene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics			4	2	5	16	28	8	23	37			6	
TCL SEMI-VOLATILE ORGANICS (ppb)														
Noncarcinogenic PAH														
Naphthalene	--		ND	ND	ND	ND	ND	ND	ND	ND J	ND	ND	ND	ND J
2-Methylnaphthalene	--		ND	ND	ND	ND	ND	ND	ND	400 J	ND	ND	ND	ND J
Acenaphthylene	--		ND	ND	ND	89 J	ND	ND	210 J	ND	ND	ND	ND	140 J
Acenaphthene	--		ND	ND	ND	49 J	ND	ND	ND	ND	ND	ND	ND	ND J
Fluorene	--		ND	ND	ND	66 J	ND	ND	ND	180 J	ND	ND	ND	ND J
Phenanthrene	--		200 J	99 J	210 J	710	ND	620 J	1400 J	860 J	ND	ND	55 J	ND J
Anthracene	--		39 J	ND	ND	190 J	ND	ND	430 J	250 J	ND	ND	ND	52 J
Fluoranthene	--		330 J	190 J	490 J	1200	ND	900 J	3700	1600 J	ND	ND	66 J	110 J
Pyrene	--		370	190 J	430 J	1500	ND	600 J	4300	2900 J	ND	ND	140 J	210 J
Total Noncarcinogenic PAH			939	479	1130	3804		2120	10040	6190			261	512

TABLE 4-46 (continued)
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	6MW1S	6MW1S	6MW2S	6MW2S	6MW3S	6MW3S	6MW4S	6MW4S	6MW5S	6MW5S	6TB1	6TB1
		DEPTH (ft):	0-2	4-6	0-2	2-4	0-2	2-4	0-2	2-4	0-2	8-10	0-2	2-4
Probable Carcinogenic PAH														
Benzo(a)anthracene	--		190 J	110 J	240 J	710	ND	400 J	3200	980 J	ND	ND	100 J	110 J
Chrysene	--		190 J	150 J	250 J	730	ND	460 J	3000	1400 J	ND	ND	93 J	210 J
Benzo(b)fluoranthene	--		210 JY	160 JY	380 JY	1000 Y	ND	520 JY	2700 Y	1400 JY	ND	ND	150 JY	600 Y
Benzo(k)fluoranthene	--		88 JY	65 JY	240 JY	300 JY	ND	390 JY	4000 Y	1300 JY	ND	ND	47 JY	100 JY
Benzo(a)pyrene	--		ND	ND	ND	780	ND	480 J	4000	1800 J	ND	ND	ND	320 J
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	680	ND	410 J	3600	ND J	ND	ND	ND	300 J
Dibenz(a,h)anthracene	--		ND	ND	ND	130 J	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	--		ND	ND	ND	610	ND	340 J	3600	1800 J	ND	ND	ND	370 J
Total Probable Carcinogenic PAH			678	485	1110	4940		3000	24100	8680			390	2010
Phthalates														
bis(2-ethylhexyl)phthalate	--		ND	ND	ND	ND	ND	460 J	ND	7700 J	ND	ND	ND	ND J
Other Semi-Volatile Organics														
4-Methylphenol	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND J
Dibenzofuran	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND J
N-Nitrosodiphenylamine	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND J
TCL PESTICIDES/PCB (ppb)														
Aroclor-1260	10000		ND	ND	ND	ND	ND J	2200 XJ	2400 X	2900 X	ND	ND	ND	450 XJ
44'-DDE	--		ND	ND	ND	ND	ND J	ND J	ND	ND	ND	ND	ND	ND
44'-DDD	--		ND	ND	ND	ND	ND J	ND J	ND	ND	ND	ND	ND	ND
44'-DDT	500		ND	ND	ND	ND	ND J	ND J	ND	ND	ND	ND	ND	ND

TABLE 4–46 (continued)
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: DEPTH (ft):	6TB2 0–2	6TB2 2–4	6TB3 0–2	6TB3 6–8	6TB4 0–2	6TB4 6–8	6TB5 0–2	6TB5 2–6	6TB6 0–2	6TB6 2–4	6TB7 0–2	6TB7 2–4
TCL VOLATILE ORGANICS (ppb)														
Vinyl Chloride	2		ND	ND	ND	ND	ND	1300 EYJ	ND	ND	ND	ND	ND	ND
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	ND	1 J	3	ND	ND
Acetone	--		ND	ND	ND	ND	ND	350 J	ND	71	ND	ND	ND	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	48 J	2 J	6	ND	4	ND	ND
1,1-Dichloroethane	--		ND	ND	ND	ND	ND	13 J	ND	ND	ND	ND	ND	ND
1,2-Dichloroethene (total)	--		ND	ND	ND	ND	ND	32000 DY	6	1 J	ND	ND	ND	6 J
Chloroform	100		ND	ND	ND	ND	ND	14 J	ND	ND	ND	ND	ND	ND
1,2 Dichloroethane	1		ND	ND	ND	ND	ND	1900 EJ	ND	ND	ND	ND	ND	ND
Trichloroethene	5		1 J	1 J	3 J	5 J	2 J	20000 D	ND	2 J	ND	ND	ND	25 J
1,1,2-Trichloroethane	--		ND	ND	ND	ND	ND	590 EJ	ND	ND	ND	ND	ND	ND
Benzene	1		ND	ND	ND	ND	ND	7 J	ND	ND	2 J	2 J	ND	ND
Tetrachloroethene	5		8	8	ND	ND	19	210 J	16 J	6	32	23	3 J	5 J
1,1,2,2-Tetrachloroethane	--		ND	ND	ND	ND	ND	34000 D	ND	ND	ND	ND	ND	ND
Toluene	1000		ND	ND	ND	ND	ND	43	5 J	2 J	13	14	ND	ND
Ethylbenzene	--		ND	ND	ND	ND	ND	44	ND	ND	4 J	10	ND	ND
Xylene (total)	--		ND	ND	ND	ND	ND	760 DYJ	ND	ND	33 X	74 Y	ND	ND
Total Volatile Organics			9	9	3	5	21	91279	29	88	85	130	3	36
TCL SEMI-VOLATILE ORGANICS (ppb)														
Noncarcinogenic PAH														
Naphthalene	--		ND	ND	ND	ND	ND J	6500	ND J	ND	ND	ND	ND	130 J
2-Methylnaphthalene	--		ND	ND	ND	ND	ND J	1700 J	ND J	ND	250 J	480 J	ND	ND
Acenaphthylene	--		ND	ND	ND	ND	ND J	ND	ND J	370 J	ND	ND	ND	130 J
Acenaphthene	--		ND	ND	ND	ND	ND J	330 J	ND J	650 J	ND	190 J	ND	180 J
Fluorene	--		ND	ND	ND	ND	ND J	ND	ND J	1000 J	ND	200 J	ND	240 J
Phenanthrene	--		ND	ND	440 J	290 J	ND J	840 J	980 J	5700 J	210 J	1100 J	ND	2800
Anthracene	--		ND	ND	ND	ND	ND J	ND	180 J	1600 J	ND	230 J	ND	740 J
Fluoranthene	--		ND	ND	1100 J	690 J	1100 J	810 J	1300 J	8300 J	330 J	1500 J	330 J	4500
Pyrene	--		ND	ND	1100 J	660 J	ND J	850 J	800 J	6200	480 J	1600 J	270 J	6500
Total Noncarcinogenic PAH					2640	1640	1100	11030	3260	23820	1270	5300	600	15220

TABLE 4-46 (continued)
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	6TB2	6TB2	6TB3	6TB3	6TB4	6TB4	6TB5	6TB5	6TB6	6TB6	6TB7	6TB7
		DEPTH (ft):	0-2	2-4	0-2	6-8	0-2	6-8	0-2	2-6	0-2	2-4	0-2	2-4
Probable Carcinogenic PAH														
Benzo(a)anthracene	--		ND	ND	600 J	440 J	ND J	450 J	590 J	4600	200 JY	1000 J	280 J	3800
Chrysene	--		ND	ND	750 J	390 J	ND J	440 J	470 J	4200	230 J	920 J	230 J	3200
Benzo(b)fluoranthene	--		ND	ND	840 JY	480 JY	ND J	ND	550 JY	4700 Y	ND	860 JY	290 JY	2000 Y
Benzo(k)fluoranthene	--		ND	ND	540 JY	ND	ND J	ND	580 JY	3800 Y	ND	830 JY	ND	3200 Y
Benzo(a)pyrene	--		ND	ND	680 J	ND	ND J	ND	580 J	4500	ND	990	ND	3100
Indeno(1,2,3-cd)pyrene	--		ND	ND	ND	ND	ND J	ND	ND J	3200	ND	ND	ND	2700
Dibenz(a,h)anthracene	--		ND	ND	ND	ND	ND J	ND	ND J	790 J	ND	ND	ND	ND
Benzo(g,h,i)perylene	--		ND	ND	ND	ND	ND J	ND	ND J	2800	ND	ND	ND	2700
Total Probable Carcinogenic PAH					3410	1310		890	2770	28590	430	4600	800	20700
Phthalates														
bis(2-ethylhexyl)phthalate	--		340	ND	3500	ND	ND	ND	290 J	1100 J	400	900	ND	430 J
Other Semi-Volatile Organics														
4-Methylphenol	--		ND	ND	ND	ND	ND	790 J	ND J	ND	ND	ND	ND	ND
Dibenzofuran	--		ND	ND	ND	ND	ND	ND	ND J	300 J	ND	ND	ND	120 J
N-Nitrosodiphenylamine	--		ND	ND	ND	ND	ND	ND	ND J	ND	400	280	ND	ND
TCL PESTICIDES/PCB (ppb)														
Aroclor-1260	10000		11000 XJ	12000 XJ	3200 XJ	ND J	2100 XJ	ND J	5100 XJ	ND J	250 X	2200 X	ND	52 JX
44'-DDE	--		ND J	ND J	ND J	ND J	ND J	ND J	ND J	8800 XJ	ND	ND	ND	ND
44'-DDD	--		ND J	ND J	ND J	ND J	ND J	ND J	ND J	16000 XJ	ND	ND	ND	ND
44'-DDT	500		ND J	ND J	ND J	ND J	ND J	ND J	ND J	33000 XJ	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4-47
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	6MW1S 0-2	6MW1S 4-6	6MW2S 0-2	6MW2S 2-4	6MW3S 0-2	6MW3S 2-4	6MW4S 0-2	6MW4S 2-4	6MW5S 0-2	6MW5S 8-10	6TB1 0-2	6TB1 2-4
TAL INORGANICS (ppm)														
Aluminum	272000		9740	9630	9030	10700	7670	10300	7030	8400	12800	4880	14500	10800
Antimony	2.95		ND R	ND R	2 BJ	4.1 BJ	ND R	ND R	19.2 J	ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		3.4 J	7.5 J	3.4 J	1.5 BJ	3	3.7	2.3	2.6	1.2 BJ	1.9 BJ	1.5 BJ	1.6 BJ
Barium	1600		57.3	111	72.7	84.1	154 J	200 J	174	170	69.8	28 B	141	111
Beryllium	3.52		0.38 B	0.37 B	0.41 B	0.54 B	1.9 J	8.1 J	0.79 B	0.54 B	0.3 B	ND	0.39 B	1.8
Cadmium	7		2.4	3.1	4	2.2	10.8 J	15.1 J	6.7	6.4	2.9	1 B	4.1	3.9
Calcium	32300		1820	2480	1490	2070	3850 J	9500 J	2750	3160	1770	981 B	2760	2030
Chromium	223		15.2	19.4	12.9 J	14.5 J	36.9 J	110 J	55 J	139 J	20.7	6.2	35	29.6
Cobalt	39		5.4 B	9.1 B	5.3 B	8.4 B	19 J	106 J	9.3 B	6.7 B	12.8	3.5 B	12.9	14.6
Copper	102		33.9 J	32 J	22.6 J	33.5 J	599	3020	513	380	32.8 J	10.6 J	59.7	227
Iron	115000		10600	18000	11600	16600	22000 J	64200 J	13400	12400	17000	6480	17800	16800
Lead	53.2		91.3	37.3	459	8.8 J	715	8130	390	245	2.9 J	2.3 J	27.6 J	168 J
Magnesium	26500		2280	4660	2470	5630	3090	5670	2750	2450	6990 J	2070	7010	5000
Manganese	3790		199 J	312 J	132 J	360 J	272 J	736 J	220	268	237 J	155 J	270 J	272 J
Mercury	0.51		0.15 J	ND	0.14	ND	0.74 J	0.4 J	0.35	0.31	ND	ND	0.14 J	0.19 J
Nickel	76.7		10.8	13.4	12.5	14.6	107 J	388 J	25.3	30.8	15.3	7.5 B	22.9	30
Potassium	12000		1170	4050	1070 B	3810	1630	1240	2040	1200	2650	1730	5150	3770
Selenium	1.79		ND	ND	ND	ND	ND J	0.68 BJ	ND J	ND J	ND	ND	ND	ND
Silver	5		ND	ND	ND R	ND R	ND R	ND R	ND J	ND J	ND	ND	ND	ND
Sodium	51800		ND	628 BJ	279 BJ	842 BJ	575 BJ	1620 J	229 BJ	339 BJ	80.5 BJ	147 BJ	459 BJ	304 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		22.6	31.7	22.4	37.9	56.4	44	39.9	63.8	35.5	9 B	45.6	33.6
Zinc	178		133 J	117 J	51.7 J	101 J	1640 J	17400 J	839 J	573 J	34.2 J	25.6 J	59.1 J	676
Boron	109		ND	141	44	46	43	121	112	73	ND	ND	48	ND
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)														
PARAMETER	TBC													
Arsenic	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1		0.25	0.27	0.36	0.28	0.7	0.29	1.4	1.3	0.2	0.26	0.3	0.39
Cadmium	0.01		ND	ND	ND	ND	0.026	0.026	0.25	0.087	ND	ND	0.031	0.02
Chromium	0.05		ND	ND	ND	ND	ND	ND	ND	ND	0.062	0.11	ND	ND
Lead	0.05		ND	ND	ND J	ND	0.21	52 *	2.6 J	0.87 J	ND	ND	ND	0.2
Mercury	0.002		ND	ND	0.008 J	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.05		0.011 J	ND	ND	ND	ND	ND	ND J	ND J	0.01 J	0.029 J	0.012 J	ND

TABLE 4-47 (continued)
DRMO
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	6TB2 0-2	6TB2 2-4	6TB3 0-2	6TB3 6-8	6TB4 0-2	6TB4 6-8	6TB5 0-2	6TB5 2-6	6TB6 0-2	6TB6 2-4	6TB7 0-2	6TB7 2-4
TAL INORGANICS (ppm)														
Aluminum	272000		7050	5840	6430	5470	5190	11700	3870	6840	7190	8730	12100	7730
Antimony	2.95		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R
Arsenic	31.5		2.4	3.3	2 B	1.1 B	2.9	6.5	2 B	2.1 B	1.4 B	3.1	1.8 B	2.6
Barium	1600		68.1	28 B	56.9	54.4	140	33.4 B	26.9 B	56.2	71.9	392	257	137
Beryllium	3.52		0.87 B	0.22 B	0.22 B	ND	0.31 B	0.52 B	0.45 B	1.3	0.25 B	1.2	3.3	1.2
Cadmium	7		2.4 J	1.7 J	2.6 J	2.2 J	5.8 J	4.9 J	2.5 J	8.3 J	6.2	14.6	6.6	6.6
Calcium	32300		1830	1040 J	1050 BJ	1270 BJ	2990	2690	1010 BJ	13000	2880	5850	4960	5690
Chromium	223		15.2	11	13.1	16.1	16.9	29	9	118	15.9 J	67.4 J	61.6 J	36.5 J
Cobalt	39		8.4 B	5 B	5 B	6.3 B	5.4 B	7.8 B	5.4 B	13.1	8.8 B	18.7	72.1	19.7
Copper	102		65.6 J	26.3 J	67.5 J	39.2 J	120 J	20.4 J	105 J	12800 J	312	2730	1230	1040
Iron	115000		10500	7350	8550	10000	11300	21400	8090	35400	12200	30500	39700	25700
Lead	53.2		40.9 J	5.6 J	63.4 J	16.6 J	652 J	8.4 J	514 J	811 J	30.3 J	563	754	545
Magnesium	26500		2700	1820	2220	3350	1870	6360	1150	2330	4280	3960	7180	4600
Manganese	3790		181 J	126 J	169 J	291 J	163 J	213 J	112 J	490 J	204	281	488	331
Mercury	0.51		0.14 J	ND J	1.9 J	ND J	0.2 J	ND J	0.17 J	0.83 J	0.12	0.31	0.32	0.31
Nickel	76.7		15	10.8	12.4	8.8 B	15.4	19.4	19.1	566	18.1	122	158	69.2
Potassium	12000		1920	1050	1720	2920	1240	3060	916 B	1120	1830	1540	3430	1850
Selenium	1.79		ND	ND	ND	ND	ND	1 B	ND	ND	ND J	1.5 J	0.58 BJ	ND J
Silver	5		ND J	ND J	ND J	ND J	2.4 J	ND J	ND J	ND J	ND J	7 J	ND J	ND J
Sodium	51800		171 BJ	146 BJ	151 BJ	1640 J	173 BJ	5860	98.9 BJ	382 BJ	307 BJ	790 BJ	559 BJ	793 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		18.5	11.8	16.1	19.3	17.2	32.5	9.4 B	17.5	29.3	88	42.9	56.2
Zinc	178		283 J	87.1 J	136 J	73.1 J	482 J	58.5 J	248 J	1210 J	138 J	2750 J	3700 J	1730 J
Boron	109		ND	ND	ND	ND	53	2810	ND	ND	58	260	112	106
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)														
PARAMETER	TBC													
Arsenic	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1		0.18	0.25	0.41	0.14	0.64	0.073	0.29	0.55	0.68	1.1	1	0.41
Cadmium	0.01		ND	ND	0.011	ND	0.028	ND	0.024	0.024	0.089	0.17	0.01	0.011
Chromium	0.05		0.11	0.08	0.05	0.093	ND	ND	ND	ND	ND	ND	ND	ND
Lead	0.05		ND	ND	0.11	ND	0.65	ND	2.2 J	32 *	1.4 J	3.1 J	2.6 J	1.4 J
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.05		ND	ND	ND	ND	ND	ND	ND	0.074 J	ND J	ND J	ND J	0.025 J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) * indicates RCRA characteristic hazardous waste level of 5 ppm exceeded.

TABLE 4–48
DRMO
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID: / DEPTH (ft):	6SS1C 0–0.5	6SS2C 0–0.5	6SS3 0–0.5	6SS4 0–0.5
TCL VOLATILE ORGANICS (ppb)						
Methylene Chloride	25		ND	2 J	2 J	ND
Trichloroethene	5		7 J	1 J	ND	ND
Tetrachloroethene	5		7 J	2 J	ND	ND
Total Volatile Organics			14	5	2	
TCL SEMI–VOLATILE ORGANICS (ppb)						
Noncarcinogenic PAH						
Phenanthrene	--		ND	840 J	250 J	ND
Fluoranthene	--		ND	1200 J	410 J	260 J
Pyrene	--		ND	940 J	410 J	180 JX
Total Noncarcinogenic PAH				2980	1070	440
Probable Carcinogenic PAH						
Benzo(a)anthracene	--		ND	570 J	240 J	ND
Chrysene	--		ND	560 J	270 J	ND
Benzo(b)fluoranthene	--		ND	ND	ND	440 JY
Benzo(k)fluoranthene	--		ND	ND	ND	310 JY
Total Probable Carcinogenic PAH				1130	510	750
TCL PESTICIDES/PCBs (ppb)						
Aroclor 1260	10000		550 XJ	1300 XJ	1400 XJ	3100 XJ

NOTES:

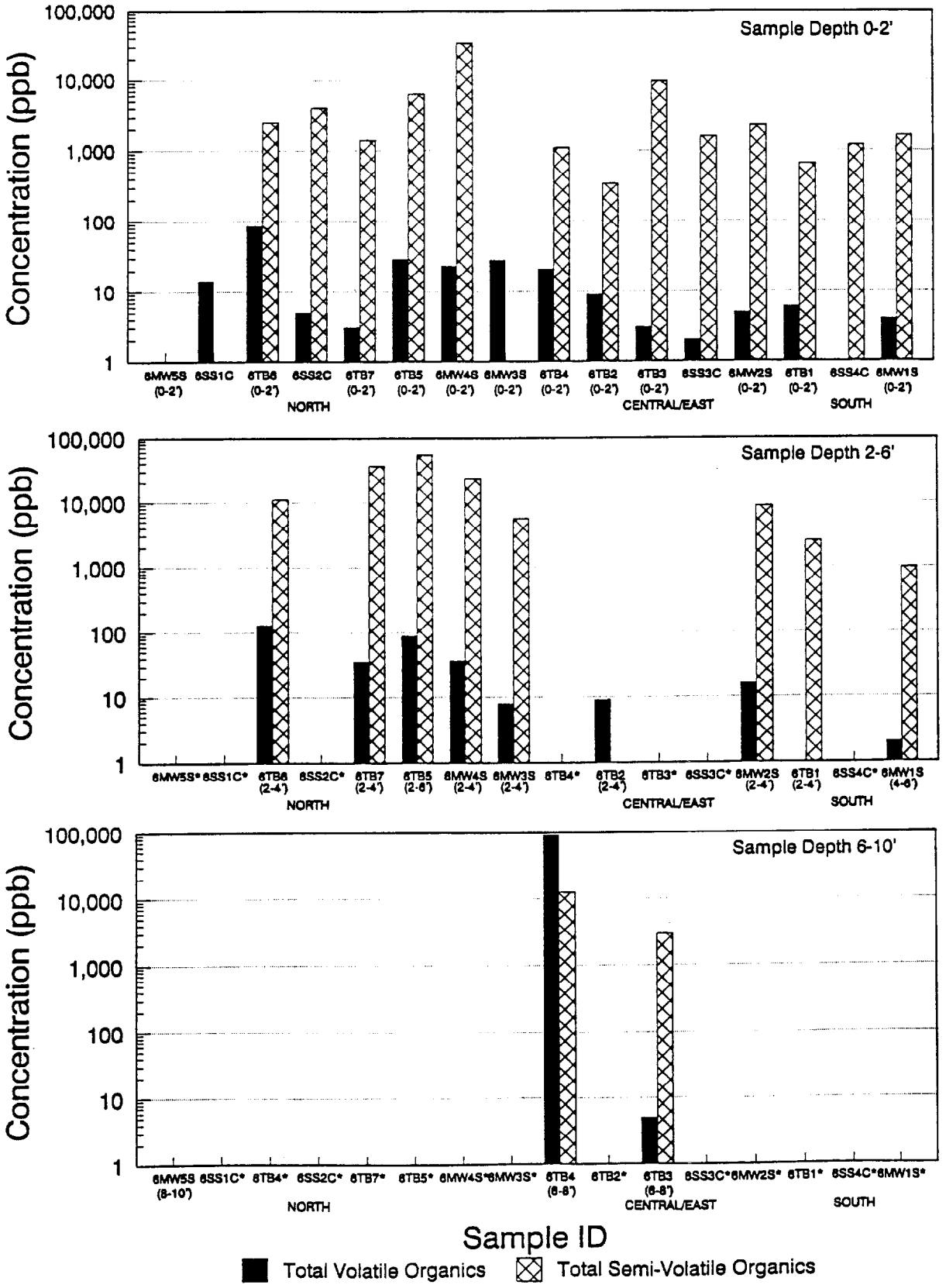
1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4-49
DRMO
SUMMARY OF SURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	6SS1C 0-0.5	6SS2C 0-0.5	6SS3 0-0.5	6SS4 0-0.5
TAL INORGANICS (ppm)						
Aluminum	272000		8560	8170	13100	5610
Antimony	2.95		ND R	ND R	ND R	ND R
Arsenic	31.5		1.4 BJ	2.8 J	2.3 J	1.5 BJ
Barium	1600		63.1	84.2	135	39.6 B
Beryllium	3.52		0.23 B	1 B	0.54 B	0.22 B
Cadmium	7		3.7	4.9	5.7	2.9
Calcium	32300		2550	3310	2260	887 BJ
Chromium	223		18.9	24.1	32.3	12.6
Cobalt	39		10.9	9.7 B	13.1	5.1 B
Copper	102		168	261	362 J	258
Iron	115000		15900	17400	19300	9700
Lead	53.2		181	20.7 J	204	27.5
Magnesium	26500		4680	4510	6120	2470
Manganese	3790		196	257	331	162
Mercury	0.51		ND J	1 J	0.22 J	0.68 J
Nickel	76.7		23.6	123	30.2	13.2
Potassium	12000		1790	1960	4780	1890
Selenium	1.79		ND	ND	0.23 B	ND
Silver	5		ND J	ND J	ND J	ND J
Sodium	51800		292 BJ	821 BJ	219 BJ	109 BJ
Thallium	5		ND	ND	ND	ND
Vanadium	271		25.9	105	47.7	15.9
Zinc	178		123	413	415	83.3 J
Boron	109		98	80	59	41
Cyanide	--		ND	ND	ND	ND
TCLP METALS (ppm)						
PARAMETER	TBC					
Arsenic	0.05		ND	ND	ND	ND
Barium	1		0.51	0.7	0.48	0.18
Cadmium	0.01		0.03	0.052	0.094 J	0.027
Chromium	0.05		0.064	0.021	0.065 J	0.013
Lead	0.05		1.3	0.6	6.2 J*	0.17
Mercury	0.002		ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND
Silver	0.05		ND R	0.0072 J	0.0082 J	0.01 J

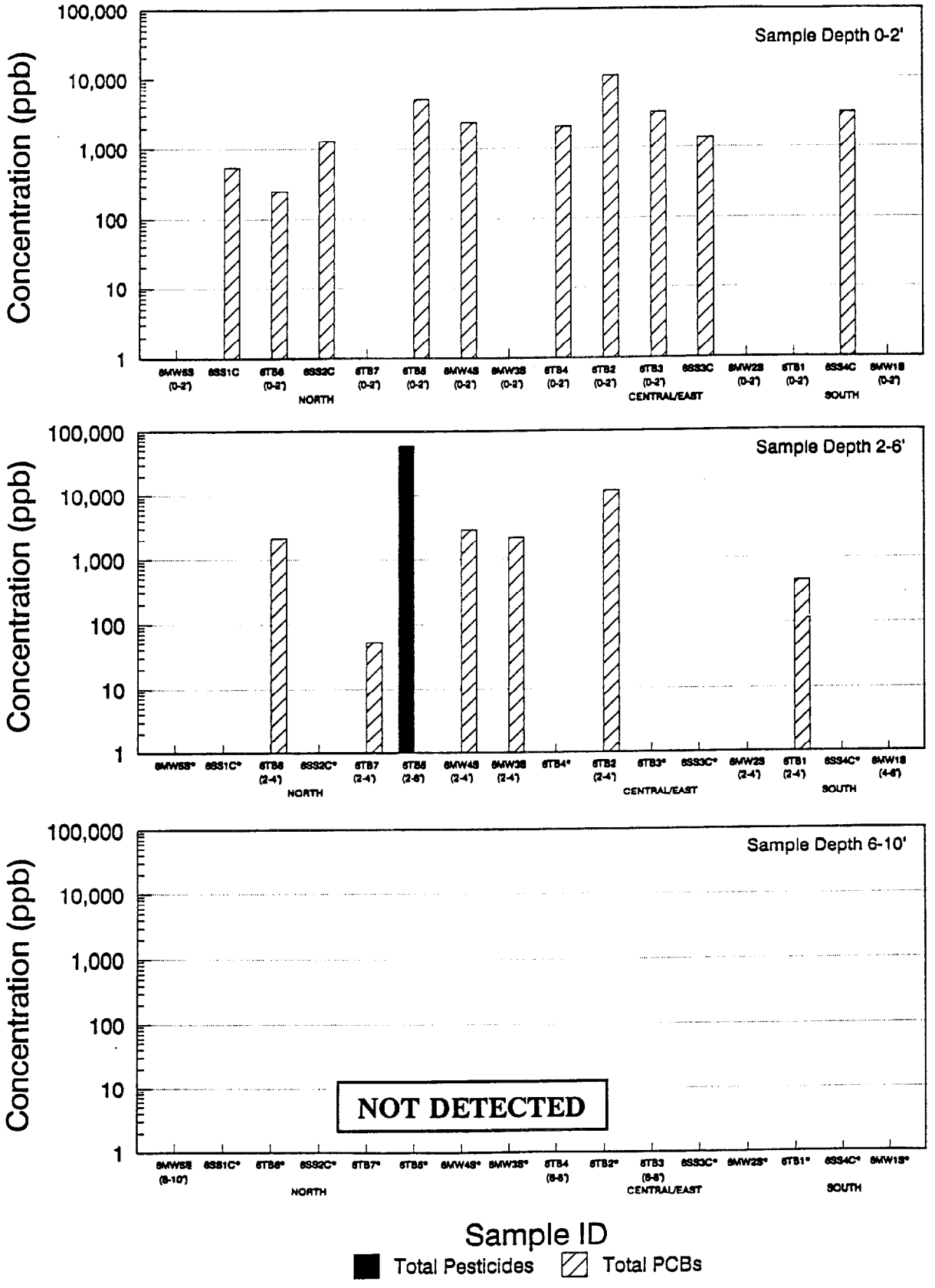
NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) * indicates RCRA characteristic hazardous waste level of 5 ppm exceeded.



* Indicates no sample collected at this interval

FIGURE 4-29 - DRMO SITE - SOIL VOC AND SVO ANALYTICAL DATA



* Indicates no sample collected at this interval

FIGURE 4-30 - DRMO SITE - SOIL PESTICIDE AND PCB ANALYTICAL DATA

concentrations. Samples collected below the three to four foot depth are below the water table, except for 6MW5S (background).

Volatile Organics

VOC concentrations in soil at DRMO are generally low. However, based on the low TBC values used by CTDEP, many soil samples exceed TBC values for VOCs as highlighted on Table 4-46. Based on inspection of the bar graphs on Figure 4-29, total VOC concentrations tend to be higher in the 0-2' and 2-6' depth intervals in the northern portion of the site, which is not paved. A diesel odor was noted in 6MW1 (4-6') in the southwest portion of the site, however, no significant VOCs were detected. The highest VOC levels were detected at 6TB4 (6-8'), where the following was found: vinyl chloride (1300 ppb), trichloroethene (20,000 ppb), and tetrachloroethene (210 ppb). The contamination appears to be generally isolated at the site based on results of the soil gas survey and other soil samples collected in this area (6TB2 and 6TB3). Based on elevated field measured organic vapor readings at 6TB4 (2-4'), which was not sampled for laboratory analysis, the elevated VOCs at this location may also be present at this shallower depth. An oil sheen was noted at 6TB4 (6-8') and 6TB4 (10-12').

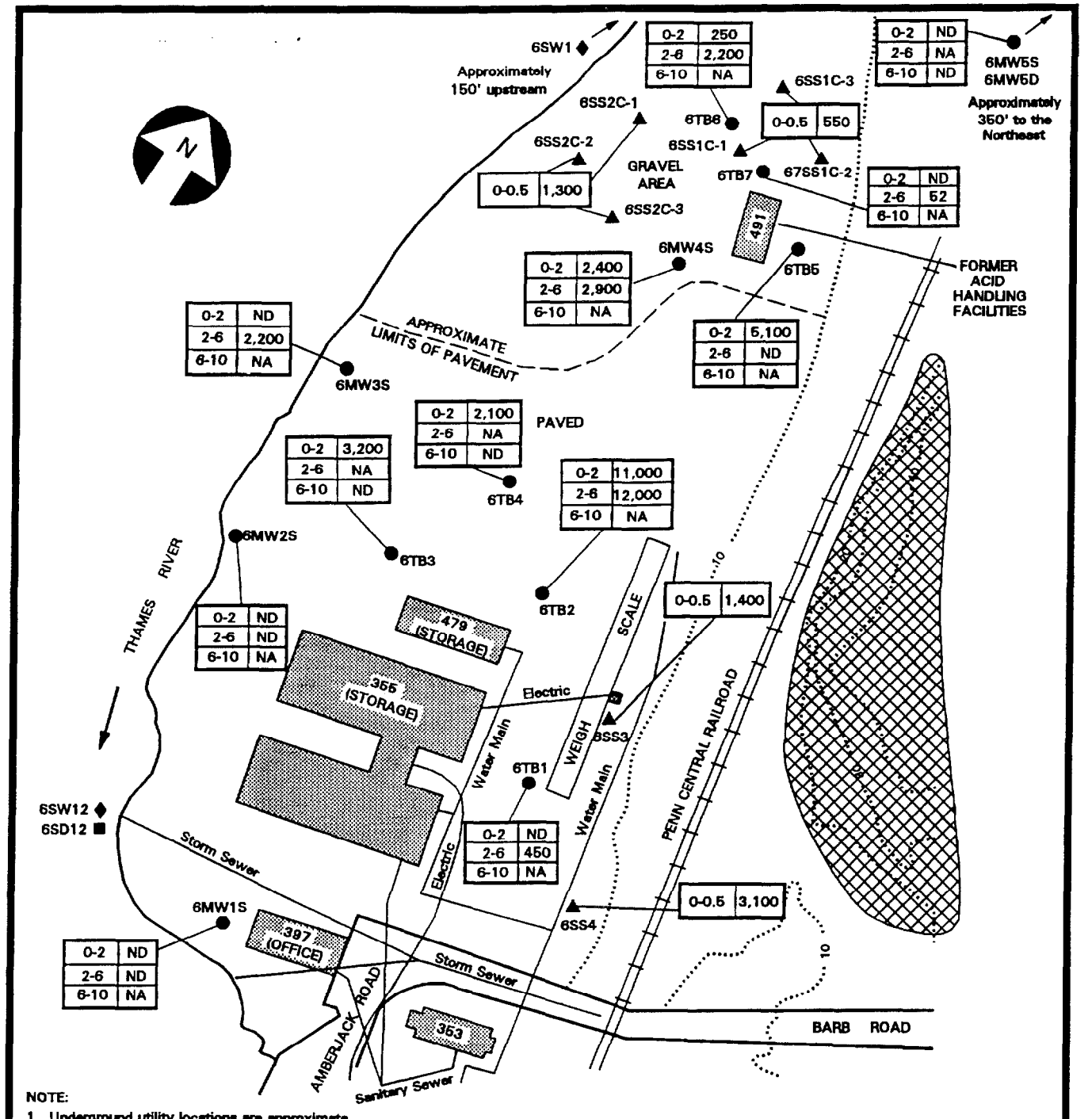
Semi-Volatile Organics

SVOs were present in most samples collected in the former landfill area. The SVOs were predominantly comprised of PAH compounds. In general, concentrations were slightly higher in the northern portion of the site for the 0-2' and 2-6' intervals (Figure 4-29). Also, concentrations were generally higher in the 2-6' interval compared to the 0-2' interval. Based on two soil samples collected in the landfill at the 6-10' interval, PAH compounds are also present at that depth. Based on the spatial density of the sample locations, PAHs are likely present throughout the DRMO site limits. Based on the former use of the site as a landfill, and an area where material was burned, the PAHs are likely a result from incomplete combustion and, perhaps to a lesser degree, due to petroleum releases. The PAH results are generally consistent with the results from the previous verification study.

PCBs/Pesticides

Total PCB and pesticide results are shown for the various reporting intervals on Figure 4-30. PCB concentrations are also illustrated on Figure 4-31.

PCB Arochlor 1260 is present at almost all sample locations except 6MW5S (background) and 6MW1S and 6MW2S (rear of office and storage building). Concentrations range from 52 ppb to 12,000 ppb. It is generally present in both the 0-2' and 2-6' sample reporting interval. At 6TB2 (0-2') and 6TB2 (2-6'), it is present at 11,000 ppb and 12,000 ppb respectively, both above the TBC value of 10,000 ppb. The presence of PCBs at this site is most likely associated with scrap metal storage (e.g., white goods) and associated capacitor leaks, and past storage of transformers. PCB (Arochlor-1260) was detected at sediment sample location 2DSD12, at the outfall of the storm drainage system from Area A, and to the rear of Building 397 at DRMO. It was not present in other upgradient sample points along the Area A downstream watercourses, and may be a result of particulate transport from DRMO.


6SW1
Approximately 150' upstream
0-2 250
2-6 2,200
6-10 NA
6TB6
6SS2C-1
6SS2C-2
0-0.5 1,300
6SS2C-3
GRAVEL AREA
6SS1C-1
6SS1C-3
0-0.5 550
6TB7
6SS1C-2
0-2 ND
2-6 NA
6-10 ND
6MW5S
6MW5D
Approximately 350' to the Northeast
0-2 ND
2-6 52
6-10 NA
491
FORMER ACID HANDLING FACILITIES
6TB5
0-2 5,100
2-6 ND
6-10 NA
6MW4S
0-2 2,400
2-6 2,900
6-10 NA
APPROXIMATE LIMITS OF PAVEMENT
0-2 ND
2-6 2,200
6-10 NA
6MW3S
PAVED
0-2 2,100
2-6 NA
6-10 ND
6TB4
0-2 3,200
2-6 NA
6-10 ND
6TB3
0-2 11,000
2-6 12,000
6-10 NA
6TB2
6MW2S
THAMES RIVER
0-2 ND
2-6 ND
6-10 NA
479 (STORAGE)
355 (STORAGE)
Electric
Water Main
WEIGH SCALE
6SS3
0-0.5 1,400
PENN CENTRAL RAILROAD
6TB1
0-2 ND
2-6 450
6-10 NA
6SW12
6SD12
Storm Sewer
Electric
Water Main
6MW1S
397 (OFFICE)
0-2 ND
2-6 ND
6-10 NA
6SS4
0-0.5 3,100
Storm Sewer
AMBERJACK ROAD
353
Sanitary Sewer
BARB ROAD
10
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.
3. Refer to analytical tables for specific sample depth interval.
LEGEND
SD1- Sediment Sample
SS1- Surface Soil Sample
SW1- Surface Water Sample
Sample Depth (ft) | PCBs (ppb)
NA - Not Analyzed
ND - Not Detected
MW1- Monitoring Well
TB1- Test Boring
95 - Existing Grade
- Building
- Exposed Bedrock
Approximate Scale
0 20 40'
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT
FIGURE 4-31
SUMMARY OF PCBs IN SOILS
DRMO
ATLANTIC ENVIRONMENTAL SERVICES, INC.

Pesticides were detected at 6TB5 (2-6') at elevated concentrations; no other pesticides were detected at other sample locations. Total pesticide concentration was 57,800 ppb, consisting of DDT, DDD, and DDE. The DDT concentration was detected above the TBC value. Due to pesticide detection at only one sample location and at a depth of 2-6 feet, it was likely associated with past landfilling rather than application.

Inorganics

Out of 24 samples analyzed for TCLP metals, 21 contained one or more metals exceeding TBC values. This included two samples at 6MW5S (background) for chromium. Metals exceeding TBC values included barium, cadmium, chromium, lead, mercury and silver. TCLP hazardous waste characteristic values were exceeded for lead (5 ppm) at 6MW3S (2-4') 52 ppm, 6TB5 (2-6') 32 ppm, and OSS3 (0-0.5') 62 ppm. Lead values were generally elevated around Building 491 (former battery acid handling facilities): 6MW4S, 6TB5, 6TB6, and 6TB7. This substantiates that battery acid releases occurred in this area.

Many inorganic constituents exceeded established background levels based on mass weight analysis. These included antimony, beryllium , cadmium, cobalt, copper, lead, mercury, nickel, zinc, and boron. The majority of these elevated metals are likely related to a combination of past landfill disposal and scrap metal storage. Lead levels correlate with the TCLP results. Detected metals and concentrations were generally consistent with what was found at the Goss Cove Landfill site.

A summary of areas of soil contamination are shown on Figure 4-32.

4.12.5 Ground Water and Surface Water

The ground water analytical program is summarized in Section 2.0, Table 2-13. Ground water and surface water analytical data is summarized in Table 4-50 (organics) and 4-51 (inorganics). No petroleum hydrocarbons were detected in the ground water samples. Trichloroethene and 1,2 dichloroethene were present in three downgradient wells (6MW2S, 6MW3S, and 6MW4S). The chemical 1,2 dichloroethene was only present at concentrations less than 2 ppb and, therefore, did not exceed TBC values (70 ppb) in these wells. Trichloroethene exceeded the ARAR value (5 ppb) with a concentration of 8 ppb at well 6MW4S. The primary source of the solvents in the ground water, based on the soil analytical results and the soil gas data, is projected to be in the area of 6TB4, 6MW4S, 6TB6 and 6TB7.

No SVOs, PAHs, pesticides or PCBs were detected in any wells at the DRMO site. Low levels of phthalates and benzoic acid were detected in the upgradient well 6MW5D.

The inorganic ground water analysis results indicate that selenium exceeds the primary drinking water standard at wells 6MW2S, 6MW3S, and 6MW4S. Selenium is at the highest levels at 6MW4S where it is present at 23.5 ppb compared to the drinking water standard of 10 ppb. The cause of the elevated selenium levels in the ground water is unclear but, based on its absence in the upgradient wells, appears to be site related. Selenium was not present in soils above background values, and also was not detected in soils based on the TCLP procedure.

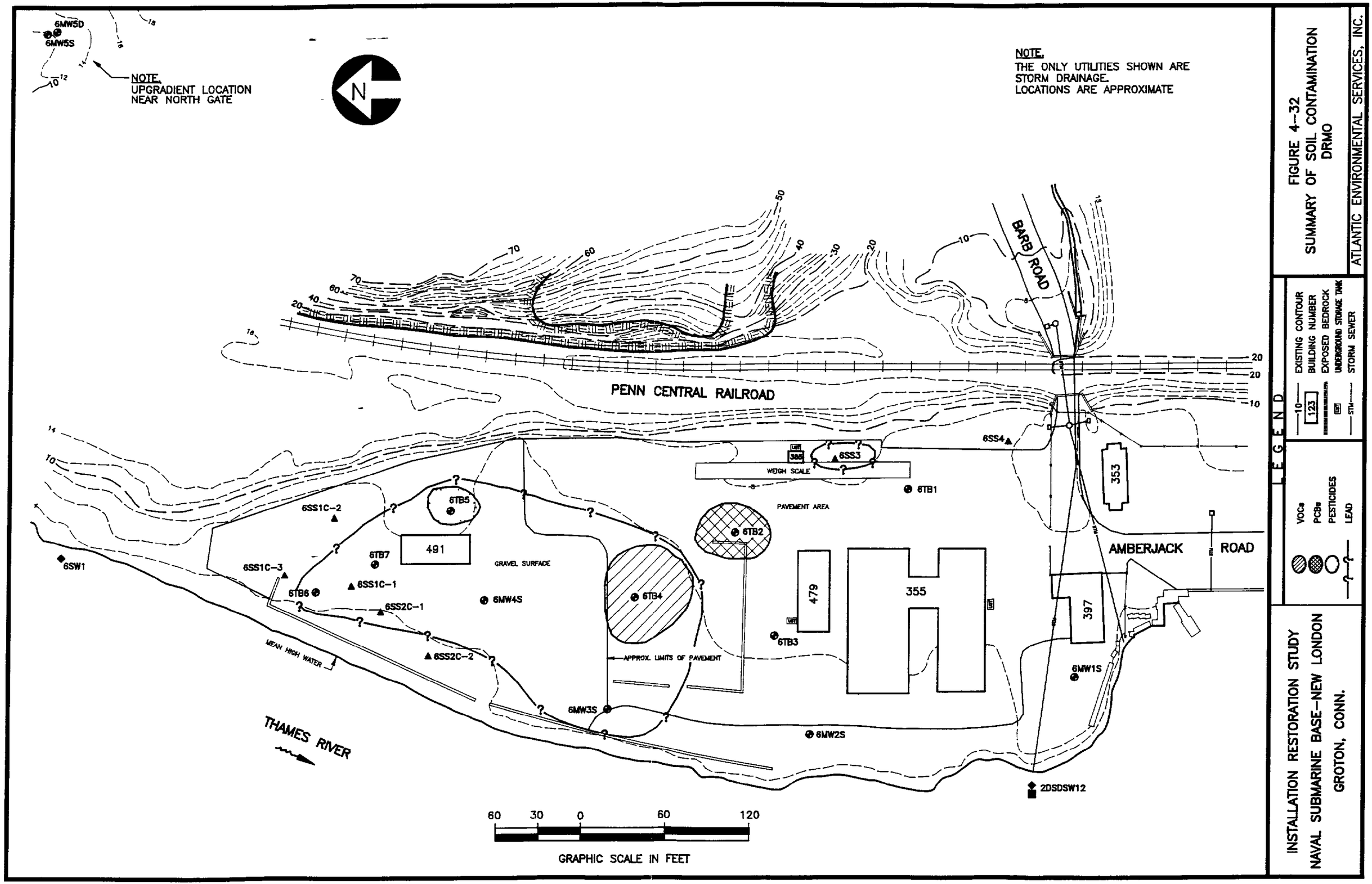


FIGURE 4-32
SUMMARY OF SOIL CONTAMINATION
DRMO

ATLANTIC ENVIRONMENTAL SERVICES, INC.

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

00172132

TABLE 4–50
DRMO
SUMMARY OF GROUND WATER AND SURFACE WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	6MW1S	6MW2S	6MW3S	6MW4S	6MW5S	6MW5D	6SW1
TCL VOLATILE ORGANICS (ppb)									
1,1–Dichloroethane	--		ND	ND	ND	2 J	ND	ND	ND
1,2–Dichloroethene (total)	70 ARAR	MCL	ND	1 J	2 J	2 J	ND	ND	ND
Trichloroethene	5 ARAR	MCL	ND	4 J	1 J	8	ND	ND	ND
Total Volatile Organics				5	3	12			
TCL SEMI–VOLATILE ORGANICS (ppb)									
Phthalates									
bis(2–ethyhexyl)phthalate			ND	ND	ND	ND	ND	10	ND
Other Semi–Volatile Organics									
Benzoic Acid			ND	ND	ND	ND	ND	21 J	ND
TCL PESTICIDES/PCBs (ppb)									
TCL Pesticides/PCBs			ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4-51
DRMO
SUMMARY OF GROUND WATER AND SURFACE WATER ANALYTICAL DATA (INORGANICS AND RADIOLOGICAL)

PARAMETER	GROUND WATER ARARs/TBC	SAMPLE ID:	6MW1S	6MW2S	6MW3S	6MW4S	6MW5S	6MW5D	SALT WATER ARARS/TBC	6SW1
TCL METALS (ppb)										
Aluminum	200 TBC	SMCL	ND	ND	ND	ND	ND	ND		83.2 BJ
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	4300 ARAR	ND
Arsenic	50 ARAR	MCL	ND	5.4 B	5.2 BJ	18.6	ND	ND	0.14 ARAR	ND
Barium[7]	1000 ARAR	MCL	ND	27.9 B	61 B	86.2 B	32.3 B	33.9 B	---	ND
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	0.13 ARAR	ND
Cadmium	5 ARAR	MCL	ND	ND	ND J	4 BJ	2.1 BJ	ND	9.3 ARAR	ND
Calcium	--		85200	125000	129000	170000	6970	10600	---	70800
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	50 ARAR	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	---	ND
Copper[7]	1000 ARAR	MCL	12.5 BJ	10.8 BJ	10.5 BJ	355 J	8 BJ	9.4 BJ	2.9 ARAR	13.7 BJ
Iron	300 TBC	SMCL	102 J	280	954	117 J	4880	ND	---	304 J
Lead	15 ARAR	Action Level	ND	ND	ND	ND	3.4 B	ND	8.5 ARAR	ND J
Magnesium	--		246000	350000	299000	396000	1270 B	1000 B	---	204000
Manganese	50 TBC	SMCL	20.1 J	35.4 J	101 J	801	1000	84.5 J	100 ARAR	30.8 J
Mercury	2 ARAR	MCL	ND	ND	ND	ND	ND	0.3	0.025 ARAR	ND
Nickel	100 TBC	PMCL	ND	ND	ND	23.2 B	11.7 B	ND	8.3 ARAR	ND
Potassium	--		76800	112000	94800	123000	3230 BJ	3460 BJ	---	63100
Selenium[7]	10 ARAR	MCL	9.9 J	15.4 J	10.6 J	23.5	ND	ND	71 ARAR	4.8 B
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	2.3 ARAR	ND
Sodium	28000 TBC	Notif. Level	2030000	3010000	3010000	3350000	7470	14600	---	1820000
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	6.3 ARAR	ND J
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	---	ND
Zinc	5000 TBC	SMCL	13.5 BJ	13.1 BJ	9.4 BJ	356 J	13.3 BJ	13.8 BJ	86 ARAR	16.5 BJ
Boron	600 TBC	USEPA HA	5500	8800	5700	8100	1400	1700	---	34000
Cyanide[7]	200 ARAR	MCL	ND J	ND J	ND J	ND J	ND J	ND J	1.0 ARAR	ND J
RADIOLOGICAL CONSTITUENTS (pCi/L)										
Gross Alpha[7]	5	Screening Level	0.0	0.0	0.0	0.0	0.0	0.0	---	0.0
Gross Beta	50	Screening Level	81.1	18.6	7.1	88.3	6.3	3.1	---	23.3

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +\- range due to sample interference; these ranges are reported in the laboratory analytical data Appendix.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4-2 or glossary for further explanation.
7) These values are base on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

There is a strong correlation between ground water sodium concentrations and elevated selenium concentrations. This occurs at DRMO and Goss Cove and may be related to a geochemical process.

Secondary drinking water standards were exceeded for several wells for iron and manganese. Elevated sodium levels appear associated with the proximity of the site to the Thames River, based on comparison of the results with surface water sample 6SW1. **The water quality standard for copper of 2.9 ppb was slightly exceeded at 6SW1 (13.7).** As previously discussed, the elevated boron levels appear to be elevated due to general background levels, and in wells close to the Thames River, due to elevated surface water concentrations.

Radiological ARARs, which are screening values, were exceeded in two of the ground water sample locations (6MW1S and 6MW4S) for gross beta. The elevated readings could be the result of naturally occurring radioisotopes which do not meet the gross screening criteria. These samples, however, have non-detectable gross alpha readings, but significant beta activity. There could be several reasons for this, one of which is that by-product material might be present. Further laboratory analysis is required to determine if these levels are associated with naturally occurring radioisotopes.

One surface water sample was collected in the Thames River to be representative of upstream water quality at NSB-NLON. No VOCs, SVOs, pesticides or PCBs were detected in this sample. Another sample was located just downstream of Goss Cove. Of the 12 inorganic constituents detected in each of these surface water samples, five had lower or equal levels downstream, and seven had higher concentrations downstream. The only two constituents located in higher concentrations downstream that are not major constituents of salt water (boron, salt, potassium, calcium, and magnesium) are manganese and gross beta radiation. The manganese and gross beta radiation downstream levels were 43% and 93% higher, respectively, than upstream levels. However, the downstream gross beta values did not exceed the regulatory screening level.

4.13 Lower Subase

The Lower Subase field investigation consisted of a utility manhole inspection and waterfront bulkhead inspection for evidence of contamination sources/residuals. Also included was a soil gas survey, test borings, ground water monitoring wells, and soil and ground water sampling and analysis.

4.13.1 Utility Manhole Inspection

A total of 212 utility manholes were inspected on two days in December 1990, and two days in April 1991. The Lower Subase study area is depicted on Figure 4-33. The utilities observed consisted of storm sewer, sanitary sewer, steam, electric, telephone, and sand manholes. Utilities numbers (e.g., 1009, C657) were used based on numbers assigned on Navy plans. Manholes that did not appear on the plans were numbered consecutively. The pipe trench for the #6 and #2 fuel oil lines was also inspected along Corvina Road. There was no evidence of petroleum contamination along this segment of pipe trench. All accessible manholes

NOTE:
THE ONLY UTILITIES SHOWN ARE
STORM DRAINAGE AND UTILITY TRENCHES.
LOCATIONS ARE APPROXIMATE.
FIGURE 4-33
FIELD SAMPLING PLAN
LOWER SUBASE
ATLANTIC ENVIRONMENTAL SERVICES, INC
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXISTING MANHOLE
UNDERGROUND UTILITY TRENCH
STORM SEWER
MONITORING WELL
TEST BORING
SEDIMENT SAMPLE
SURFACE SOIL SAMPLE
SURFACE WATER SAMPLE
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.
SHARK BOULEVARD
GRENADIER STREET
PENN CENTRAL RAILROAD
AMBERJACK ROAD
ARGONAUT ROAD
CORVINA ROAD
CISCO ROAD
CAPELIN ROAD
BULLHEAD ROAD
BONEFISH ROAD
DARTER ROAD
ALBACORE ROAD
PIER 10
PIER 9
PIER 8
PIER 6
PIER 4
THAMES RIVER
100 50 0 100 200
GRAPHIC SCALE IN FEET

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in the study area were opened and inspected. The study area consisted of the following roads from north of Building 29 to the south of Building 85, and from the west of Buildings 345, 37, 2, 17, 27, and 105 to the Thames River: Darter, Albacore, Argonaut, Corvina, Amberjack (small segment), Cisco, Capelin, Bullhead, and Bonefish. The inspection consisted of removing manhole covers and noting manhole type, if possible, and any visual evidence of oil contamination such as an oil sheen on water or discolored sediments, or any petroleum odors. A wooden stick was used to probe the sediments. Observations were noted in a field log book, and a video recording of each manhole was made.

Observations of significance are summarized in Table 4-52. Four areas of significant accumulation of petroleum were observed. These areas are listed below.

TABLE 4-52
LOWER SUBASE MANHOLE INSPECTION OBSERVATIONS

Location	Description	Oil Sheen	Odor in Sediments	Visible Oil	Comments
MH-12	Storm sewer	•	•		
MH-13	Concrete electrical vault	•	•	•	thick black oil
MH-17	Concrete electrical vault	•	•	•	thick black oil
MH-18	Concrete electrical vault	•	•	•	thick black oil
MH-21	Steam	•			
MH-28	Telephone	•			
MH-29	Brick construction	•			
C655	Storm sewer		•		
C657	Storm sewer	•			
MH-34	Storm sewer			•	apparent oil globules
MH-38	Steam	•			
MH-39	Telephone	•			
MH-41	Telephone	•			
MH-404	Brick construction		•		
MH-44	Steam	•			
MH-50	Concrete vault		•		
MH-53	Storm	•	•		
MH-58	Conduits		•		
C520-1	Storm sewer	•	•		
MH-73	Conduits in concrete vault			•	very heavily contaminated
C479-1	Storm	•	•	•	heavy thick oil
MH-81	Telephone	•			
MH-83	Concrete block	•	•	•	1/16" floating light brown milky oil
MH-87	Conduits		•		
MH-88	Telephone	•			
C978	Storm	•	•		
MH-110	Pipes in manhole		•	•	small clear floating oil globules
MH-139	Steam	•			thin oil
MH-141	Concrete conduit			•	visible evidence of black oil seep on west side manhole where conduits enter
Corvina Road	#6 Oil trench				no evidence petroleum contamination

- MH-13, 17, 18 - West of Building 29 - thick black oil
- MH-141 - North of Building 16 - thick black oil
- MH-73, C479-1 - West of Building 80 - thick black oil
- MH-83 - West of Building 79 - brown milky oil

The contamination sources in all but MH-83 appear to be from product releases. The exact source of these product releases is not readily apparent and appears to be from underground fuel line or storage tank leaks following a preferential flow path (e.g., utility pipe or trench). There was no evidence of an ongoing release and appears related to previous releases. No areas of free product in the subsurface were identified by this inspection.

The oil in MH-83 possibly originated from the former waste oil pits in Building 79. An old drawing shows the outlet from the waste oil pit 29 feet south of the north side of Building 79. MH-83 is located adjacent to the west side of Building 79.

The oil observed in the manholes has not changed substantially since the previous inspection (Wehran, 1987), with the possible exception of MH-83.

4.13.2 Waterfront Inspection

An inspection of the bulkhead along the waterfront of the Lower Subase was conducted during the last hour of the tidal cycle prior to low tide on May 8, 1991. The purpose of this inspection was to see if any oil seeps or sheens were visible. Historically, such seeps or sheens have been observed at the waterfront near the Power House and Building 79. The inspection was conducted from a small boat and started at the bulkhead near the Navy Marina and continued southerly to Pier 2. A typical cross-section of the bulkhead is shown in Figure 4-34. The inspection was concentrated on the water area beneath the concrete slab. The entire waterfront was inspected with the exception of small segments that were not accessible due to docked vessels. The areas that were not accessible were between the following piers: 6 and 8, 12 and 13, 13 and 15, and 17 and 31. These areas were inspected from shore to the extent possible.

No oil seeps or sheens or evidence of such were observed anywhere along the waterfront at the Lower Subase.

4.13.3 Soil Gas

The soil gas survey of the Lower Subase was performed at various times between September 27 and October 16, 1990. A total of 127 soil gas points were sampled and analyzed, most of which were under pavement. The sampling depth was limited to only 12 to 18 inches due to significant numbers of underground utilities. The limited depth of this survey may have reduced the detection of deeper VOCs. Soil gas sample locations are shown on Figure 4-35. Three soil gas points (SG125, 126 and 127) do not appear on figure 4-35 and were located to the north of Building 107.

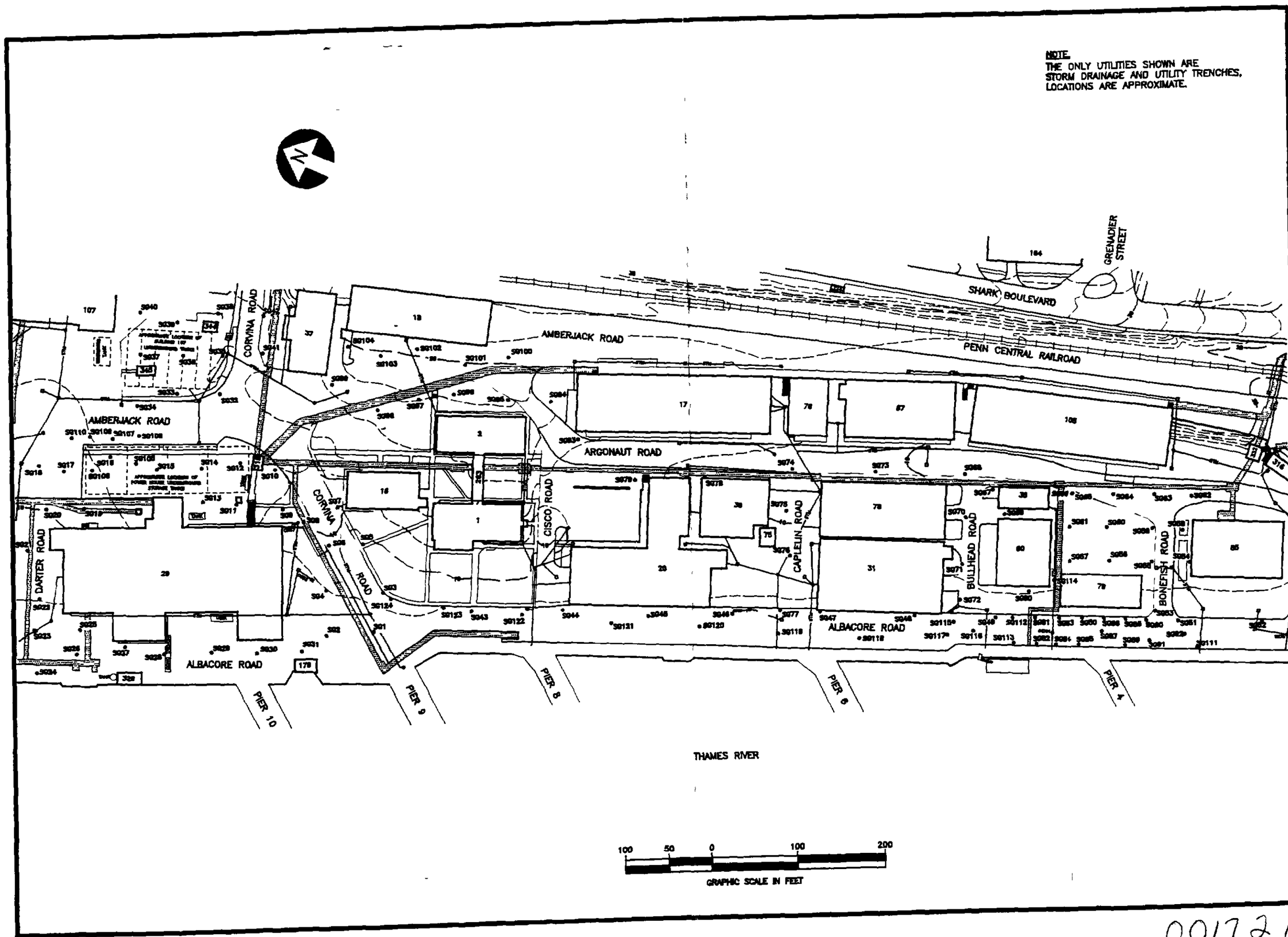

FIGURE 4-35
SOIL GAS SURVEY POINTS
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

LEGEND

—10—	EXISTING CONTOUR
123	BUILDING NUMBER
	EXISTING MANHOLE
	UNDERGROUND UTILITY TRENCH
—STM—	STORM SEWER
• 5026	SOIL GAS SAMPLE NO

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

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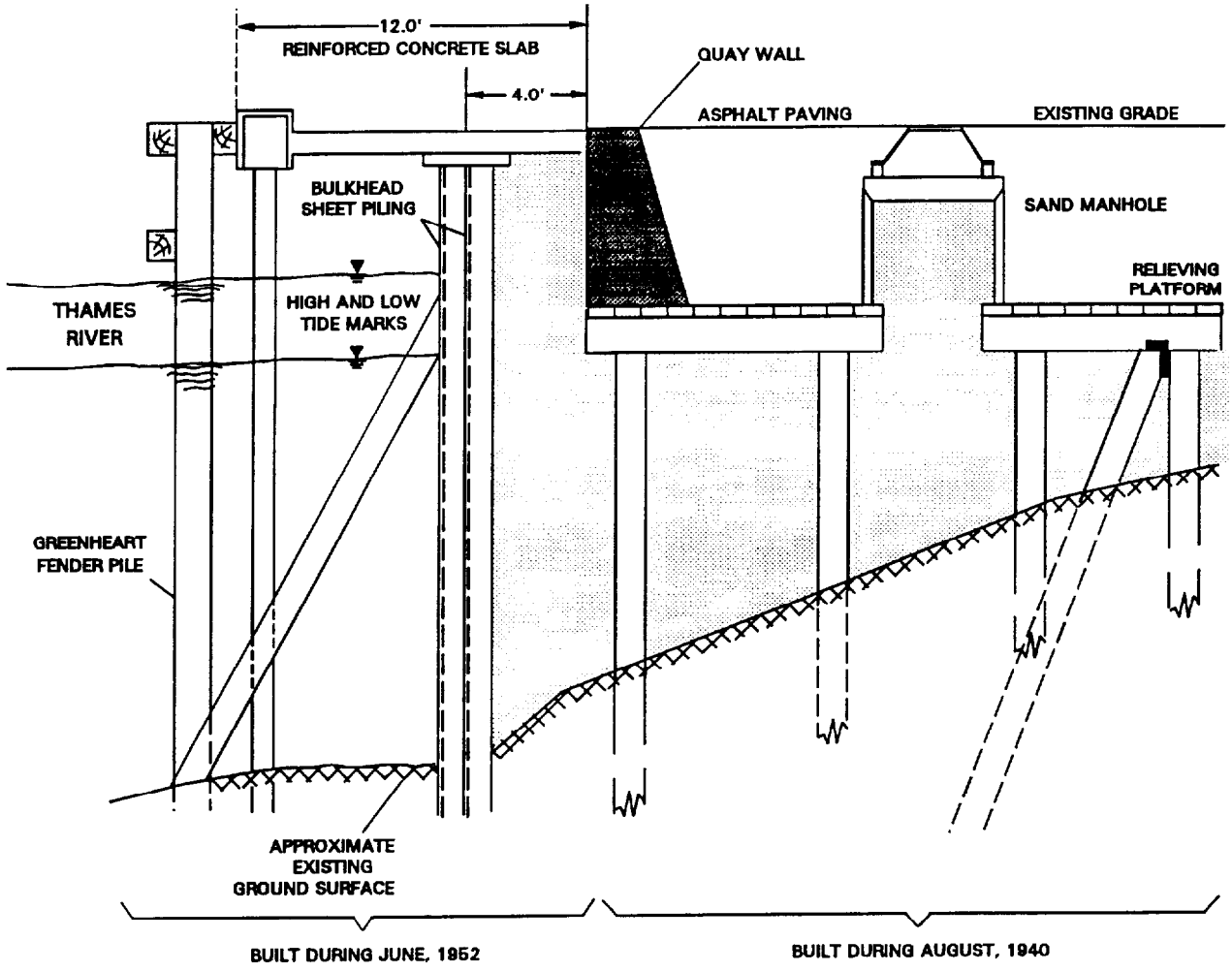


NOT TO SCALE

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND SOURCE: Wehran, 1987	FIGURE 4-34 TYPICAL SECTION - BULKHEAD ATLANTIC ENVIRONMENTAL SERVICES, INC.

VOCs were detected in fewer than one-half of the samples analyzed. Of the remaining sample analyses, the majority showed trace to low level concentrations of benzene, toluene, xylenes, ethyl benzene, trichloroethene, and/or unknowns. The most elevated soil gas measurements are described below. Soil gas concentrations are depicted on Figure 4-36. Only low levels of trichloroethene are shown on Figure 4-36 due to delineation of a plume in the vicinity of Building 79; other low concentrations are not shown. The remainder of the soil gas sample locations depicted are moderate or high levels.

- Soil gas sample points SG-16, 107, 109, and 110 were all located near the Power House storage tanks and into Amberjack Road. These soil gas points contained trace to moderate concentrations of benzene, toluene, xylenes, and pre-benzenes suggestive of petroleum products.

- Soil gas sample point SG-26, on the river side of the Power House, showed a moderate concentration suggestive of a petroleum product, possibly diesel fuel.

- Soil gas sample point SG-2, located south of the power plant (Building 29), showed high concentrations of primarily pre-benzenes, unknowns and toluene. This was in a parking lot area and may be due to surface rather than subsurface petroleum product contamination.

- Soil gas sample point SG-100, located southwest of Building 18, showed a moderate concentration of toluene, pre-benzenes, and other early unknown peaks. This may be due to surface contamination. Several buses were parked approximately 20 feet upgradient of this sample point.

- All the soil gas points to the river side (west) of Building 79, extending approximately 100 feet to each side of the building, contained trace to low levels of trichloroethene and low levels of a petroleum product.

These areas were further characterized by subsurface investigations discussed below.

4.13.4 Subsurface Soil

Seventeen borings from which split-spoon soil samples were collected for analysis were made from November 5 through November 13, 1990. The purpose of these borings was to identify the extent and degree of soil contamination. The sample from each boring selected for analysis was chosen based upon a consideration of visual evidence of contamination, field measured organic vapor readings, and location relative to the elevation of ground water. Only one sample was collected in the 0-6' depth interval. In addition to the 17 samples described above, five test borings were made near Building 79 to better define the extent of soil contamination. Soils from these borings were screened in the field for organic vapors and examined visually, but were not chemically analyzed. Based upon historical drawings of the bulkhead and the soil borings, the site has been extensively filled. Depths of fill near the Thames River approach 20 feet. It is difficult to estimate the amount of fill, if any, at the

NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE AND UTILITY TRENCHES. LOCATIONS ARE APPROXIMATE.
FIGURE 4-36
SOIL GAS CONCENTRATIONS
LOWER SUBASE
ATLANTIC ENVIRONMENTAL SERVICES, INC
LEGEND
EXISTING CONTOUR
BUILDING NUMBER
EXISTING MANHOLE
UNDERGROUND UTILITY TRENCH
STORM SEWER
SOIL GAS CONCENTRATIONS
HIGH
MODERATE
LOW
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.
AMBERJACK ROAD
CORVINA ROAD
DARTER ROAD
ALBACORE ROAD
ARGONAUT ROAD
CISCO ROAD
CAPELIN ROAD
BULLHEAD ROAD
BONEFISH ROAD
SHARK BOULEVARD
GRENADIER STREET
PENN CENTRAL RAILROAD
THAMES RIVER
PIER 10
PIER 9
PIER 8
PIER 6
PIER 4
GRAPHIC SCALE IN FEET

00172162

eastern limit of the Lower Subase. The fill consists primarily of sand and gravel and did not contain any refuse such as bricks, metal, ash, etc. Visual indication of petroleum hydrocarbons was evident in 14 of the 22 borings (17 wells and five borings). Sample locations are depicted on Figure 4-33. The soil sampling and analytical program is summarized in Section 2.0, Table 2-8.

Subsurface soil analytical results are summarized in Table 4-53 (organics), 4-54 (fluorescence), and 4-55 (inorganics), and an explanation of the results follows below. Figure 4-37 is a bar graph showing key constituents orientated from north to south.

Volatile Organics

Seven different volatile organic compounds were detected. The VOCs detected include toluene, ethylbenzene, and xylene (all of which are found in petroleum products), methylene chloride, trichloroethene, and tetrachloroethene (all of which are cleaning solvents), and carbon disulfide. Only at sample 13MW13 did tetrachloroethene (6 ppb) slightly exceed the TBC value of 5 ppb. VOCs were found in soils from sampling locations 13MW13, 13MW14, 13MW15, 13MW16 and 13MW17. These locations define an area of VOCs in soils principally adjacent to Building 79. The former pit in Building 79 contained petroleum products and solvents which contain the VOCs detected.

The total petroleum hydrocarbons (TPH) and fluorescence spectroscopy analysis defined the extent of petroleum hydrocarbons in three areas. The three areas, each of which is discussed below, were identified as follows:

- Building 29 (Power House) and Building 107 (Firehouse) tanks, #2 oil and lubricating oil;
- Building 79 former waste oil pit, #6 and waste oil; and
- Bullhead Road east end, #2 oil.

Buildings 29 and 107

Based upon the TPH and fluorescence soils analysis, it appears that both #2 oil and lubricating oil have leaked from the underground storage tanks near Buildings 29 and 107. MW1, MW5, and MW7 soils were all identified as containing lubricating oil, indicating lube oil contamination extending from the tanks to the Thames River. Adjacent to and coincident with the lube oil is an area of #2 oil contamination as indicated by the results from MW2, MW3, and MW9. This area also extends from the tanks to the Thames River. It is noted, however, that no VOCs (petroleum constituents) were detected in the soil samples from this area. Plate 4-3 provides a summary of fluorescence, TPH and VOC data. The limits of soil containing petroleum constituents are also shown on this plate.

TABLE 4-53
LOWER SUBASE
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	13MW1	13MW2	13MW3	13MW4	13MW5	13MW6	13MW7	13MW8	13MW9
		DEPTH (ft):	12-14	10-12	12-14	6-8	10-12	14-16	8-10	8-10	6-8
TCL VOLATILE ORGANICS (ppb)											
Methylene Chloride	25		ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	5 J	ND	ND
Trichloroethene	5		ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5		ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1000		ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	--		ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	--		ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics									5		
TOTAL PETROLEUM HYDROCARBONS (ppm)											
Total Petroleum Hydrocarbons	--		1200	14000	11000	450	7000	ND	830	4900	ND

TABLE 4–53 (continued)
LOWER SUBASE
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (ORGANICS)

PARAMETER	TBC	SAMPLE ID:	13MW10	13MW11	13MW12	13MW13	13MW14	13MW15	13MW16	13MW17
		DEPTH (ft):	6–8	2–4	8–10	8–10	12–14	12–14	10–12	8–10
TCL VOLATILE ORGANICS (ppb)										
Methylene Chloride	25		ND	ND	ND	12	1 J	2 J	3 J	2 J
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	5 J	ND
Trichloroethene	5		ND	ND	ND	5 J	4 J	2 J	4 J	1 J
Tetrachloroethene	5		ND	ND	ND	6	4 J	3 J	5 J	ND
Toluene	1000		ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	--		ND	ND	ND	ND	ND	ND	6 J	ND
Xylene (total)	--		ND	ND	ND	ND	ND	ND	20 YJ	ND
Total Volatile Organics						23	9	7	43	3
TOTAL PETROLEUM HYDROCARBONS (ppm)										
Total Petroleum Hydrocarbons	--		130	150	3400 J	310	110	170	960	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–54
LOWER SUBASE
SUMMARY OF SUBSURFACE SOIL FLUORESCENCE SPECTROSCOPY DATA

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.
13MW6	14–16	Spectra is similar to asphalt/tar.
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.
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.
13MW12	8–10	Spectra is typical of No. 2 fuel/diesel oil.
13MW13	8–10	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.
13MW14	12–14	Spectra is similar to waste oil/ heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW15	12–14	Spectra is similar to waste oil/ heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW16	10–12	Spectra is similar to waste oil/ heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW17	8–10	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.

TABLE 4-55
LOWER SUBASE
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

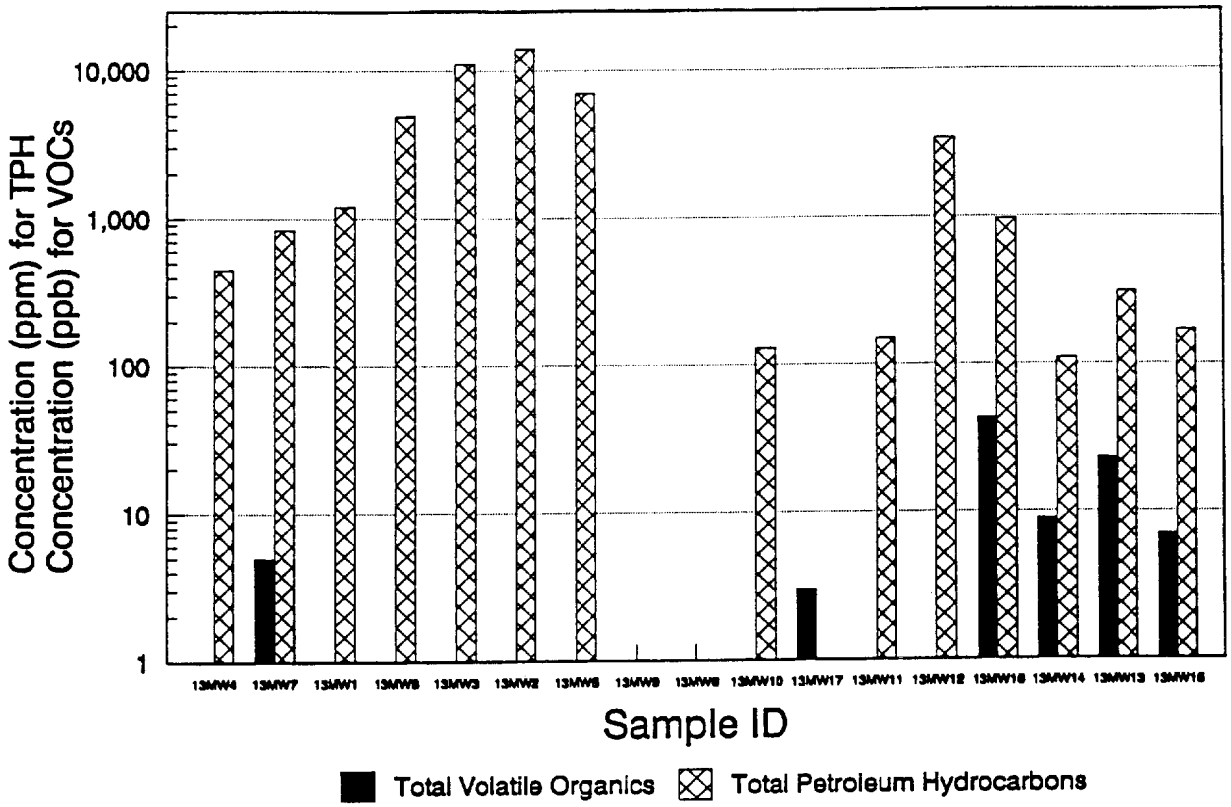
PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	13MW1 12-14	13MW2 10-12	13MW3 12-14	13MW4 6-8	13MW5 10-12	13MW6 14-16	13MW7 8-10	13MW8 8-10	13MW9 6-8
TCL METALS (ppm)											
Aluminum	272000		5470	4480	4310	6490	6980	4720	3250	3490	3370
Antimony	2.95		NDJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J
Arsenic	31.5		0.59 B	1.3 B	4.3	1.9 B	2 B	ND	0.75 B	0.53 B	ND
Barium	1600		34.3 B	31.5 B	32 B	37.1 B	40.5 B	39.6 B	14.7 B	20.6 B	21.3 B
Beryllium	3.52		ND	0.25 B	ND	0.4 B	0.28 B	ND	ND	ND	ND
Cadmium	7		1.2 J	0.8 BJ	0.81 BJ	1 BJ	1.1 BJ	1.2 J	0.57 BJ	1.4 J	0.7 BJ
Calcium	32300		593 BJ	1070 BJ	647 BJ	1870 J	900 BJ	645 BJ	539 BJ	870 BJ	621 BJ
Chromium	223		15.4	7.7	7.5	13.8	12.5	9.6	4.6	7.1	7.4
Cobalt	39		3.5 B	3.4 B	3.1 B	5.5 B	5.5 B	3.9 BJ	1.8 B	3.3 B	2.9 B
Copper	102		9.1 J	10.3 J	8.2 J	59.6	18.1 J	9.6	7.7 J	10.7 J	14 J
Iron	115000		8200	6420	7610	9030	10400	7830	3770	6280	5380
Lead	53.2		4.2 J	22.8 J	3 J	383 J	17.6 J	2 J	3.8 J	15.3 J	23.3 J
Magnesium	26500		2590	1830	2170	3020	2890	2520	1310	1600	1550
Manganese	3790		118	125	95.9	148	173	145 J	56.1	85.2	139
Mercury	0.51		ND	ND	ND	0.48 J	ND	ND J	0.12 J	ND	ND
Nickel	76.7		4.8 B	4.4 B	4.4 B	12	10.3	6.6 B	2.4 B	4.8 B	4.3 B
Potassium	12000		2830 J	1500 J	1870 J	1950 J	2190 J	2570	1170 BJ	1590 J	1520 J
Selenium	1.79		ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	5		ND	ND	ND	2.2 J	ND	ND	ND	ND	ND
Sodium	51800		140 BJ	74 BJ	117 BJ	365 BJ	114 BJ	123 B	184 BJ	444 BJ	821 BJ
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		12	10.6 B	11.1	27.1	16.9	13.5	5.7 B	13.6	14.9
Zinc	178		37.4	24.6	20.7	70.4	29.1	24.5 J	20.3	28.5	32.7
Boron	109		45	68	349	48	75	ND	48	338	53
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)											
PARAMETER	TBC										
Arsenic	0.05		ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	1		0.14	0.22	0.092	0.19	0.33	0.16	0.087	0.13	0.098
Cadmium	0.01		ND	ND	ND	ND	ND	ND	ND	0.0029	ND
Chromium	0.05		0.016 J	0.0084 J	ND J	0.0052 J	0.0085 J	ND	0.0077 J	0.007 J	0.0061 J
Lead	0.05		ND	0.15	ND	1.7	ND	ND	ND	0.2	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.05		NDJ	0.045 J	ND J	ND J	ND J	ND R	ND J	ND J	ND J

TABLE 4–55 (continued)
LOWER SUBASE
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA (INORGANICS)

PARAMETER	BACK-GROUND	SAMPLE ID: DEPTH (ft):	13MW10 6–8	13MW11 2–4	13MW12 8–10	13MW13 8–10	13MW14 12–14	13MW15 12–14	13MW16 10–12	13MW17 8–10
TAL INORGANICS (ppm)										
Aluminum	272000		4590	7210	8120	6510	6280	5510	10600	2670
Antimony	2.95		NDJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J
Arsenic	31.5		1.9 B	1.8 B	2.8	1.9 B	ND	0.77 B	4	ND
Barium	1600		24.7 B	30.1 B	29.2 B	48.3 J	26.4 B	42.7 B	30.7 B	15.3 B
Beryllium	3.52		ND	0.29 B	0.33 B	ND	ND	ND	0.34 BJ	ND
Cadmium	7		0.6 BJ	1.3 J	0.83 BJ	1 BJ	1.5 J	1.7 J	2.5 J	0.69 BJ
Calcium	32300		1650	1540 J	1100 BJ	867 BJ	783 BJ	603 BJ	2710	604 BJ
Chromium	223		7	12.4	10.5	17.5 J	20.3	13.5	27.8	3.9
Cobalt	39		2.4 B	4.1 B	4.4 B	4.1 BJ	4 BJ	4.1 BJ	6.7 BJ	2.2 BJ
Copper	102		8.6 J	17.8 J	8.8 J	14	32.5	12.7	15.1	8.7
Iron	115000		5120	9560	7230	8560	9940	9140	16900	4310
Lead	53.2		7.6 J	178 J	2.6 J	50.2 J	68.7	34.4	41.3	5.4 J
Magnesium	26500		1850	2330	1930	2660	3670	3100	5510	1150 BJ
Manganese	3790		125	153	88.1	155 J	147 J	139 J	191 J	208 J
Mercury	0.51		ND	0.11 J	ND	ND J	ND J	ND J	ND J	ND J
Nickel	76.7		5.5 B	8.2 B	7 B	9.5	9.9	7.9 B	16.3	3.8 B
Potassium	12000		1390 J	1590 J	910 BJ	1890	1850	2660	2780	1120 B
Selenium	1.79		ND	ND	ND	ND	ND	0.28 BJ	1 BJ	ND
Silver	5		ND	ND	ND	ND	ND	ND	ND	ND
Sodium	51800		250 BJ	184 BJ	114 BJ	124 B	306 B	1360	5890	238 B
Thallium	5		ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	271		9.4 B	16.8	15.7	16.1	16.7	15.9	35.9	6 B
Zinc	178		20.2	54.3	17	62.4 J	38.7 J	48.9 J	43.1 J	14 J
Boron	109		44	44	81	ND	ND	330	2200	ND
Cyanide	--		ND	ND	ND	ND	ND	ND	ND	ND
TCLP METALS (ppm)										
PARAMETER	TBC									
Arsenic	0.05		ND	ND	ND	ND	ND J	ND	0.36	ND
Barium	1		0.16	0.26	0.21	0.24	0.072	0.07	0.035	0.044
Cadmium	0.01		ND	0.0024	ND	ND	ND	ND	ND	ND
Chromium	0.05		0.01 J	0.014 J	0.071 J	ND	ND	ND	ND	ND
Lead	0.05		0.2	8.6 *	ND	ND J	0.56 J	ND	7.4 *	ND
Mercury	0.002		ND	ND	ND	ND	ND	ND	ND	ND
Selenium	0.01		ND	ND	ND	ND	ND	ND	ND	ND
Silver	0.05		NDJ	ND J	ND J	ND R	ND R	ND R	ND R	0.008 J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Background values are discussed in Section 4.3. Shaded numbers exceed TBC or background values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) * indicates RCRA characteristic hazardous waste level of 5 ppm exceeded.



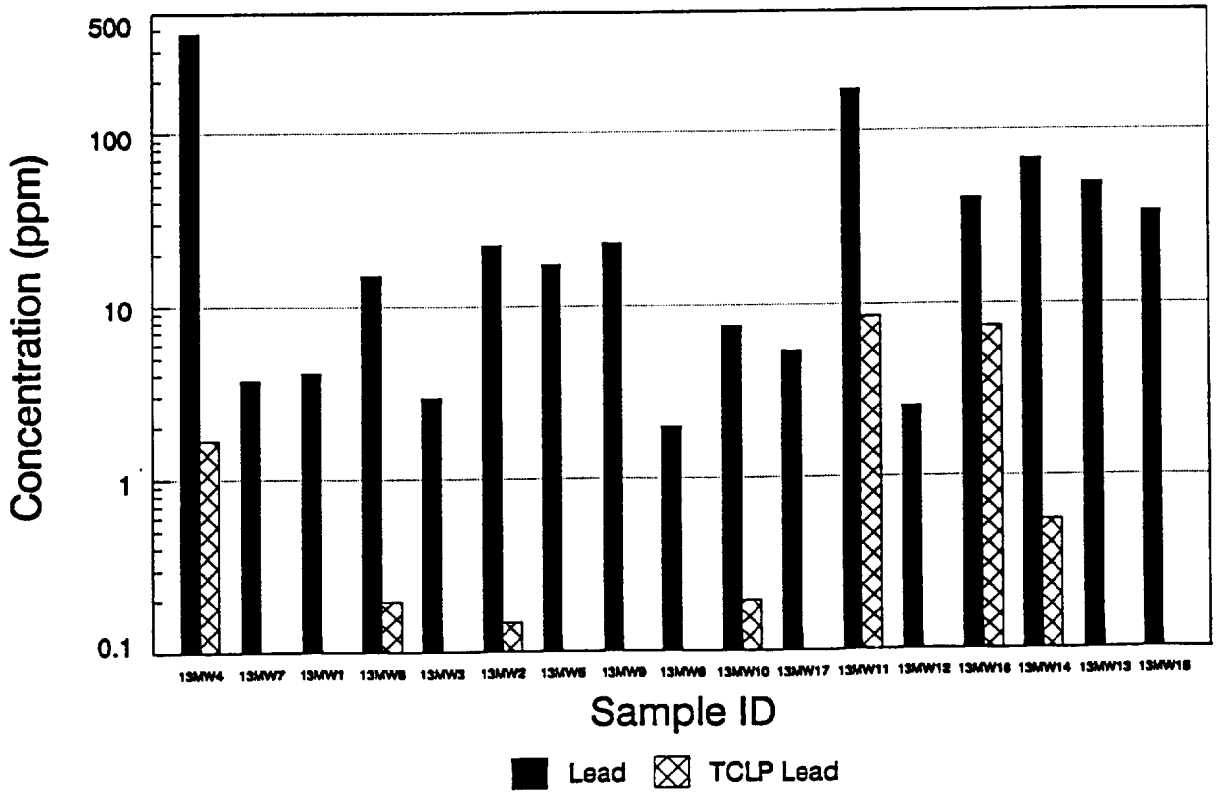


FIGURE 4-37 - LOWER BASE - SUBSURFACE ANALYTICAL DATA

Building 79

The following soil samples, all adjacent to Building 79, were identified to contain a mixture of #6 and waste oil: 13MW14, 13MW15, and 13MW16. This indicates an area of petroleum hydrocarbons from Building 79 to the Thames River. Also near Building 79, five soil borings were made to define the extent of subsurface oil contamination. While some evidence of oil was apparent in each boring except 13TB1, two borings, 13TB3 and 13TB2, had heavier concentrations of oil present as indicated by the presence of oil globules. As discussed above, several soil samples analyzed from this area contained low levels of VOCs. Plate 4-3 provides a summary of fluorescence, TPH and VOC data in this area. The highest concentration of TPH was at 13MW16 (960 ppm). Based on the evaluation of the soil analytical data and the utility inspection, an area of oil contamination northwest of Building 79 is also shown on Plate 4-3.

Bullhead Road (East)

Petroleum hydrocarbons were also detected at 13MW12 where #2 oil was identified with a TPH concentration of 3400 ppm. The most likely source of contamination in this area is from the adjacent underground oil pipeline. The full extent of contamination here is unknown, however it appears to be limited based upon the lack of total petroleum hydrocarbons in ground water from this sampling location. It is further noted that no VOCs were present in the soil sample at this location.

Inorganics

The total metals analyses were compared to the established background levels. Two constituents, lead and boron, are present in concentrations above typical background ranges, lead at three of 17 locations (13MW4S, 13MW11S, 13MW14S) and boron at four of 17 locations (13MW3S, 13MW8S, 13MW15S, 13MW16S). Boron is a constituent of salt water and its concentration in the Thames River at Goss Cove was measured at 38,000 ppb.

There does not appear to be any consistent pattern regarding the distribution of lead in the subsurface. It is possible that the lead was a contaminant mixed in with the fill materials deposited in this area. More likely, based upon a knowledge of the history of the Lower Subase, the lead is from battery acid spillage or disposal. Building 31 was once used for battery storage and maintenance. In addition, the proportions between total lead and TCLP lead are similar to those observed in areas of known battery acid storage and disposal. If the source of lead contamination was the result of surface spills, concentrations would most likely be higher in soils closer to the surface. Only one sample 13MW11 was collected near the surface at a depth of two to four feet. All other samples are from below 6 feet.

TCLP analysis results were compared to CTDEP cleanup standards which are TBC values. Arsenic (13MW16), chromium (13MW12) and lead (seven locations) were measured above the TBC values. For the arsenic, there is no correlation between the total amount of arsenic in the soil and the leachate concentrations. Several other soil samples had similar or higher concentrations of total arsenic and did not leach detectable levels of arsenic. Mass analyses produce more reproducible results than TCLP extracted analyses and the higher TCLP

level was only measured at one location. For these reasons, this arsenic result is considered anomalous. For similar reasons to those above for arsenic, the one exceedance of TCLP chromium above TBC is also considered anomalous.

For lead, there is a correlation between total mass analysis and TCLP concentrations. Two of the TCLP lead results are above 5 ppm which is the threshold level defining a RCRA characteristic hazardous waste. In comparing leachate values to total values, it is evident that all or nearly all of the lead is leaching from the soil during the TCLP. The two sample locations with lead above the hazardous waste level are 13MW11 and 13MW16.

The Lower Subase has been active since the 1800s. Underground storage and subgrade oil transfer lines extend throughout the study area. The results of this investigation indicate that petroleum hydrocarbon constituents are ubiquitous in this area, with several higher concentrations of oil defined. Based on recent underground storage tank and fuel transfer line replacements, ongoing releases of oil are believed to have been predominantly corrected.

4.13.5 Ground Water

Samples were collected from 24 ground water monitoring wells to determine the extent and degree of ground water contamination at the Lower Subase. The ground water sampling program is summarized in Section 2.0, Table 2-14. The analytical results for the ground water are summarized in Table 4-56 (organics), 4-57 (fluorescence), and 4-58 (inorganics).

Volatile Organics

Volatile organic compounds (VOCs) were only detected at low levels in six of the 24 monitoring locations. The only exceedance of ARAR/TBCs were at two monitoring wells, 13MW2S (near Building 107) for benzene, and 13MW13S (east of Building 79) for vinyl chloride and 1,1,-dichloroethene. Wells 13MW13S, NESOMW10, and NESOMW11 all contain chlorinated VOCs and are located near Building 79. Wells 13MW2S and 13MW8 both contain aromatic VOCs which are typical components of oil and are located near the Power House.

Total petroleum hydrocarbons were only present in detectable concentrations west of Building 79 (13MW16S - 5,400 ppm).

The fluorescence spectroscopy data showed oil to be present at all but five locations: 13MW6, 13MW13, WEMW1, WEMW4, and WEMW5. Trace concentrations from which identification of oil type cannot be made existed at six locations: 13MW8, 13MW9, 13MW11, 13MW12, NESO10, and NESO11. Oils identified consisted of waste oil/residual #6 fuel oil, lubricating oil and No. 2 diesel fuel. The types of oils identified differed from those identified in soils at the same location. The major discrepancy is that ground water near the power plant contained #6 oil, and soils did not, based upon the fluorescence analyses.

Measurable levels of free product was only detected in 13MW5 at a thickness of less than 1/16 of an inch. The oil was bailed from this well and an oil layer was not evident three hours later.

TABLE 4–56
LOWER SUBASE
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW1S	13MW2S	13MW3S	13MW4S	13MW5S	13MW6S	13MW7S	13MW8
TCL VOLATILE ORGANICS (ppb)										
Vinyl Chloride	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	--		ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	200 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	5 ARAR	MCL	ND	5	ND	ND	ND	ND	ND	ND
Toluene	1000 TBC	CTDOHS HA	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	700 ARAR	MCL	ND	8	ND	ND	ND	ND	ND	ND
Styrene	100 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	2 J
Xylene (total)	10000 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics				13						2
TOTAL PETROLEUM HYDROCARBONS (ppb)										
Total Petroleum Hydrocarbons			ND	ND	ND	ND	ND	ND	ND	ND

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW9S	13MW10S	13MW11S	13MW12S	13MW13S	13MW14S	13MW15S	13MW16S
TCL VOLATILE ORGANICS (ppb)										
Vinyl Chloride	2 ARAR	MCL	ND	ND	ND	ND	12	ND	ND	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	7 ARAR	MCL	ND	ND	ND	ND	57	ND	ND	ND
1,1-Dichloroethane	--		ND	ND	ND	ND	15	ND	ND	ND
1,1,1-Trichloroethane	200 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1000 TBC	CTDOHS HA	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	700 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Styrene	100 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	10000 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatile Organics							84			
TOTAL PETROLEUM HYDROCARBONS (ppb)										
Total Petroleum Hydrocarbons			ND	ND	ND	ND	ND	ND	ND	5400

TABLE 4–56 (continued)
LOWER SUBASE
SUMMARY OF GROUND WATER ANALYTICAL DATA (ORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW17S	WEMW1S	WEMW4S	WEMW5S	NESOMW4S	NESOMW6S	NESOMW10S	NESO11
TCL VOLATILE ORGANICS (ppb)										
Vinyl Chloride	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	--		ND	ND	ND	ND	ND	2 J	ND	ND
1,1-Dichloroethene	7 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	4 J
1,1-Dichloroethane	--		ND	ND	ND	ND	ND	ND	3 J	1 J
1,1,1-Trichloroethane	200 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	1 J
Benzene	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1000 TBC	CTDOHS HA	ND	ND	ND	ND	ND	ND	36	ND
Ethylbenzene	700 ARAR	MCL	ND	ND	ND	ND	ND	ND	2 J	ND
Styrene	100 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	10000 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	18 Y	ND
Total Volatile Organics								2	59	6
TOTAL PETROLEUM HYDROCARBONS (ppb)										
Total Petroleum Hydrocarbons			ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Only the parameters detected are listed above, all others were not detected.

TABLE 4–57
LOWER SUBASE
SUMMARY OF GROUND WATER FLUORESCENCE SPECTROSCOPY DATA

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.
13MW6S	No detection of these compounds was observed.
13MW7S	Spectra is similar to diesel fuel/heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW8	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.
13MW10S	Spectra is typical of heavy residual fuel oil.
13MW11S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
13MW12S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
13MW13S	No detection of these compounds was observed.
13MW14S	Spectra is similar to waste oil/heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW15S	Spectra is similar to waste oil/heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
13MW16S	Spectra is typical of heavy residual fuel oil.
13MW17S	Spectra is similar to waste oil/heavy residual fuel oil (i.e. No. 6 fuel oil) mixture.
WEMW1S	No detection of these compounds was observed.
WEMW4S	No detection of these compounds was observed.
WEMW5S	No detection of these compounds was observed.
NESOMW4S	Spectra is typical of residual fuel oil.
NESOMW6S	Spectra is typical of heavy residual fuel oil.
NESOMW10S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
NESO11	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.

TABLE 4–58
LOWER SUBASE
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW1S	13MW2S	13MW3S	13MW4S	13MW5S	13MW6S	13MW7S	13MW8
TAL INORGANICS (ppb)										
Aluminum	200 TBC	SMCL	ND	ND	31 B	10600	178 B	ND	625	89.3 B
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	5 B	3.7 B	8.5 B	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	24.1 B	45.7 B	24.3 B	ND	210	21 B	ND	ND
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	6.7 J
Calcium	--		17900	30600	27800	4820 B	53300	31100	5330	14900
Chromium[7]	50 ARAR	MCL	ND	ND	ND	5.9 BJ	5.1 BJ	ND	8.7 BJ	ND J
Cobalt	--		ND	ND	8.2 B	ND	ND	ND	ND	ND J
Copper[7]	1000 ARAR	MCL	ND	ND	ND	15.6 B	ND	ND	10.4 B	9.2 BJ
Iron	300 TBC	SMCL	5650	11600	5860	984	3260	46.7 BJ	697	1230
Lead	15 ARAR	Action Level	NDJ	2.2 BJ	ND J	9.4 J	ND J	4.2 BJ	2 BJ	15.3
Magnesium	--		2930 B	3150 B	4770 B	129 B	17200	5390	3260 B	10700
Manganese	50 TBC	SMCL	1090	697	472	10.2 B	344	ND	58.3	433
Mercury	2 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	100 TBC	PMCL	27.2 BJ	19.7 BJ	23.2 BJ	23.5 BJ	22 BJ	18.7 BJ	19.6 BJ	ND J
Potassium	--		3070 B	4700 B	4810 B	2090 B	12700	5450	5130	8720 J
Selenium[7]	10 ARAR	MCL	ND	ND	ND	ND	ND	1.2 B	ND	1 B
Silver[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	7.4 BJ
Sodium	28000 TBC	Notif. Level	18200	14800 J	39200	354000	177000	53400 J	260000	192000
Thallium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	20 TBC	USEPA HA	ND	ND	ND	22.6 B	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	28 J	13.4 BJ	18.3 BJ	26.5 J	12.9 BJ	11.4 BJ	11.7 BJ	14.8 B
Boron	600 TBC	USEPA HA	1800	700	4100	18000	1800	3600	4300	6790
Cyanide[7]	200 ARAR	MCL	NDJ	ND J	ND J	ND J	ND J	ND J	ND J	ND

TABLE 4–58 (continued)
LOWER SUBASE
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW9S	13MW10S	13MW11S	13MW12S	13MW13S	13MW14S	13MW15S	13MW16S
TAL INORGANICS (ppb)										
Aluminum	200 TBC	SMCL	ND	ND	ND	ND	ND	ND	ND	ND
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	ND	ND	ND	4.5 B	ND	ND	ND
Barium[7]	1000 ARAR	MCL	47.2 B	ND	ND	22.4 B	ND	25 B	49.8 B	39.6 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND	ND J	ND J	ND J	ND	ND J	ND
Calcium	--		90100	28200	15300	26100	35800	75300	157000	150000
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	ND	ND	ND	ND
Copper[7]	1000 ARAR	MCL	ND	ND	ND	ND	ND	9.4 B	6.4 B	ND
Iron	300 TBC	SMCL	414	68.2 BJ	3210 J	3160 J	3390 J	258 J	283 J	522 J
Lead	15 ARAR	Action Level	NDJ	ND J	2.2 BJ	3.2 BJ	2.8 BJ	2.6 BJ	ND R	ND R
Magnesium	--		263000	57700	4540 B	3690 B	7100	204000	604000	489000
Manganese	50 TBC	SMCL	102	ND	278	253	113	51.6	56.5	88
Mercury	2 ARAR	MCL	ND	ND	ND J	ND J	ND J	ND	ND J	ND J
Nickel	100 TBC	PMCL	15.2 BJ	21.8 BJ	18.7 BJ	19.1 BJ	17.4 BJ	17.8 BJ	16 BJ	19.3 BJ
Potassium	--		86200	20700	3970 B	4020 B	6160	67500	175000	163000
Selenium[7]	10 ARAR	MCL	22	2.8 B	ND J	ND J	ND J	7.7	ND J	ND J
Silver[7]	50 ARAR	MCL	ND	ND	ND J	ND J	ND J	ND	ND J	ND J
Sodium	28000 TBC	Notif. Level	1550000	15500 BJ	39200 J	39200 J	58100 J	1790000	4930000 J	2250000 J
Thallium	1 TBC	PMCL	ND	ND	ND R	ND R	ND R	ND	7.8 BJ	3.6 BJ
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	10.6 BJ	22.9 J	14.8 BJ	27.8 J	20.3 J	31.6 J	7.4 BJ	9.8 BJ
Boron	600 TBC	USEPA HA	42000	12000	1500	600	600	37000	9900	5300
Cyanide[7]	200 ARAR	MCL	NDJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J

TABLE 4–58 (continued)
LOWER SUBASE
SUMMARY OF GROUND WATER ANALYTICAL DATA (INORGANICS)

PARAMETER	ARARs/TBC	SAMPLE ID:	13MW17S	WEMW1S	WEMW4S	WEMW5S	NESOMW4S	NESOMW6S	NESOMW10S	NESO11
TAL INORGANICS (ppb)										
Aluminum	200 TBC	SMCL	ND	ND	ND	ND	ND	ND	ND	ND
Antimony	5 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	50 ARAR	MCL	ND	4.8 B	ND	5.2 B	ND	ND	ND	ND
Barium[7]	1000 ARAR	MCL	ND	ND	17.1 B	32.2 B	ND	ND	51.3 B	25.8 B
Beryllium	1 TBC	PMCL	ND	ND	ND	ND	ND	ND	ND	ND
Cadmium	5 ARAR	MCL	ND	ND J	ND J	ND J	ND	ND J	25.5 J	6.9 J
Calcium	--		28600	23500	23600	22400	19600	20800	51800	36100
Chromium[7]	50 ARAR	MCL	ND	ND	ND	ND	10.7 J	ND	ND	ND
Cobalt	--		ND	ND	ND	ND	5.4 B	ND	ND	ND
Copper[7]	1000 ARAR	MCL	ND	ND	ND	ND	ND	6.8 B	5.2 B	9.2 B
Iron	300 TBC	SMCL	225 J	1080 J	1020 J	10200 J	862	112 J	4560 J	384 J
Lead	15 ARAR	Action Level	2.5 BJ	2.1 BJ	2.9 BJ	2 BJ	2.3 BJ	2 BJ	ND R	22.2 J
Magnesium	--		15000	7570	3630 B	3950 B	14200	5980	116000	2530 B
Manganese	50 TBC	SMCL	18.6	95.2	68.9	673	351	ND	403	234
Mercury	2 ARAR	MCL	ND	ND J	ND J	ND J	ND	ND J	ND J	ND J
Nickel	100 TBC	PMCL	21.8 BJ	17.3 BJ	14.9 B	17.1 BJ	19.5 BJ	23.9 BJ	18.9 BJ	20.9 BJ
Potassium	--		7780	6410	4490 B	6380	10000	3990 B	37600	6700
Selenium[7]	10 ARAR	MCL	ND	ND J	ND J	ND J	ND	ND J	ND J	ND J
Silver[7]	50 ARAR	MCL	ND	ND J	ND J	ND J	ND	ND J	ND J	ND J
Sodium	28000 TBC	Notif. Level	112000	48900 J	50900 J	48900 J	169000	48100 J	1440000 J	40800 J
Thallium	1 TBC	PMCL	ND	ND R	ND R	ND R	ND	ND R	ND R	ND R
Vanadium	20 TBC	USEPA HA	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000 TBC	SMCL	19.8 BJ	8.2 BJ	11 BJ	9.6 BJ	12.6 BJ	34 J	63.4	55.6 J
Boron	600 TBC	USEPA HA	5700	1400	1800	400	4200	2400	19000	1200
Cyanide[7]	200 ARAR	MCL	NDJ	ND J	ND J	ND J	ND J	ND J	ND J	ND J

NOTES:

1) ARARs/TBC indicates applicable or relevant and appropriate requirements; TBC indicates to be considered values (refer to Section 4.2 for further explanation). Shaded numbers exceed ARAR/TBC values.
2) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.11 for further explanation.
3) ppb indicates a concentration of parts per billion; ppm is parts per million.
4) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.
5) Radiological constituent values have an assigned +/– range due to sample interference.
6) The acronym adjacent to the ARAR/TBC value indicates the source of the value. Refer to Table 4–2 or glossary for further explanation.
7) These values are based on CTDOHS MCLs which are lower than USEPA MCLs. CTDOHS may at some future time revise their MCLs to correspond to U.S. EPA's.

Generally speaking, low level oil contamination is ubiquitous at the Lower Subase. Two areas of higher concentration oil contamination are evident, one downgradient of the tanks near the Power House and Fire Station, and one downgradient of Building 79. This finding is generally consistent with those from two previous studies (NEOS, 1979 and Wehran, 1987). The primary difference is that the previous studies indicated the presence of substantial amounts of free product. It is likely that the free product previously identified was not as extensive as estimated, and that what free product existed is non residual oil contained in the soil or it has seeped to the Thames River. Active seepage to the Thames River is not presently evident. Early estimates of free product were based upon the thickness of the oil layer in monitoring wells. The thickness of oil in a monitoring well is typically greater than in the adjacent aquifer.

Inorganics

Several findings regarding the inorganic analyses are evident. MCLs **or action levels for lead** are exceeded at **four** locations, **NESO11 for cadmium and lead, 13MW8 for cadmium and lead,** NESOMW10 (adjacent to Building 20) for cadmium and 13MW9 (foot of Corvina Road) for selenium. USEPA health advisories are exceeded at three locations, 13MW4S for vanadium and 13MW15 and 13MW16 for thallium. No thallium was detected in any subsurface soil samples. No cadmium, thallium or selenium was detected above background levels in soils. Secondary MCLs for iron or manganese are exceeded at 20 of the 24 wells. The four wells without exceedance of secondary MCLs are 13MW6, 13MW10, 13MW17 and NESOMW6. Sodium and boron, both present at high concentrations in salt water, are present above notification levels for sodium or the USEPA health advisory for boron at all monitoring wells except for wells 13MW1S, 13MW2S, and 13MW10S, which have acceptable sodium levels. The only other result of note is the high aluminum concentrations in wells 13MW4 and 13MW7 near the power plant.

The range of pH levels at the Lower Subase was between six and seven, except for at three locations. Values between six and seven are considered normal for ground waters. The three locations where values were not measured in this normal range are 13MW4S at 11.11, 13MW7S at 9.09, and 13MW9S at 7.34. Field notes also indicate elevated temperature at 13MW4S. These high values indicate the subsurface release of an alkaline material near Building 29. Ground water from wells 13MW4S and 13MW7S both show elevated levels of aluminum which is probably due to this release. Navy personnel indicated that they have been trying to find the outlet for boiler blowdown from the Power Plant. Previous dye tests did not indicate the outlet of the boiler blowdown in adjacent storm or sanitary sewers. Boiler blowdown has a high temperature and pH. It is likely that the high pH values observed in ground water are due to a subsurface release of boiler blowdown.

5.0 CONTAMINANT FATE AND TRANSPORT

This section addresses the behavior of chemicals in the environment and the properties that determine their fate.

5.1 Fate and Transport Data

Contaminants detected in environmental media at NSB-NLON include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOs), polychlorinated biphenyls (PCBs), organochlorine pesticides, total petroleum hydrocarbons, and inorganics.

The chemical properties for the organic compounds are listed on Table 5-1. These chemical properties are molecular weight, water solubility, vapor pressure, Henry's Law constant (H), the organic carbon partition coefficient (K_{oc}), and the octanol/water partition coefficient (K_{ow}).

Water solubility is the maximum amount of a compound that will dissolve per unit measure of water at a given temperature. Solubilities listed on Table 5-1 are for temperatures of 20 to 30°C. Compounds with higher solubilities will tend to be more mobile in the environment as they will be more likely to dissolve in precipitation or infiltration and leach to groundwater or surface water.

The vapor pressure of a compound is the pressure exerted by its vapor phase in equilibrium with its liquid or solid phase at a given temperature. Table 5-1 lists vapor pressures for organic compounds at temperatures from 20 to 30°C. Compounds with higher vapor pressures are more likely to be volatile and partition to the air.

The Henry's Law constant (H) can be thought of as an air/water partition coefficient with larger H values indicating a greater tendency to volatilize. It relates the concentration of the compound in the gas phase to its concentration in the liquid phase and can be calculated as the compound's vapor pressure over its solubility. The Henry's Law constant is temperature dependent. According to Lyman et al. (1982), compounds with H less than 3×10^{-7} atm-m^3/mole are less volatile than water and can be considered essentially non-volatile. Some of the semi-volatile compounds are in this category. For H between 10^{-7} and 10^{-5} (most of the semi-volatile compounds), the compound slowly volatilizes at a rate controlled by molecular diffusion through air. Below an H of 2×10^{-5}, the compound partitions to water at a rate controlled by the gas phase. For H between 10^{-5} and 10^{-3} atm-m^3/mole, both liquid phase and gas phase resistances are important and, although slower than for compounds with higher H values, volatilization is an important environmental process. For compounds with H greater than 10^{-3} atm-m^3/mole, the resistance of the water film is the controlling factor to volatilization. Most of the volatile organic compounds are in this category. Soluble compounds in this category will have a high volatility. However, for compounds with low solubilities, **and high values of the Henry's Law coefficient, resistance in the liquid phase controls volatilization.**

The organic carbon partition coefficient (K_{oc}) is a measure of the tendency of a compound to adsorb to the organic matter in soils or sediments. It is the ratio of the amount of chemical

TABLE 5-1
CHEMICAL PROPERTIES OF COMPOUNDS

	Molecular Weight, g/mole	Aqueous Solubility, mg/l	Vapor Pressure, mm Hg	Henry's Law Constant, atm-m3/mole	Koc, ml/g	Log Kow	Ref.
VOLATILE ORGANIC COMPOUNDS							
Nonchlorinated Aromatics							
Benzene	78	1.75E+03	9.52E+01	5.59E-03	8.30E+01	2.12	a
Ethylbenzene	106	1.52E+02	7.00E+00	6.43E-03	1.10E+03	3.15	a
Toluene	92	5.35E+02	2.81E+01	6.37E-03	3.00E+02	2.73	a
Xylene (total)	106	1.98E+02	1.00E+01	7.04E-03	2.40E+02	3.26	a
Chlorinated Compounds							
Chloromethane	50.5	6.48E+03	4.31E+03	2.40E-02	2.70E+01	0.91	b,c
1,1-Dichloroethane	99	5.50E+03	1.82E+02	4.31E-03	3.00E+01	1.79	a
1,2-Dichloroethane	99	8.52E+03	6.40E+01	9.78E-04	1.40E+01	1.48	a
1,1-Dichloroethene	97	2.25E+03	6.00E+02	3.40E-02	6.50E+01	1.84	a
Cis-1,2-Dichloroethene	97	3.50E+03	2.08E+02	7.58E-03	4.90E+01	0.70	a
Trans-1,2-Dichloroethene	97	6.30E+03	3.24E+02	6.56E-03	5.90E+01	0.48	a
Methylene Chloride	85	2.00E+04	3.62E+02	2.03E-03	8.80E+00	1.30	a
Tetrachloroethane							
Tetrachloroethene	166	1.50E+02	1.78E+01	2.59E-02	3.64E+02	2.60	a
Trichloroethene	131	1.10E+03	5.79E+01	9.10E-03	1.26E+02	2.38	a
1,1,1-Trichloroethane	133	1.50E+03	1.23E+02	1.44E-02	1.52E+02	2.50	a
1,1,2-Trichloroethane	133	4.50E+03	3.00E+01	1.17E-03	5.60E+01	2.47	a
Vinyl Chloride	63	2.67E+03	2.66E+03	8.19E-02	5.70E+01	1.38	a
Other VOCs							
Acetone	58	1.00E+06	2.70E+02	2.06E-05	2.20E+00	-0.24	a
2-Butanone	72	2.68E+05	7.75E+01	2.74E-05	4.50E+00	0.26	a
4-Methyl-2-Pentanone	100	2.04E+04	1.45E+01	9.40E-05	2.09E+01	1.19	b,c
Carbon Disulfide	76	2.94E+03	3.60E+02	1.23E-02	5.40E+01	2.00	a
SEMIVOLATILE COMPOUNDS							
Noncarcinogenic PAHs							
Acenaphthene	154	3.42E+00	1.55E-03	9.20E-05	4.60E+03	4.00	a
Acenaphthylene	152	3.93E+00	2.90E-02	1.48E-03	2.50E+03	3.70	a
Anthracene	178	4.50E-02	1.95E-04	1.02E-03	1.40E+04	4.45	a
Fluoranthene	202	2.06E-01	5.00E-06	6.46E-06	3.80E+04	4.90	a
Fluorene	116	1.69E+00	7.10E-04	6.42E-05	7.30E+03	4.20	a
2-Methylnaphthalene	142.2		6.81E-02		4.08E+03	3.86	e,c
Naphthalene	128.2	3.17E+01	8.20E-02	5.18E-04	1.22E+03	3.30	b,c
Phenanthrene	178	1.00E+00	6.80E-04	1.59E-04	1.40E+04	4.46	a
Pyrene	202	1.32E-01	2.50E-06	5.04E-06	3.80E+04	4.88	a
Carcinogenic PAHs							
Benzo(a)Anthracene	228	5.70E-03	2.20E-08	1.16E-06	1.38E+06	5.60	a
Benzo(a)Pyrene	252	1.20E-03	5.60E-09	1.55E-06	5.50E+06	6.06	a
Benzo(b)Fluoranthene	252	1.40E-02	5.00E-07	1.19E-05	5.50E+05	6.06	a
Benzo(g,h,i)Perylene	276	7.00E-04	1.03E-10	5.34E-08	1.60E+06	6.51	a
Benzo(k)Fluoranthene	252	4.30E-03	5.10E-07	3.94E-05	5.50E+05	6.06	a

TABLE 5-1 (CONTINUED)
CHEMICAL PROPERTIES OF COMPOUNDS

	Molecular Weight, g/mole	Aqueous Solubility, mg/l	Vapor Pressure, mm Hg	Henry's Law Constant, atm-m3/mole	Koc, ml/g	Log Kow	Ref.
Chrysene	228	1.80E-03	6.30E-09	1.05E-06	2.00E+05	5.61	a
Dibenz(a,h)Anthracene	278	5.00E-04	1.00E-10	7.33E-08	3.30E+06	6.80	a
Indeno(1,2,3-cd)Pyrene	276	5.30E-04	1.00E-10	6.86E-08	1.60E+06	6.50	a
Other Semi-Volatile Compounds							
bis(2-Ethylhexyl)Phthalate	390.5	3.00E-01	6.45E-06	1.10E-05	6.05E+04	5.11	b,c
Di-n-Butylphthalate	278	1.30E+01	1.00E-05	2.82E-07	1.70E+05	5.60	a
2,4-Dimethylphenol	122	5.90E+02	2.60E-02	1.75E-05	9.60E+01	2.81	a
4,6-Dinitro-2-methylphenol	198	2.90E+02	5.00E-02	4.49E-05	2.40E+02	2.70	a
2-Methylphenol	108.2	3.08E+04	3.10E-01	1.60E-06	6.62E+01	1.95	b,c
4-Methylphenol	108.1	2.26E+04	1.30E-01	9.60E-07	6.48E+01	1.94	b,c
Phenol	94	9.30E+04	3.41E-01	4.54E-07	1.42E+01	1.46	a
Benzoic Acid	122.4	2.70E+03	4.50E-03	7.00E-08	5.57E+01	1.87	b,c
4-Chloroaniline	127.6	3.90E+03	2.50E-01	1.07E-05	5.11E+01	1.83	b,c
Dibenzofuran	168.2	1.00E+01	4.40E-03		7.15E+03	4.12	e,c
2-Nitroaniline	138.1						
N-Nitrosodiphenylamine (1)	198.2	3.50E+01	6.69E-04	5.00E-06	8.45E+02	3.13	d,c
PESTICIDES							
4,4' DDE	320	1.00E-01	1.89E-06	7.96E-06	4.40E+06	6.20	a
4,4' DDD	318	4.00E-02	6.50E-06	6.80E-05	7.70E+05	7.00	a
4,4'-DDT	355	5.00E-03	5.50E-06	5.13E-04	2.43E+05	6.19	a
Beta-BHC	290.9	5.00E+00	5.00E-03		5.12E+03	3.78	e,c
Endrin	380	2.40E-01	2.70E-07	4.00E-07	1.70E+03	5.34	a
Endrin Ketone							
Methoxychlor	346	1.00E-01			8.00E+04	7.00	a
PCBs							
Aroclor 1260	375.7	2.70E-03	7.71E-05	2.00E-03	5.30E+05	6.50	d
Aroclor 1254	328.4	1.20E-02	4.05E-05	4.60E-03	5.30E+05	6.80	d

TABLE 5-1 (CONTINUED)
CHEMICAL PROPERTIES OF COMPOUNDS

	Molecular Weight, g/mole	Aqueous Solubility, mg/l	Vapor Pressure, mm Hg	Henry's Law Constant, atm-m3/mole	Koc, ml/g	Log Kow	Ref.
INORGANICS							
Metals							
Aluminum	27						a
Antimony	121.7						a
Arsenic	74.9						a
Beryllium	9						a
Boron	10.8						a
Cadmium	112.4						a
Copper	63.54						a
Iron	55.8						a
Lead	207.2						a
Manganese	54.9						a
Mercury	200.6						a
Nickel	58.7						a
Selenium	79						a
Zinc	65.4						a

Key to references:
a: Superfund Public Health Evaluation Model (1986)
b: Howard (1989)
c: Estimated Koc from Lyman et al. (1982)
d: ATSDR (1988)
e: TOXNET database

NOTE: The reported temperature at which solubility, vapor pressure, Henry's Law constant, K_{oc} and K_{ow} were measured was in the range of 20° to 30°C.

adsorbed per unit weight of organic carbon in the soil or sediment to its concentration in solution at equilibrium (Lyman et al., 1982). If a measured K_{oc} value is not available for a particular compound, it can be estimated from the compound's solubility or octanol water partition coefficient.

The octanol water partition coefficient, K_{ow}, is a measure of how an organic compound will partition between an organic phase (octanol) and water. It is dimensionless and is usually reported as Log K_{ow}. It can be used to assess how a compound will partition to organic environmental media such as organic soils or sediments or into biota. Higher values of K_{ow} indicate that a compound is more likely to partition to an organic phase, such as soils or sediment that contain organic carbon.

Physical, chemical, and microbial processes governing the environmental fate of contaminants include volatilization, biodegradation, photolysis, hydrolysis, oxidation, and adsorption to soils, sediments, or suspended particulate matter.

Volatilization is the transfer of a compound from the solid or liquid phase into the vapor phase. It is controlled by the compound's solubility, molecular weight, and vapor pressure, and by physical properties of the air-water interface (Lyman et al., 1982). In general, the less soluble compounds with lower molecular weights and higher vapor pressures are more volatile. For volatilization from water, properties of the water body that control the rate of volatilization are depth, flow rate, waves, sediment content, and atmospheric conditions such as wind speed. Volatilization from soil is affected by environmental factors such as humidity and by the soil moisture content, organic matter content, porosity, density, and clay content.

Biodegradation is the environmental process by which organic contaminants are broken down by microbial action to simpler compounds, eventually to water and either carbon dioxide or methane. It can occur in either an aerobic or anaerobic environment in soil, sediment, surface water, and groundwater. Factors influencing biodegradation rates are the chemical characteristics of the compound and the concentrations present, the types of microbes present and their previous exposure to the contaminant, and environmental parameters. The types of microorganisms present and the rate at which they can use organic contaminants as a source of carbon depends on environmental factors such as pH, soil moisture content, temperature, salinity, and the presence of oxygen. Generally, certain types of microorganisms will be active in a given range of these parameters.

Bioaccumulation is the accumulation and transport of a chemical via the water and through the food chain. The potential for bioaccumulation is quantified by bioconcentration factors (BCFs) which define the ratio of a pollutant concentration in animal or plant tissue to the concentrations of the same chemical in the environmental media of contact (air, water or soil).

Contaminants are transformed to smaller, less complex compounds via the chemical processes of hydrolysis, photolysis, and oxidation. Hydrolysis is due to the reaction of hydrogen bonds in water with the compound. In general, hydrolysis is only important in determining the fate of organic acids or bases. Photolysis is the transformation of an organic compound caused by absorbing energy from sunlight. It can be an important process in the attenuation of organic contaminant concentrations in surface water. Some organic compounds may be oxidized by

exposure to oxidizing agents such as atmospheric oxygen. However, for many of the organic compounds detected at NSB-NLON, the oxidation rate is too slow to substantially affect contaminant concentrations.

The adsorption of organic compounds onto soils, sediments, and suspended sediments plays an important role in determining the compound's environmental fate. The degree to which a compound will adsorb onto soils or sediments depends on its chemical properties and physical and chemical properties of the soils or sediments. The organic carbon partition coefficient (K_{oc}) or octanol/water partition coefficient (K_{ow}) is a measure of how a particular compound will adsorb to soil. Higher coefficients indicate a greater tendency for the compound to adsorb to organic matter in soil. Soil characteristics influencing adsorption are organic carbon content, clay content, cation exchange capacity, pH, and particle size. In general, the soil characteristic that most influences the adsorption of organic compounds to soils is its organic carbon content. Compounds with higher K_{oc} or K_{ow} values have a higher tendency to partition to other organic media such as organic soils.

The way in which a chemical is released into the environment and the quantity of the chemical released also governs its environmental fate. A spill of a relatively insoluble organic chemical onto soil can remain in a non-aqueous phase (known as a non-aqueous phase liquid of NAPL). If the spill is of enough volume that the liquid reaches ground water in bulk (small spills will remain adsorbed to soil), liquids that are less dense than water will tend to float on top of the water table (light non-aqueous phase liquids or LNAPL), while liquids that are denser than water (dense non-aqueous phase liquids or DNAPL) can sink through the aquifer. Products that behave as LNAPL are petroleum hydrocarbons such as gasoline and fuel oil and their constituents. High density, low viscosity materials comprise DNAPL. Materials with these characteristics include chlorinated hydrocarbons such as trichloroethene and tetrachloroethene. LNAPL and DNAPL have not been detected at NSB-NLON.

A spill of sufficient volume will descend through the pore spaces of the unsaturated soil in the vadose zone. Some of the product will remain adsorbed to vadose zone soil. Once in the vadose zone, the chemical is dissolved in infiltrating precipitation and is acted upon by environmental processes such as volatilization, biodegradation, etc.

If a spill of LNAPL is of large enough volume, it can reach the capillary fringe on top of the water table. As more product reaches this area, the capillary fringe becomes compressed, the water table becomes depressed, and LNAPL accumulates in the depression. Seasonal fluctuations of the water table can raise and lower the non-aqueous layer and carry contaminants to the area of soil between the seasonal high and low water tables.

Because of its density and low viscosity, DNAPL travels through the vadose zone and continues migrating downward through the capillary fringe and the water table. As it comes into contact with infiltration and ground water, it begins to dissolve, and can volatilize or be biodegraded. If sufficient DNAPL is present, it can sink through the aquifer to a confining layer or bedrock. If DNAPL reaches bedrock, its movement is governed by the bedrock surface. Therefore, under certain situations, the bulk movement of the DNAPL can differ in direction from ground water flow.

5.1.1 Volatile Organic Compounds

The types of volatile organic compounds (VOCs) detected in samples of environmental media from NSB-NLON include aromatics, chlorinated aliphatics, ketones, and one sulfur compound, carbon disulfide. In general, because these compounds are partially soluble in water and have a relatively high vapor pressure, they are mobile in the environment and tend to partition between water and the atmosphere. Most VOCs can undergo biodegradation or biotransformation in soil or water under certain conditions.

5.1.1.1 Nonchlorinated Aromatic Volatile Organic Compounds

The nonchlorinated aromatic VOCs detected include benzene, toluene, ethylbenzene, and xylenes. These compounds are commonly used as solvents and are found in gasoline and other light fraction petroleum distillate products. Benzene is the basic molecule in this series and the other members of this class have methyl or ethyl groups substituted on the benzene ring. These compounds will have a similar environmental fate as they have similar solubilities, vapor pressures, and K_{ow} values.

5.1.1.2 Chlorinated Volatile Organic Compounds

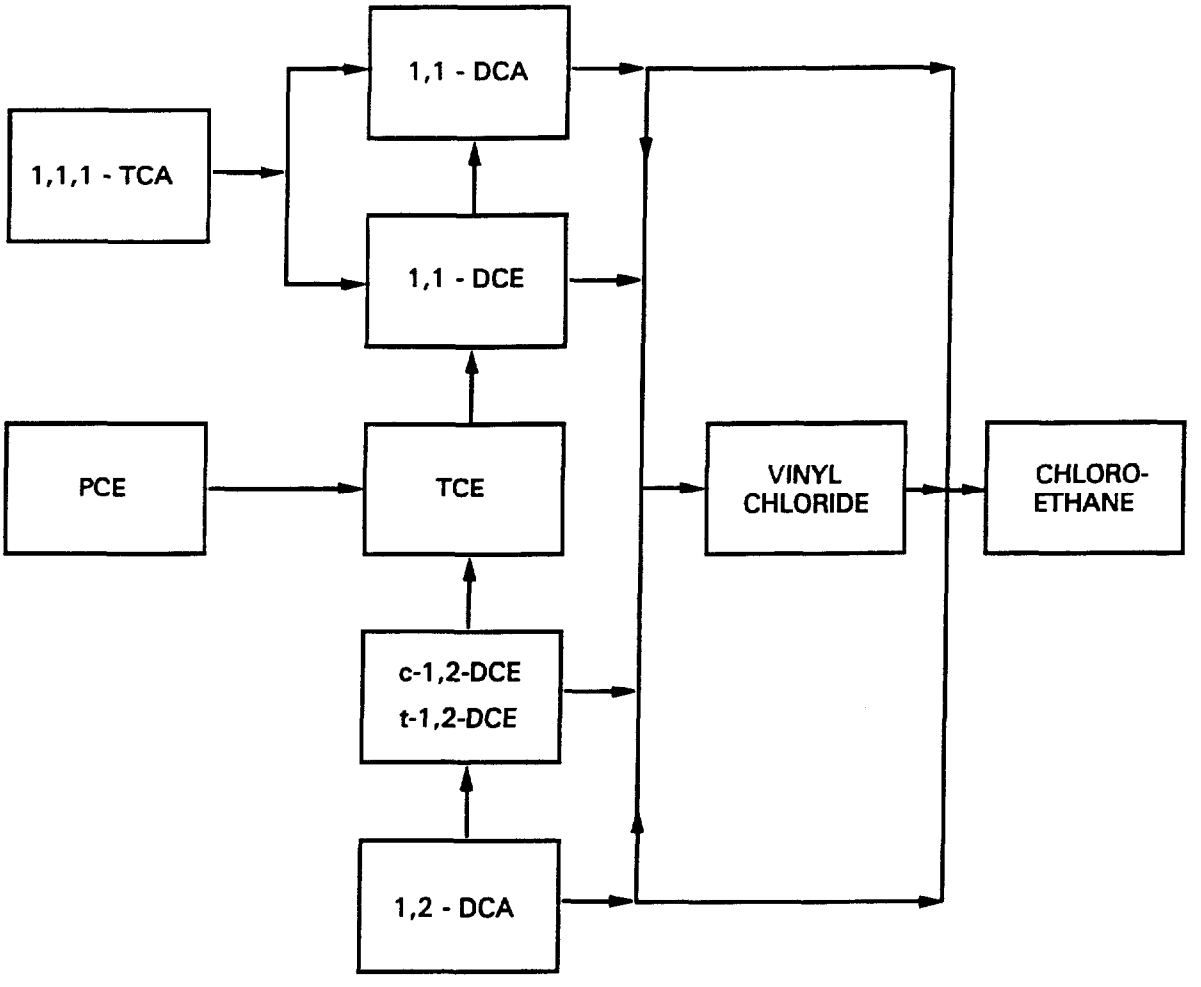
The chlorinated VOCs detected at NSB-NLON include chloromethanes, chloroethanes, and chloroethenes. These compounds are commonly used as solvents and degreasers. Soil bacteria are capable of biotransforming the larger, more complex compounds in this group such as 1,1,1-trichloroethane and trichloroethene to smaller and/or less chlorinated compounds. These transformation pathways are shown in Figure 5-1. The presence of some of these compounds in environmental media at the site may be due to microbial degradation of parent compounds rather than a loss or spill of the compound itself.

The chloromethanes detected (chloromethane and methylene chloride) are the smaller molecules of this class. Chloromethane and methylene chloride are more water soluble than the other compounds in this class and hence are more mobile in the environment. The solubilities and vapor pressures, and hence the Henry's Law constant of the chloroethanes and chloroethenes are similar. However, their K_{ow} values tend to increase with increasing chlorination indicating that the more chlorinated compounds of this class will tend to partition to organic soil or sediment.

5.1.1.3 Other Volatile Organic Compounds

The ketones detected include acetone, 2-butanone, and 4-methyl-2-butanone. Ketones are also commonly used as solvents. These compounds tend to be more soluble and have lower Henry's Law constants than the other VOCs. They are, therefore, more likely to remain in solution and less likely to volatilize. They also tend to have lower K_{ow} values than the other VOCs indicating that they are less likely to partition to organic media.

The only sulfur-containing VOC detected was carbon disulfide. Carbon disulfide is a naturally occurring product of anaerobic biodegradation (Howard, 1990). It is also a waste by-product of viscose rayon and cellulose manufacturing and is used as a grain fumigant. Its



INSTALLATION RESTORATION STUDY

NAVAL SUBMARINE BASE - NEW LONDON

GROTON, CT

LEGEND

1,1,1-TCA = 1,1,1-Trichloroethane
PCE = Tetrachloroethene
1,2-DCA = 1,2-Dichloroethane
1,1-DCA = 1,1-Dichloroethane
1,1-DCE = 1,1-Dichloroethene
TCE = Trichloroethene
c-1,2-DCE = cis-1,2-Dichloroethene
t-1,2-DCE = trans-1,2-Dichloroethene

FIGURE 5-1
TRANSFORMATION PATHWAYS FOR VARIOUS CHLORINATED VOLATILE HYDROCARBONS IN SOIL SYSTEMS (DRAGUN, 1988)

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chemical properties indicate that its behavior in the environment will be similar to the chlorinated VOCs.

5.1.2 Semi-Volatile Organic Compounds

The semi-volatile organic compounds detected include polynuclear aromatic hydrocarbons (PAHs), two phthalate esters, five phenolic compounds, two aniline derivatives, benzoic acid, dibenzofuran, and N-nitrosodiphenylamine. As their name implies, the compounds in this class are less volatile and less likely to migrate or volatilize than the VOCs.

5.1.2.1 Polynuclear Aromatic Hydrocarbons

Polynuclear aromatic hydrocarbons (PAHs) are composed of multiple aromatic or benzene-like rings. Naphthalene, the smallest molecule of the PAHs, is composed of two rings. PAHs detected at NSB-NLON range in size from naphthalene (molecular weight of 128 g/mole) to 6 ring structures such as benzo(g,h,i)perylene (molecular weight of 276 g/mole).

Sources of PAHs are petroleum and coal and formation during the combustion of organic matter. The widespread burning of fossil fuels has resulted in aerial deposition of PAHs to surface soils and sediments.

The smaller PAHs (molecular weights less than 200 g/mole) such as naphthalene are slightly soluble, have Henry's Law constants in the range of 10^{-3} to 10^{-5} and hence are relatively mobile in the environment. They will tend to volatilize from soil, sediment, or water. The larger PAHs have lower solubilities, low Henry's Law constants, and large K_{ow} values. They will not volatilize to a great extent and will remain adsorbed to soils or sediments. Photolysis, chemical oxidation, and biodegradation are important degradative processes controlling the fate of PAHs in the aquatic environment (Neff, 1979).

5.1.2.2 Other Semi-Volatile Organic Compounds

Phthalate esters are dispersed throughout the environment due to their common use as plasticizers. Di-n-butylphthalate and bis(2-ethylhexyl)phthalate were detected in environmental media at NSB-NLON. Phthalate esters have relatively low Henry's Law constants (10^{-5} to 10^{-7} atm-m^3/mole) and high K_{ow} values indicating that, although they may volatilize, it is at a slow rate and they will tend to partition to organic soils and sediments. Phthalate esters will undergo biodegradation in soil and sediment. Photolysis and oxidation do not appear to be important processes in governing the fate of these compounds (Clement Associates, 1985).

Phenolic compounds detected onsite include phenol, 2-methyphenol, 4-methylphenol, 2,4-dimethylphenol, and 4,6-dinitro-2-methylphenol. Phenol, the parent compound of this class, consists of a hydroxyl group attached to a benzene ring. These compounds are weak acids due to the hydroxyl group and they dissociate slightly in water. This characteristic also makes them more soluble in water than most of the other classes of compounds discussed in this section (solubilities of 290 to 93,000 mg/l). Based on their Henry's Law constants, phenols volatilize in the environment at a slow rate. Their K_{oc} and K_{ow} values indicate a moderate ability to adsorb to soil, similar to that of VOCs. The process governing the environmental fate of phenols is

biodegradation; they are biodegraded rapidly in both soil and water. Photolysis of phenols also occurs rapidly in the environment, but biodegradation has a greater effect on their fate since it can occur in the subsurface as well as in environmental media exposed to sunlight.

Benzoic acid can be naturally occurring; it has several uses in industry, including as a food preservative. The acid dissociation constant (pK_a) for benzoic acid is 4.205 and, therefore, it will be found in the dissociated form at typical environmental pH values. Benzoic acid is relatively soluble in water but has a low Henry's Law constant indicating that it will tend to remain dissolved rather than to volatilize. It is readily biodegraded in soil and water (Howard, 1990).

The aniline compounds are composed of an amine group attached to a benzene ring. The amine group causes them to be weak bases and to be more soluble in water than similar organic compounds. The compounds 4-chloroaniline and 2-nitroaniline were detected in environmental media at NSB-NLON. Volatilization is an important process governing the environmental fate of these compounds; a half-life of 6.4 hours in the water column has been measured for 4-chloroaniline (Howard, 1989). The aniline compounds biodegrade rapidly in soil and water. In surface water and soils, photolysis also occurs rapidly.

There is little available literature on the behavior of dibenzofuran in the environment. The structure of dibenzofuran is similar to a three ring PAH molecule with oxygen substituted for a carbon atom. Its chemical properties are also similar to those of the smaller PAH compounds. It is moderately soluble in water (solubility of 10 mg/l) and its Henry's Law constant (9.8×10^{-5} atm-m^3/mole) indicates that volatilization will be an important process in determining its environmental fate. It also has a relatively high K_{oc} value and is likely to adsorb to soils and sediments.

The use of N-nitrosodiphenylamine has been discontinued in the United States. It was formerly used as a retarder in the manufacture of rubber to prevent premature vulcanization. N-nitrosodiphenylamine will volatilize from water at a slow rate ($H = 5 \times 10^{-6}$ atm-m^3/mole). Reported organic carbon partition coefficients (K_{oc}) for this compound are in the range of 830 to 1830, indicating a tendency to adsorb to organic soils and sediments (ATSDR,1988). The main process affecting the fate of N-nitrosodiphenylamine in the environment is biodegradation, although photolysis is also likely to be a significant process in surface water and surficial soils.

5.1.3 Pesticides/PCBs

The organochlorine pesticides beta-BHC, endrin, endrin ketone, methoxychlor, and DDT and its breakdown products DDD and DDE were detected in environmental media at NSB-NLON.

Beta-BHC is an isomer of hexachlorocyclohexane produced during the manufacture of gamma-BHC or lindane. Of the organochlorine pesticides detected, it is the most mobile in the environment based on its higher aqueous solubility and lower K_{oc} and K_{ow} values. These indicate that it tends to remain dissolved and that it adsorbs to soil to a lesser degree than the other organochlorine pesticides. It volatilizes slowly from soil and water. Biomagnification of hexachlorocyclohexane isomers occurs in the terrestrial food chain. However, they tend not to

accumulate in fish (ATSDR, 1989). The beta isomer is fairly resistant to biodegradation in soil or water.

Due to former uses, low levels of DDT and its breakdown products are widespread in the environment. They are only slightly soluble in water and have relatively low Henry's Law constants indicating that they are unlikely to be present in the dissolved form in the environment and are unlikely to partition to the atmosphere. They have high Log K_{ow} values (6.2 to 7) and hence adsorb strongly to organic soils and sediments. They are also taken up by biota and bioaccumulated.

Endrin and methoxychlor have similar chemical properties to DDT and hence behave in a similar manner in the environment. They tend to adsorb strongly to soils and sediments. Although they are taken up by biota, they do not bioaccumulate or biomagnify in the food chain to the degree that DDT does.

Polychlorinated biphenyls (PCBs) detected in environmental media at NSB-NLON include Arochlor 1254 and Arochlor 1260. The Arochlor formulations are composed of complex mixtures of chlorinated biphenyls. Arochlor 1254 and Arochlor 1260 contain 54% and 60% chlorine, respectively. Arochlor 1254 is composed mainly of tetrachloro-, pentachloro-, and hexachlorobiphenyls with smaller amounts of the mono-, di-, tri- and heptachloro- congener groups while Arochlor 1260 is composed mainly of the pentachloro-, hexachloro-, and heptachlorobiphenyls with lesser amounts of the other congeners (ATSDR,1989).

Up until the 1970s, PCBs were used widely as dielectric fluids in electrical capacitors and transformers because of their resistance to thermal degradation. Although the manufacture and use of PCBs for this purpose was discontinued in the United States in the 1970s, older equipment may still contain PCBs.

PCBs in general have a relatively high Henry's Law constant and dissolved PCBs will tend to partition to the atmosphere. However, since PCBs are only slightly soluble in water, their rate of partitioning to the atmosphere is controlled by their low solubility. PCBs are strongly adsorbed onto organic soils and sediments. Log K_{ow} values for the PCB congeners in Arochlor 1254 and 1260 range up to 9.35 (Shaw and Connell, 1982). (An average value is in Table 5-1.) PCBs are also likely to be taken up by biota and stored in lipids.

Biodegradation of PCBs in the environment depends on their degree of chlorination. The highly chlorinated congeners of Arochlors 1254 and 1260 are fairly resistant to biodegradation. Photolysis may be an important process for the environmental degradation of dissolved PCBs.

5.1.4 Inorganics

Inorganic contaminants detected in environmental media NSB-NLON include metals and cyanide.

5.1.4.1 Metals

Unlike most of the other contaminants detected in environmental media at NSB-NLON,

metals occur naturally in the environment in addition to resulting from anthropogenic sources. Section 4.0 discussed the distribution of metals in the environment and assessed whether the metals detected at NSB-NLON occur at concentrations in excess of their naturally occurring levels.

The fate and transport of metals in the environment depends on chemical properties of the metal as well as chemical and physical characteristics of the environment. The solubility of metals and metal salts controls the amount of metal available to ground water or surface water, although other physical and chemical processes control the observed concentrations of those metals in water. Environmental factors influencing the mobility of metals in the environment include pH, Eh, the presence or lack of oxygen, **the presence of other metal compounds such as iron oxides,** and the presence of anions and complexing agents.

In general, metals are more soluble and more mobile in the environment at lower pH values. Higher pH values tend to cause metals to precipitate from solution.

The oxidation/reduction potential of the aquatic system being assessed (surface water, ground water, or interstitial pore water in sediments) determines the equilibrium valence state of the metal. The more oxidized form of the metal will be favored under aerobic conditions; the reduced form is favored under anaerobic conditions. Many metals, including lead and cadmium, are less mobile in anoxic environments because they form nearly insoluble sulfide salts. However, some metals such as iron are more soluble in their reduced (Fe II or ferrous) form. When dissolved iron moves from a reducing to an oxidizing environment, the iron is oxidized to its ferric (Fe III) form and precipitates out of solution forming orange floc generally observed downgradient of landfills.

The presence of dissolved salts and gases (e.g., carbon dioxide and hydrogen sulfide) and the system pH determine the mineral form controlling the metal's solubility. For example, the presence of sulfur in the form of sulfide in a reducing environment will cause precipitation with many metals cations (e.g., cadmium and lead) to form the metal sulfide. In addition, metals solubility can be enhanced in the presence of complexing agents such as humic acids formed from organic materials such as rotting leaves.

Metals have a high affinity to adsorb to soils and sediments. The degree to which metals adsorb to soils depends on the environmental factors discussed above and on characteristics of the soil or sediment including organic content, cation exchange capacity, clay content, and the presence of iron oxides in the soil.

5.1.4.2 Cyanide

The behavior of cyanide in the environment depends on the form of cyanide present. Factors influencing cyanide include pH, the presence or lack of oxygen, and the presence of iron which forms complexes with cyanide. Hydrogen cyanide is a weak acid with a pK_a of 9.21. At most environmental pH values, hydrogen cyanide is in its associated form (HCN). In this form, cyanide is very mobile in the ground water and volatilizes as cyanide gas. However, cyanide forms hexacyanoferrate complexes with the ferrous (Fe II) and ferric (Fe III) forms of iron which are abundant in soil. Cyanide in these forms is much less toxic than free cyanide.

The hexacyanoferrate complexes can bind to ferrous or ferric ions to form ferroferro- or ferriferrocyanide compounds that are much less soluble than free cyanide and have a much greater tendency to bind to soil or sediment.

5.2 Contaminant Migration

This section of the report evaluates potential migration pathways of chemicals in the environment.

5.2.1 Potential Routes of Migration

Chemicals will migrate within a specific media, and will also undergo interphase transport between media such as evaporation of chemicals from water to air. Plants and animals can also take up chemicals from soils and water which can cause transport of contaminants in the food chain. This pathway is of particular concern for chemicals that bio-accumulate as described in the previous section. The following sections will discuss potential migration routes for each media. For purposes of this section, the media, or primary migration routes, are air, ground water and soils, and surface water and sediments.

5.2.1.1 Air

Airborne transport of chemicals occurs via two primary routes. These are volatilization and adsorption to small soil particles that become airborne as fugitive dust. Volatile chemicals were not detected at NSB-NLON in high enough concentrations to have a measurable effect on ambient air quality. The only pathways of concern for VOCs is the possible migration to indoor air in buildings from contaminated subsurface soils and ground water. Transport of fugitive dusts is a concern in areas with contaminated surface soils that have an erodible surface. The rate and extent of contaminant migration of airborne materials will be primarily determined by modelling air transport. Subsurface migration of volatiles is governed primarily by preferential flow pathways such as sand lenses, or gravel bedding for subsurface utilities. Dispersion for VOCs and particle size for fugitive dusts are physical parameters that will affect the rate and extent of migration. Airborne contaminants from this site will migrate in the direction of wind currents. The prevailing winds are southwesterly in the summer and northwesterly in the winter. The average wind speed is around ten miles per hour. Transport in any direction is possible at certain times. The chemicals once airborne will either degrade, settle on land or the Thames River. As concentrations are low for VOCs and other contaminants in surface soils, effects on water quality in the Thames River are considered negligible. Fugitive dusts could have measurable impacts on soils within a short distance of a contaminated site and could have temporary adverse impacts on ambient air quality.

In the following sections, airborne contaminant migration will be addressed by identifying areas with contaminated surficial soils that are erodible, and sites with VOC subsurface contamination that has a potential to migrate to confined spaces.

5.2.1.2 Ground Water and Soils

Contaminated soils can release contaminants to both air and ground water. The release

to air by evaporation or fugitive dust is discussed above. Water percolating through soils will mobilize chemicals from soils to infiltrating water by dissolution and desorption. Chemicals are also leached from soils below the water table by the same mechanism. Due to the shallow depth to ground water and relatively permeable overburden at NSB-NLON, this infiltrating water will migrate to and mix with the ground water. The mobility of a chemical is its rate of transport relative to ground water velocity. Contaminants will not migrate faster than ground water. Ground water at the NSB-NLON eventually migrates and discharges to the Thames River. In Area A, the ground water may first discharge to wetlands areas and small streams that flow to the Thames River. There are no wells located hydraulically downgradient of any of the contamination sources. In discharge areas, ground water could be close enough to the ground surface whereby direct uptake by biota is possible.

In the site specific sections, where possible, estimates are made of ground water flow rate and direction, and the specific discharge points of ground water.

5.2.1.3 Surface Water and Sediments

Contaminants enter surface water primarily by runoff and ground water infiltration. Runoff becomes contaminated by contact with surficial soils and atmospheric chemicals. Runoff and ground water can contain dissolved chemicals and contaminated suspended particles. Once introduced to the stream, contaminants will migrate with the surface water or be incorporated into river sediments by partitioning or sedimentation. The more volatile compounds can also evaporate to the air. The sediment bedload will also migrate downstream, although at a much slower rate than surface water. Sediments accumulate at dams and other obstructions. Contaminants can also enter surface water via air releases, however, this is not considered a significant pathway at this site due to the relatively low surface soil contaminant concentrations and limited amount of erodible surfaces. The exchange of surface water to ground water is also considered negligible in that the small streams tributary to the Thames River are normally recharged by ground water. The Thames River during high tide does recharge small areas of ground water up to 200 feet inland, however, the Thames River is the ultimate discharge point for contaminants from NSB-NLON. Due to the large flow of the Thames River, contaminant concentrations are only potentially a concern in the mixing zone within the Thames River adjacent to NSB-NLON and adjacent sediments. **The section of the Thames River near NSB-NLON is an estuary. Within an estuary, the changing of the river from fresh to salt water conditions has substantial effects on suspended and dissolved material in the river. Destabilization of colloids, alternation of adsorption equilibrium and precipitation of cationic species are among the commonly observed changes. There is a general tendency for trace metals, and potentially hydrophobic organic compounds, to be trapped in estuarine sediments as a result of these processes.** Contaminants once in the surface water/sediment system are available for uptake by biota. The Thames River does support a significant sport fish population.

The following site specific sections, to the extent possible, will estimate flow rates and directions, and discharge points for sediments and surface water.

5.2.2 Site Specific Potential Routes of Migration

Site and chemical specific potential migration routes for each of the investigation sites is discussed below.

5.2.2.1 CBU Drum Storage Area

Based upon the chemical analyses performed, no significant release was identified at this site. As such, an assessment of contaminant migration potential is not necessary.

5.2.2.2 Rubble Fill at Bunker A

Documented releases of concern at this site consist of surface soils with moderate levels of PAHs, low levels of pesticides, arsenic well above background concentrations, and trace levels of VOCs.

Air: The soils at this site are not covered with asphalt or other impervious materials, and are only sparsely vegetated. Therefore, potential migration routes are transport in fugitive dust. VOCs are only present in trace concentrations, and are not further considered.

Ground Water and Soils: The chemicals present in soils will migrate slowly with infiltrating precipitation and could enter the ground water. No ground water monitoring wells exist at this location to confirm ground water flow directions, however, ground water flow is likely to the north toward Area A. The mobility of arsenic is dependent upon its chemical form, e.g., metal arsenides versus arsenic sulfides. Different arsenic compounds have medium to high mobilities. The pesticides and PCBs detected have a low mobility.

Surface Water and Sediments: As this site is not covered, surface runoff from it could contain dissolved and suspended contaminants. Surface water flows to the north as overland flow in a small drainage swale and discharges into Area A. Contaminants detected do not readily dissolve except for some arsenic compounds, and will be transported primarily on suspended particles in runoff.

5.2.2.3 Torpedo Shops

Releases have been detected in subsurface soils and ground water at the Torpedo Shops. Low concentrations of VOCs and SVOs were detected in soils, along with antimony and silver concentrations above background. There was one occurrence each of PCB and DDT in relatively low concentrations in soils. SVOs, pesticides and PCBs were not detected in ground water. Several VOCs and antimony were detected in ground water.

Air: Hazardous substances are not known or suspected to exist in surface soils and this area has a vegetative or asphalt cover, therefore, transport by fugitive dusts is not considered a potential migration route for soils. VOCs at low to moderate concentrations were present in subsurface soils and ground water. There are no buildings within the current study area.

Ground Water and Soils: Contaminants in soil do have the potential to leach to ground water at this site. Ground water flow is to the south-southwest. The hydraulic conductivity was estimated to be 6.5 feet per day. Ground water discharges either to Area A Downstream and/or the Thames River. The only constituents detected in ground water were VOCs and antimony. The presence of antimony in ground water is consistent with its presence in soils. The source of the VOCs is not apparent. Mobility of the VOCs detected is high. The mobility of antimony is dependent upon its chemical form and could be medium to high.

Surface Water and Sediments: Surface water flows generally to the south-southeast overland and is collected by storm sewers and drainage ditches which flow to the west, eventually discharging downstream of Area A and from there into the Thames River. Surface soils are not believed to be contaminated and are grass covered, therefore, this is not considered a potential migration route.

5.2.2.4 Goss Cove Landfill

Hazardous substances have been detected in site soils and ground water. Soils contain moderate to high levels of VOCs, SVOs which are predominantly PAHs, PCBs and pesticides. The following inorganics were detected above background levels in soils: arsenic, cadmium, chromium, lead, and mercury.

Ground water contained moderate levels of VOCs, low levels of SVOs, **sodium above the CTDOHS notification level, and iron and manganese above secondary MCLs.**

Air: The entire area has a vegetative or asphalt cover, therefore, air transport of fugitive dust is not considered a potential pathway for contaminant migration. VOCs and low molecular weight SVOs are present in significant concentration and could potentially migrate to subsurface confined spaces such as the Nautilus Museum and proposed trenches for installation of new storm sewers. Although elevated VOCs have not been detected in soil gas near the museum to date, this requires further evaluation.

Ground Water and Soils: Contaminants are located above and below the ground water table. As a result, contaminants will leach from soils by flowing ground water and, to a limited degree, infiltrating precipitation. Ground water flow is to the northwest at this site with discharge to the adjacent Thames River.

Ground water at Goss Cove flows to the northwest at an estimated velocity of 1.7 feet per day. The pesticides and PCBs are not partitioning from soils to ground water at detectable concentrations due to their low solubility and partition coefficients. VOCs which have higher solubilities and, thus high mobility, are detected in ground water. SVOs which have moderate to high soil concentrations were only detected at low levels in ground water, and have moderate to low migration rates. The metals present above background concentrations in soils were not detected in ground water above MCLs. This suggests that the metal compounds present are tightly adsorbed to soils and have a low migration potential. The metals with elevated levels in ground water are barium, iron and manganese. The iron and manganese appear to be leached from soils due to reduced conditions in the fill. There is no apparent reasons for the presence of barium. Sodium was also present at elevated levels, however, it is present due to salt water

intrusion in this area.

Surface Water and Sediments: Surface water at this site primarily migrates as sheet flow to the west where it is collected by storm sewers and discharged to the Thames River. Most of the site is paved or covered with vegetated loam, which is believed to be clean. As such, migration of contaminants by surface water is not considered a potential route for chemical transport. Some ground water infiltration to the storm water culvert is possible.

5.2.2.5 OBDANE

Based upon investigations performed, there have been no release of hazardous substances at this site. As such, an assessment of potential contaminant migration pathways is not necessary.

5.2.2.6 Spent Acid Storage and Disposal Area

Subsurface soils contain elevated levels of lead. Low levels of VOCs and PAHs were detected, however, not in concentrations of concern.

Air: The site is covered with pavement, therefore, transport of lead in fugitive dust will only be a migration route when this surface layer is disturbed during construction activities. Lead will not volatilize in air, therefore, volatilization is not a potential migration route.

Ground Water and Soils: Lead is present in soils and does have the potential to be leached to ground water. The pavement in place will minimize but not eliminate infiltration, and some lead is likely present below the ground water table. Most lead compounds migrate slowly, adhere tightly to soils, and will not partition to ground water in significant concentration.

No ground water monitoring wells have been installed in this area. The ground water flow direction is inferred to be generally to the west/southwest.

Surface Water and Sediments: Surface water flow is generally to the west-southwest where it is collected by the storm sewer system and eventually discharges to the Thames River at Goss Cove. As this site is covered with pavement, transport by surface water is not a significant contaminant migration route. Depending on the depth of the storm sewer system, some ground water infiltration to the storm sewer is possible. It would be expected that lead will not readily dissolve in surface water and would be transported primarily on suspended soil particles it adsorbs to.

5.2.2.7 Former Gasoline Station

Based upon sampling results, there were no documented releases of hazardous substances at the Former Gasoline Station. As such, potential contaminant migration pathways have not been defined.

5.2.2.8 Area A/OBDA

There are a number of documented releases in Area A soils and sediments. These include low levels of VOCs and SVOs in the landfill, wetland and Downstream/OBDA areas. Some areas of the wetland contained moderate levels of VOCs and some of the sediments near OBDA contained moderate levels of SVOs and VOCs. PCBs were detected at moderate levels in one surface soil sample at the landfill, and at low levels in the wetlands. DDTR was detected at low levels in the landfill and wetlands and in high concentrations in the Downstream/OBDA area sediments. Several inorganics were detected above background concentrations. The specific metals are listed below by site.

Area A Landfill: beryllium, cadmium, lead, mercury, copper, nickel, boron
Area A Wetland: lead, mercury, cadmium, silver
Area A Downstream/OBDA: beryllium, cadmium, lead, selenium, zinc, boron

The only inorganic detected which is not found naturally occurring in soils is cyanide. Low levels of cyanide were detected in a drainage channel at the Weapons Center.

Area A ground water was found to contain low levels of VOCs, one occurrence of PCB in the landfill, and cadmium above MCLs. The following other inorganics were measured above ARAR or TBC values: iron, manganese, sodium and aluminum.

Surface water in the Area A Wetlands and Downstream contained low levels of aromatic VOCs in one stream segment, one occurrence of DDTR, and the following metals above ARAR or TBC values: cadmium, lead, copper, iron and manganese.

Air: Several portions of this area are uncovered and contain contaminants in surficial soils such as PCBs and DDTR that tightly adsorb to soil particles. Fugitive dust containing adsorbed contaminants, therefore, will be generated in this area and transported offsite. VOCs are present in low concentrations and will not have a measurable impact on ambient air quality, however, there is potentially significant exposures in subsurface confined spaces (e.g., utilities).

Ground Water and Soils: Contaminants are present above and below the water table, therefore, contaminants will be leached from soils by both infiltrating precipitation and flowing ground water. In the overburden, the highest ground water elevation is in the middle of the Area A Landfill. It appears that ground water in the central/eastern portion of Area A flows north toward the Area A wetland, and ground water in the northwestern portion of the Area A Landfill flows northwest toward the Area A Downstream and eventually to the Thames River. The velocity of ground water flow through soils in the landfill and wetland portions of Area A was estimated to be 0.04 feet per day. The ground water flow velocity through the soils in Area A Downstream was calculated to be 0.13 feet per day. Ground water discharges to the wetlands, Area A Downstream surface waters and the Thames River.

Ground water flow in the bedrock is generally to the west. Transmissivity values in the bedrock range from 4.7 to 250 ft^2/day, indicating a high variability of transmissive properties within the fractured bedrock.

VOCs which were detected in soils and sediments in low to moderate concentrations are highly mobile and were detected in low concentrations in ground water. The SVOs, PCBs and pesticides detected in site soils have low mobilities. There was only one occurrence of PCB in ground water. If this result is correct, the presence of PCBs in ground water suggests a concentrated source of PCBs in soil near the location where it was observed (2LMW18S). Metals are generally immobile and partition strongly to soils except for some metal compounds. Of the seven different metals detected above background in soils, only cadmium was detected in ground water above MCLs. Cadmium is substantially more soluble in natural waters than many metals, therefore, its existence in ground water is not surprising. All other metals are apparently in forms that are relatively immobile. Other inorganics were detected in ground waters above ARAR or TBC values. These inorganics were not present above background in soils, however, their natural concentrations found in soils are high. These include: iron, manganese and sodium. These inorganics are more soluble in reduced environments. Therefore, it appears that the landfill and wetland have altered the natural environment to cause the leaching of these materials from soils into ground water at elevated levels.

Surface Water and Sediments: There are erodible surfaces that may contain adsorbed contaminants in Area A. Surface soils also contain chemicals that could dissolve in runoff. As a result, surface water may contain both dissolved and suspended contaminants.

Surface water from this site originates from runoff within the northern Subase watershed area (refer to Figure 3-5), and ground water discharge in Area A Wetlands and Downstream surface waters. The primary discharge point from the Area A Wetland is through four 24-inch metal culverts through the dike. This discharge forms a small stream which flows west for approximately 200 feet and into a small pond. Wetlands sediments accumulate upstream of the dike. Under normal flow conditions, this pond discharges to a small stream which flows north and then west toward Triton Avenue (past OBDANE site). The stream continues flowing west under Triton Avenue and Shark Boulevard and eventually discharges to the Thames River at the DRMO outfall. This pond also has a discharge structure on the south side. During periods of high flow and high water at the pond, water also flows out through this structure to a stream which flows south from the Over Bank Disposal Area site. A second pond to the south of the pond referenced above is formed by ground water inflow, and flows to the west around North Lake.

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

A substantial amount of surface water flow at this site is due to ground water discharge. As a result, the above discussion of inorganics in ground water also applies to inorganics in surface water. In addition, surface waters also contained lead and copper in concentrations above ARAR or TBC values. The surface water ARAR standards for these metals are more stringent than the MCLs for potable water. Lead and copper were present in ground water. When ground water in a reduced condition discharges to surface water, it is oxidized. This change in chemical environment can cause metal compounds to oxidize to a less soluble form. Iron is less soluble in the oxidized state. This phenomena explains the orange precipitates forming at the base of OBDA.

The majority of VOCs discharged to surface water will volatilize to air and a smaller percentage will adsorb to sediments. VOCs were only detected at low concentrations in one small segment of one of the small streams downstream of Area A.

DDTR was measured in high concentration in sediments and only once in measurable concentrations in surface water. This is as expected based upon DDTR's chemical properties. DDTR is highly persistent and strongly adsorbs to soils and organic matter. Sorption appears to be the dominant environmental process affecting the fate of DDTR. Water solubilities indicate that transport in ground water or surface water of dissolved DDTR is not likely. Transport of DDTR on particles that it is strongly adsorbed to is a significant migration route for contaminated sediments in Area A Downstream. The sediment sample results indicate that DDTR contaminated sediments have migrated to the Thames River. Some volatilization of DDTR could take place in surface soils exposed to the atmosphere. DDTR are also taken up by biota and bioaccumulated.

The behavior of cyanide in the environment is strongly dependent upon its chemical form (Section 5.1.4.2). Under CLP, cyanide values given are for total cyanide only. There is not enough data regarding the occurrence or form of cyanide to define the most significant migration pathways.

5.2.2.9 DRMO

Documented releases to soils at this site consist of: low concentrations of VOCs with one isolated hot spot; moderate levels of SVOs comprised predominantly of PAHs; PCBs in low to moderate concentrations; moderate to high concentrations of DDTR at one sample point; and metals concentrations above background. The most significant metals (relative to health or ecological risk) detected above background levels include cadmium, lead, and mercury. In ground water, VOCs were present in low levels, and the following metals were present above TBC or ARAR values: boron, sodium, iron, manganese and selenium.

Air: The northern portion of this site is not paved or vegetated, therefore, fugitive dusts are easily generated and constitute a potential migration route.

VOCs in subsurface soil and ground water were present at low to moderate levels. There are no subsurface confined spaces or trenches in existence or proposed in this area, therefore, migration to such spaces is not a potential pathway. VOC levels near the office building were low and, therefore, not considered to be an indoor air quality concern. Concentrations of

volatile compounds are far too low to be of concern in ambient air.

Ground Water and Soils: Contaminants are present in subsurface soils above and below the water table and can migrate with infiltrating precipitation and ground water. Ground water in this area flows to the west and discharges to the Thames River at an estimated velocity of 0.7 feet per day.

VOCs are highly mobile and their concentrations are consistent with those in soils. SVOs, comprised predominantly of PAHs, pesticides and PCBs, all appear to be tightly bound to soils and are not partitioning to ground water in detectable concentrations. All of these compounds have low mobilities. The inorganics detected in ground water above TBC or ARAR values are either constituents of salt water (boron, sodium) or appear to be leached from the soils due to reduced conditions in the fill (iron, manganese). The only exception is selenium. The reasons for its elevated concentration are not apparent.

Surface Water and Sediments: Surface water at DRMO flows as sheet flow to the west and discharges to the Thames River. The soil surface here is erodible and the compounds present strongly partition to soil particles and have low solubilities. Therefore, the primary migration route by surface water is transport of contaminated suspended particles in runoff. PCBs were detected in Thames River sediment adjacent to the DRMO site.

5.2.2.10 Lower Base

Documented releases to soils include moderate to high concentrations of petroleum hydrocarbons, moderate levels of lead, and low concentrations of aromatic and halogenated VOCs. Ground waters contained low levels of VOCs and traces of petroleum hydrocarbons, and metals above ARAR or TBC values.

Air: This area is completely covered with vegetation, asphalt, concrete or buildings. Therefore, fugitive dusts are not considered a potential migration pathway under present conditions. VOCs are only present in trace to low concentrations in subsurface soils and ground water, however there are extensive subsurface confined spaces in this area such as utility trenches that offer a potential contaminant migration pathway.

Ground Water and Soils: Contaminants in this area are present in soils above and below the ground water surface. Therefore, contaminants can migrate in ground water from infiltrating precipitation and by leaching directly by ground water. Ground water in this area flows to the west at an estimated velocity of 1.3 feet per day, except for those areas near the Thames River that ebb and flood with the tides. This area extends less than 200 feet inland. In addition, the Lower Subase contains extensive underground utilities and structures which could offer preferential flow paths for contaminants. Regardless of tides and utilities the ultimate disposition and discharge point of ground waters at the Lower Subase is the Thames River. Oils contain a complex mixture of hydrocarbons which include aromatic hydrocarbons and PAHs. The aromatic hydrocarbons have a medium to high mobility rate whereas the PAHs have a lower mobility. Weathered oils typically contain lower VOCs and higher PAHs than new oils. Lead compounds normally partition to soils and are not found in high concentrations in ground water and, therefore, have a low mobility. This appears to be the case at the Lower

Subase. Chlorinated VOCs also detected at the Lower Subase are highly mobile.

Surface Water and Sediments: Surface waters here are all collected by an extensive storm sewer system and discharge to the Thames River. This site is completely covered by buildings and pavement, therefore, runoff is not believed to contact contaminants in soils. However, ground water infiltration to the storm sewer system is possible.

6.0 HUMAN HEALTH RISK ASSESSMENT

This section of the report provides an assessment of the human health risks associated with conditions at selected sites within NSB-NLON. A risk assessment provides estimates of potential risks in probabilistic terms. These estimates were developed for various exposure groups that might encounter contaminants either directly or indirectly at the sites. As such, the assessment is not an epidemiological study of specific individuals or specific reported health effects. The risk assessment presented in this section should be viewed as a tool to assist in identifying conditions that may require remediation by providing an indication of the relative magnitudes of potential health risks at the various sites.

The risk assessment was conducted in accordance with the most recent U.S. Environmental Protection Agency guidance (USEPA, 1990). To ensure that the methodology was consistent with regional guidance (USEPA Region I), the general approach was discussed with appropriate risk assessment personnel within the agency prior to carrying out the quantitative aspects of the analyses.

The risk assessment includes a qualitative component and a quantitative component. These were utilized for Step I and Step II sites, respectively. Limited sampling has been performed at Step I sites and the qualitative risk assessment is intended to provide an initial indication concerning the need for additional investigation or no action. Factors considered in the qualitative assessment included: site history, site use and potential exposure groups, and contaminant concentrations. Quantitative risk assessments were performed for the Step II sites.

The Step I Sites that were evaluated qualitatively include:

- Construction Battalion Unit (CBU) Drum Storage Area;
- Rubble Fill at Bunker A-86;
- Torpedo Shops;
- Goss Cove Landfill;
- Over Bank Disposal Area Northeast (OBDANE);
- Spent Acid Storage and Disposal Area; and
- Former Gasoline Station.

The Step II Sites that were evaluated within the quantitative risk assessment include:

- Area A;
- Over Bank Disposal Area;
- Defense Reutilization and Marketing Office (DRMO); and
- Lower Subase;

Risk assessment is an explicit process that takes into account the nature of the hazard posed by onsite contaminants, the potential effects associated with particular exposure levels, the magnitude and duration of exposure, and an integrated assessment of exposure information with health effects information. This section is organized into the following subsections:

6.1 Hazard Identification

6.2 Exposure Assessment
6.3 Toxicity Assessment
6.4 Risk Characterization
6.5 Recommendations

6.1 Hazard Identification

The objective of the Hazard Identification phase of the assessment is to provide an initial evaluation of data, to provide a preliminary assessment of potential hazards, and to select compounds of interest for the qualitative and quantitative risk assessment.

6.1.1 Evaluation of Data for Risk Assessment

This assessment relied upon the QA/QC review of data presented in Appendix C of this report. The following items were addressed as part of the evaluation:

- analytical methods;
- quantification limits; and
- qualified and coded data.

Data were judged to be adequate for risk assessment purposes and met the standards set by the EPA. Details are provided in Appendix C.

Treatment of Non-Detects

Chemical analytical methods have associated detection limits below which the presence of a contaminant can not be detected. These data are reported as non-detects. Data reported in this fashion need to be considered with regard to the potential that the contaminant might be present at some level below the detection limit. A procedure was developed for handling such data in the present program.

Compounds that were not detected in any of the media sampled throughout the base were judged to be insignificant as site compounds of interest and, thus, were excluded from further analyses. In developing exposure point concentrations (EPCs) associated with a particular site, the compound needed to have been detected in at least one sample in order to be included in risk calculations. In such cases, the following methods were used to treat values reported as non-detects.

Treatment of Non-Detects for Chemicals in Water

The first step in dealing with non-detects was to consider the CLP Contract Required Quantitation Limits (CRQLs). Non-detect values for water samples were assigned values that were one-half of the laboratory CRQLs presented in Section 2.0 of this report. A value of 300 ug/l was used for boron based on a review of the analytical data presented and recognition of the EPA drinking water health advisory for boron (600 ug/l). This is consistent with EPA Superfund guidance which states that when the sample quantitation limit is not known, a health-based reference concentration may be applied.

Treatment of Non-Detects for Organic Chemicals in Soil

To estimate sample quantitation limits for organic chemicals in soil and sediment samples, it was first necessary to transform the CRQL reported by the laboratory on a wet weight basis to a dry weight basis. This was accomplished by using available site and sample data on percent moisture content. One-half the detection limit was used for values reported as non-detect.

Treatment of Non-Detects for Inorganic Chemicals in Soil

Contract Required Detection Limits (CRQLs) were not available for the following inorganic compounds: antimony, arsenic, beryllium, boron, cadmium, mercury, and selenium. For these compounds, the data were reviewed and an average detection limit was estimated. One-half of this limit was used to assign values for data reported as "non-detect". For the remaining inorganic compounds, one-half the EPA CLP quantification limits were used to assign values for data reported as "non-detect".

6.1.2 Activities/Operations Near Sites

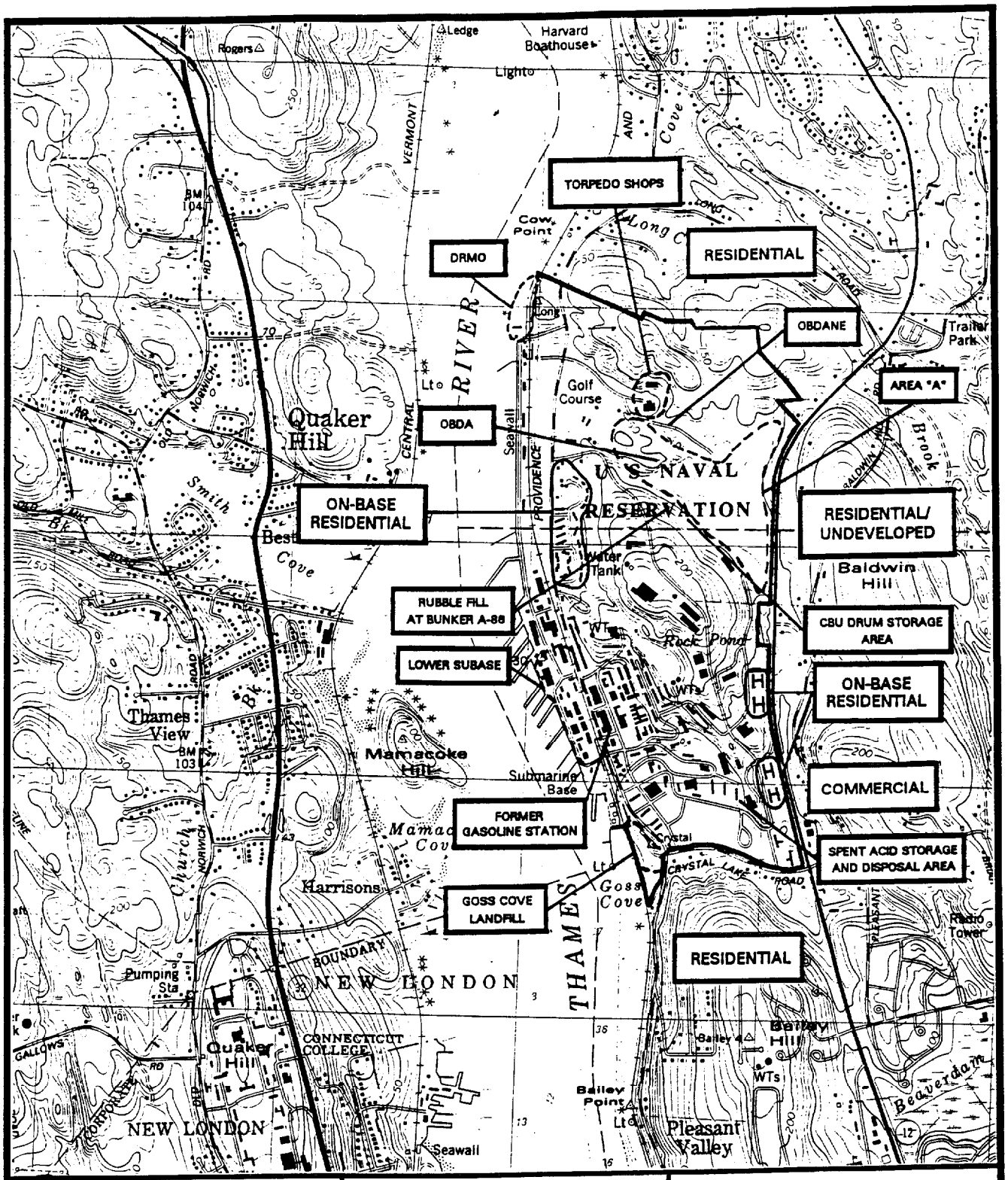
The following section provides an overview of activities in the vicinity of sites. The Groton Subase includes housing for Navy personnel and their families, submarine training facilities, military offices, medical facilities, and facilities designed for the maintenance, repair, and overhaul of submarines. Onsite residences for junior officers and their families are located off Shark Boulevard. Bachelor quarters are on Thresher Avenue. Locations of the residential areas with respect to the sites investigated are provided in Figure 6-1.

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

Information on onsite activities was obtained primarily from discussions with civilian and naval personnel familiar with the various facilities at the Subase. This was supplemented with information available in the IAS report and the site inspection. Information on future land use and construction was provided by Mr. Joseph Simmons, Shore Facilities Planner. Results of the discussions with onsite personnel are provided in Appendix E.

Major activities at Step I and Step II sites are provided in Table 6-1. Groups of individuals who might encounter contaminants at one or more sites include:

- public works personnel who access buried utility lines or excavate soil;
- on-base residential children;



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

SOURCE: Uncasville, Ct., U.S.G.S. Topographic Map, 1984

- - - - - Outline of Sites Investigated

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FIGURE 6-1
AREA LAND USE
AND ON-BASE RESIDENTIAL

ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 6-1
ACTIVITIES AT SITES

	Personnel Working in Buildings	Potential Utility Line Work	Periodic Outside Physical Labor	Periodic Visits by Offsite Visitors	Recreational Events for On-base Families	Scheduled Future Construction
Step I Sites						
CBU Drum Storage Area			X			
Rubble Fill at Bunker A-86						
Torpedo Shops	X	X	X			X
Goss Cove (includes Nautilus Museum)	X	X	X	X	X	X
OBDANE						
Spent Acid Storage and Disposal Area	X	X		X		X
Former Gasoline Station	X	X		X	X	X
Step II Sites						
Area A (includes landfill, wetland, streams, North Lake)		X	X	X	X (explore)	
Over Bank Disposal Area					X (explore)	
DRMO Area	X	X	X	X (auctions)	X (auctions)	X
Lower Subase (includes Piers)	X	X	X			X

- local residents who occasionally visit the submarine base;
- independent contractors who are involved in construction on the submarine base; and
- Navy employees who work in the buildings onsite.

6.1.3 Selection of Compounds-of-Interest

This section develops the list of chemical compounds known as the compounds of interest that were quantitatively evaluated with respect to their health and environmental effects for Step II sites and qualitatively addressed for Step I sites. The selection procedure for the compounds of interest identified those that were judged to be most important site-related contaminants with regard to potential human health or environmental risks. The selection was based on the following factors:

- the compound must have been detected at least once in any medium somewhere within the selected sites on the submarine base;
- a compound must have been detected at least once in the selected medium to be considered as a compound of interest for a particular site;
- the toxicity of the compound (all carcinogens were included except for inorganics present at natural elemental abundance);
- the frequency of occurrence and spatial extent of contamination; and
- the presence of an inorganic compound within its natural range of elemental abundance.

Based on the factors considered above, a list of compounds of interest was developed for the site as a whole (Table 6-2). A number of compounds that were detected at the site were not included in the quantitative assessment for one or more reasons. Arsenic was detected at elevated levels at a few locations but throughout most of the site this metal was present within natural background levels. Thus, it was considered qualitatively in this report but is not included in the quantitative assessment. Three organic compounds detected in soil and excluded from the risk analysis were chloroform, diethylphthalate, and isophorone. Chloroform was excluded because it was not associated with site activities, is a common laboratory contaminant, and was observed only once in subsurface soil within the DRMO site. Diethylphthalate was found only in deep soil at very low concentrations in a single sample from the Torpedo shop site. Isophorone is not considered a carcinogen and is only minimally toxic. It was detected in a single soil sample at the Goss Cove site.

6.1.4 Presentation of Data for Risk Assessment

The average and maximum concentrations of compounds of interest were determined for each of the Step II sites for each medium. These were used to develop Exposure Point

TABLE 6-2
COMPOUNDS OF INTEREST FOR NSB-NLON

VOLATILE ORGANIC COMPOUNDS
Nonchlorinated Aromatics
Benzene
Ethylbenzene
Toluene
Xylene (total)
Chlorinated Compounds
Chloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
Cis-1,2-Dichloroethene
Trans-1,2-Dichloroethene
Methylene Chloride
Tetrachloroethane
Tetrachloroethene
Trichloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Vinyl Chloride
Other VOCs
Acetone
2-Butanone
4-Methyl-2-Pentanone
Carbon Disulfide
SEMIVOLATILE COMPOUNDS
Noncarcinogenic PAHs
Acenaphthene
Acenaphthylene
Anthracene
Fluoranthene
Fluorene
2-Methylnaphthalene
Naphthalene
Phenanthrene
Pyrene
Carcinogenic PAHs
Benzo(a)Anthracene
Benzo(a)Pyrene
Benzo(b)Fluoranthene
Benzo(g,h,i)Perylene
Benzo(k)Fluoranthene
Chrysene
Dibenz(a,h)Anthracene
Indeno(1,2,3-cd)Pyrene

TABLE 6-2 (continued)
COMPOUNDS OF INTEREST FOR NSB-NLON

Other Semi-Volatile Compounds
bis(2-Ethylhexyl)Phthalate
Di-n-Butylphthalate
2,4-Dimethylphenol
4,6-Dinitro-2-methylphenol
2-Methylphenol
4-Methylphenol
Phenol
Benzoic Acid
4-Chloroaniline
Dibenzofuran
2-Nitroaniline
N-Nitrosodiphenylamine (1)
PESTICIDES
4,4' DDE
4,4' DDD
4,4'-DDT
Beta-BHC
Endrin
Endrin Ketone
Methoxychlor
PCBs
Aroclor 1260
Aroclor 1254
METALS
Aluminum
Antimony
Arsenic
Beryllium
Boron
Cadmium
Copper
Iron
Lead
Manganese
Mercury
Nickel
Selenium
Zinc

Concentrations for use in the Exposure Assessment. As described earlier, non-detect values for compounds observed at least once within a particular site, were assigned values of one-half the CRQL or other "default" values to account for the possibility that the compound might have been present at levels below the detection limit. This was done in accordance with EPA guidance.

6.2 Exposure Assessment (Human Health)

The exposure assessment provides site specific information related to pathways by which humans are potentially exposed to compounds of interest at the sites as well as the magnitude, frequency, and duration of potential exposures. A qualitative assessment of exposures was made of Step I sites based on information on activities and the presence and extent of contamination. Quantitative estimates of exposure were developed for Step II sites. Nominal estimates of exposure (based on average concentrations) and upper bound estimates (based on maximum concentrations) were used to represent the range of exposures that may be associated with conditions at a site.

The following elements are incorporated into the exposure assessment:

- nature and extent of contamination and potential migration pathways;
- identification of potentially exposed populations and environmental receptors;
- delineation of potential receptor-specific exposure pathways corresponding to an activity;
- development of exposure intake assumptions associated with each exposure pathway;
- estimation of the range of exposure point concentrations; the arithmetic average exposure point concentration represents the nominal case while the maximum exposure point concentration predicts the worst case;
- estimation of pathway and receptor-specific intakes and doses of compounds-of-interest.

6.2.1 Characterization of Exposure Settings

This section describes the site-specific features of each site that may result in human contact with compounds of interest in one or more environmental media. This discussion is provided first for Step I sites and second for the Step II sites. Details are provided in Appendix E. The physical setting of each site including figures is provided in Section 1.0.

6.2.1.1 Step I Sites

Construction Battalion Unit (CBU) Drum Storage Area

Access to this site is limited as the site has security surveillance. The site is located adjacent to Area A Landfill. Under current conditions, site activity is related to storage of contractor trailers and occasional visits by site contractors.

Rubble Fill at Bunker A-86

This Step I site is only used for storage of materials, and future construction is not scheduled. The Rubble Fill area is located adjacent to Bunker A-86 with limited access.

Torpedo Shops

This site is highly secured and is fenced. Current activities involve routine maintenance of utility lines, torpedo overhaul, and administrative operations for the undersea weapons and quality assurance departments. Future construction plans include an addition onto building 325 and construction of an auto reclaim facility. The areas actually investigated were former septic systems which are located west/southwest of the buildings.

Goss Cove Landfill

The area is primarily a paved parking lot and an associated building housing the museum. The site is open to the public. A utility tunnel exists from the building to the pier. Standing water has been observed inside the tunnel, but its origin has not been confirmed. Navy personnel believe the water is from the Thames river, which is adjacent to the site. Various underground utilities are located at the site. (For a list of future activities planned in this area, refer to Appendix E.)

Over Bank Disposal Area Northeast (OBDANE)

Presently, no activity exists within this site. It is located within a wooded area near the Weapons Center and within Area A.

Spent Acid Storage and Disposal Area

This is a relatively small site and is paved. Two active buildings (410 & 409) are located nearby which are used primarily for storage. Water mains and sanitary and storm sewers are present on the site.

Former Gasoline Station

The former gasoline station site is located in front of the Dealey Center. The area is paved and is below a roadway. The Dealey Center serves many functions for D.O.D employees and visitors. Current uses of the Dealey Center are described in Appendix E. Building 96 functions as a counselling and assistance center, but it is scheduled for demolition.

6.2.1.2 Step II Sites

More detail is provided for Step II sites than for Step I sites to provide the basis for quantitative risk assessment. Additional detail is provided in Appendix E.

Area A

This site consists of three areas: 1) Area A Landfill, 2) Area A Wetland, and 3) Area A Downstream Watercourses.

Area A Landfill: Naval authorities refer to this site as Alpha Area Storage and deployed parking. It is approximately 7 acres in size. Access is via a dirt road off Wahoo Avenue. Details on the operations of Alpha Area Storage are found in Appendix E. Military serviceman store their cars in deployed parking when on sea duty. Public auctions are held to remove abandoned cars in the deployed parking area.

The North Lake recreational area and on-base residential housing are located west of the Area A landfill. The Area A landfill site is not fenced. A standing watch exists when Alpha Area storage is closed, but access is possible from the road and the wooded hillside to the west. Children of junior officers living on the Subase may explore the wooded areas (Area A Downstream) adjacent to the landfill or might investigate the landfill itself. Various materials are stored on wooden palettes. A further description of this site and the nature and extent contamination is provided in Section 4.0.

Storm sewers which direct runoff to the area are located to the east near the vicinity of tennis courts and building 460. They also run through the deployed parking area and at the entrance to Alpha area storage off Wahoo Avenue. The storm sewers for this site represent less than 1% of the existing utility lines on the base.

Recreational activities occur in close proximity to Area A landfill, include military servicemen jogging along Wahoo Ave, and playing tennis in nearby tennis courts.

Approximately 22,300 square meters of this site are unpaved. The unpaved portion of the landfill represents approximately 97 percent of the site. A small portion of the site is covered by a concrete pad in the southwest portion of the landfill for aboveground storage of several transformers, removed underground storage tanks, and crane weights. A portion of the site is used for sandbag storage and a portion for automobile parking. Current onsite activities entail daily moving of storage items onto the wooded pallets, sandbagging in the summer and repairing storm sewers. Because of the existing uncovered dirt piles and current onsite activities in the unpaved areas, fugitive dust generation is likely. Receptors that could be exposed to fugitive dust include base personnel who are working on the site, base personnel who are jogging or playing tennis on base, and on-base and off-base residents. The nearest Groton/Ledyard resident who lives along Route 12 is only 425 meters from the site. Residential housing for junior officers and their families is approximately 490 meters from the landfill.

No construction is planned for the area.

Area A Wetland: The wetland spans 30 acres. To the east, a security fence separates Route 12 from the perimeter security road which abuts the wetland. Therefore, access is restricted from Route 12 into the Area A wetland. At the southern edge, the wetland borders the Area A landfill. The wetland extends in a northwesterly direction to the Weapons Storage Area. The Weapons Area's security fence forms a boundary line. In the far southeastern corner, tennis courts and a racquetball facility are directly adjacent to the wetland. Access to Area A wetland is possible from the unpaved extension of Thresher Ave which is the entrance to the deployed parking area, tennis courts and the Area A landfill.

There are no buried or aboveground utility lines in the wetland. There is no routine human activity in Area A wetland itself. The activities which occur in the vicinity of Area A wetland are the daily activities conducted in Area A landfill; usage of tennis or racquetball courts; routine operations of Weapons Storage Area and visits to the Hobby shop. Groton/Ledyard residents on Route 12 live directly adjacent to the Area A wetland. None of the potentially exposed populations associated with the above mentioned activities have direct contact with the wetland. Fugitive dust is not an issue for this site because the soils are wet.

On-base children who might explore the Area A Downstream from North Lake could enter the wetland through the far west corner between the Weapons Storage area and the Area A landfill. Their exploration would probably be limited to this corner of the wetland because of the thickness of the brush and potential observation by Weapons Center security watch.

Future development may include the reconstruction of a portion of the Weapons Center, but is not likely to encroach on the wetland proper.

Area A Downstream Watercourses/OBDA: The Area A Downstream Watercourses drain the Area A Landfill and Wetland. The Area A downstream watercourses include several small streams, two small ponds, and North Lake, which is a man-made swimming pond. The site is not fenced, but access is limited to only Navy Officers and their families. North Lake is filled with municipal water and drained in the Fall. During the months of recreational operation, North Lake is chlorinated. A stream flows from the OBDA wetland west toward North Lake. Under normal flow conditions, the stream enters a culvert which bypasses North Lake and discharges to a stream below the outfall of North Lake. Under heavier runoff conditions, it is possible that some water from the stream discharges to North Lake. At the time of the site inspection, North Lake had been drained; yet some water remained in the pond, indicating that it does receive some ground water discharge. Ground water sampling locations, 2DMW15 and 2DMW16 which includes overburden and bedrock wells are in vicinity of North Lake. Ground water measurements from these wells indicate that shallow ground water likely discharges to North Lake. Snow melt and stormwater runoff collects in North Lake basin over the winter months.

From the second week of June to Labor day, the North Lake recreational area functions as a playground, beach, and picnic area for the Naval families. The woods and streams surrounding North Lake offer interesting places for children to explore. The wooded area is dense and prevents observation from the Wahoo Ave and North Lake. During the fall and winter, access to this site does not appear restricted except near the perimeter of the Weapons Storage area.

Further development is not planned for this area and is unlikely because most of the downstream watercourse area is within designated Explosive Safety Quantity Distance (ESQD) arcs of the Weapons Storage Area.

Discussions of OBDA are grouped with those of Area A. Because of its close proximity to Area A wetland and Downstream area, it is a potential place of exploration for on-base children. Exposures within OBDA, are incorporated in exposure scenarios pertaining to Area A Downstream. Military activity is absent.

Defense Reutilization and Marketing Office (DRMO)

Access to this site is restricted. A fence prevents on-base access from Amberjack Road to the south. North of this site, another fence deters trespassers from coming onto the submarine base. In the easterly direction, the site is bounded by an active railroad line and to the west by the Thames River. The DRMO functions as a collection facility. Salvageable items are sold at auctions and sales that are held periodically throughout the year. The northern portion of the site is unpaved and consists of gravel surface. The unpaved portion is occupied by a large scrap yard and Building 491 that is used for storage. During the Fall, Winter and Spring, base personnel daily sort the metal scraps within the scrap yard. The scrap metal is then sold at the DRMO auctions. Buildings 397, 353, 479 and 355 are on the paved area. Buildings 479 and 355 are used for storage.

Building 397 serves as the DRMO Office. Within this site, Building 397 is the only structure which is occupied by a full-time administrative staff. State and federal agencies visit the office on a daily basis. Weekly deliveries of purchased materials are made to the office. The DRMO building is a quonset hut on a concrete slab with a metal roof. The other buildings are constructed on concrete slabs.

All auctions and sales are open to the public. Monthly auctions are held inside Building 397. Three days prior to the auction, auctioned items are available for viewing inside Buildings 355 and 479 or on pavement outside the buildings. Weekly sales are conducted inside the DRMO complex.

Utility lines are present near active buildings and represent approximately five percent of the utility lines on the base. Routine repair and maintenance of these utility lines has been documented. Construction of a temporary hazardous waste storage facility is planned for the northern portion of the site.

Because of the unpaved gravel surface in the DRMO site, there is the potential for fugitive dust generation. Gales Ferry residents live approximately 485 meters from the DRMO site. The potential for fugitive dust exposures is evaluated for the Gales Ferry residents and for children of junior officers who live approximately 915 meters from the DRMO.

Lower Subase

The Lower Subase is a high security area. A barbed wire fence with control gates regulate access from Shark Boulevard to the east, and along Amberjack Road to the north. The

site is completely paved except for the piers. To the west, the area is bounded by the Thames River. There are an extensive amount of utility lines in this area. The utility lines are either in enclosed concrete trenches with accessible covers or buried below the surface. These utilities include storm sewers, sanitary sewers, and steam, electric, telephone, and fuel lines. A total of 200 manholes are available for accessing the utility lines within the area. Inspections of fuel lines in the trenches are performed to check for leakage. Soil excavation is required for routine maintenance and repair of the buried utility lines.

Many buildings occupy this site. Most of the buildings function as administrative offices or storage facilities. Within the active buildings, the full-time administrative staff consists of military servicemen and authorized NSB-NLON employees.

Daily pier activities encompass berthing and fueling submarines. Visual inspection of the bulkhead along the waterfront of the Lower Subase revealed no oil seeps or sheens anywhere along the waterfront at the Lower Subase.

Future activities scheduled for this site are described in detail in Appendix E. In general, demolition or reconstruction of some structures is planned. At piers 32 and 33, new quaywalls will replace deteriorated sheet pile bulkhead. In preparation of the berthing of SEAWOLF submarines, extensive dredging is needed around piers 32 and 33, however, these piers are outside the study area. Maintenance dredging will occur at piers 2, 6, and 31.

6.2.2 Identification of Exposure Pathways

An exposure pathway describes the path by which a chemical migrates from the source of contamination to a human receptor. Factors influencing exposure pathways are the source and mechanism of contaminant releases, fate and transport of the chemicals, and points of contact with human populations. Exposure routes may include dermal contact, ingestion or inhalation. An exposure scenario summarizes all potential exposure pathways associated with an activity and an exposure group. The fate and transport mechanisms for the compounds of interest are described in Section 5.0.

6.2.2.1 Step I Sites

Construction Battalion Unit (CBU) Drum Storage Area

The primary function of this site is a storage area for contractor trailers. The area is occasionally accessed by contractors who are working on the NSB-NLON. Due to the lack of significant chemicals identified onsite, exposures are considered negligible.

Rubble Fill at Bunker A-86

Since the present activity at the site is minimal, the exposures are considered negligible.

Torpedo Shops

Military personnel work at the Torpedo shop buildings and the grounds are maintained by base personnel. Exposures to soils is possible during repairs of existing underground utility lines and the ongoing construction.

Ground water within the overburden aquifer at the Torpedo Shop contains VOCs below ARAR and TBC drinking water standards/guidance values. Antimony is present above a USEPA proposed MCL, indicating a potential health risk, if consumed. No potable water supply wells exist or are planned by the Navy in the potentially affected downgradient area. The Navy owns the land within the potentially affected area. Therefore, under existing and projected future land use conditions, no exposure pathway exists for human consumption of degraded ground water. The potential effect of ground water discharge on surface water quality is evaluated in Section 7.0.

Goss Cove Landfill

A full-time civilian staff currently occupies the museum year round. Tourists also visit the museum all year round. Inhalation of subsurface volatile organics migrating into the building is a possible exposure pathway.

Excavation of buried utility lines or future construction could expose utility or construction workers to contaminated landfill material.

The construction of a coastal viewing park is currently underway. Residential children could gain access to Goss Cove by climbing the retaining wall. The construction of a public boat launch has also been proposed. For children, exposures to sediment and surface water are possible.

Spent Acid Storage and Disposal Area

Demolition of the buildings and construction of a new warehouse are scheduled. Either installation or removal of utility lines will coincide with these events. For construction workers and naval laborers, contact with soils highly contaminated with metals is probable.

Former Gasoline Station

At present there is no exposure at this location. The site is paved and available data indicate that there has been little or no release from the underground storage tank. Additional investigation is recommended on conditions beneath the tank to confirm the lack of exposure.

6.2.2.2 Step II Sites

Area A Landfill

The exposure scenarios for this site are presented below:

- Utility Worker Repairing Storm Sewers in Area A Landfill;
- Weapons Center Personnel Exposed to Fugitive Dust from Area A Landfill;
- Military Servicemen Moving Palettes in Alpha A Storage;
- Military Servicemen Exposed to Fugitive Dust While Engaging in Nearby Recreational Activities;
- Groton/Ledyard Residents Exposed to Fugitive Dust;
- Citizens Attending Car Auctions in Deployed Parking.

These exposure scenarios are presented in Tables 6-3 to 6-8 in this section. Site sample locations for Area A are provided on Plate 4-1.

For scenarios involving exposures to fugitive dust from Area A landfill, dust concentrations were either modeled or an ambient particulate concentration was selected.

There are storm sewers to depths of eight feet in Area A Landfill. Thus, soil samples collected to a depth of eight feet were used to calculate the soil exposure point concentrations during repair of storm sewers. Referring to Table 2-10, the depth of ground water in Area A Landfill ranges from approximately eight to 25 feet below the surface. Thus, exposures to ground water are not likely while repairing storm sewers.

Exposure associated with sandbagging activity was judged to be small compared to the other Area A Landfill exposure scenarios because of the short duration of this activity. Therefore, health risks were not quantified for this less frequent activity.

Ground water within Area A contains VOCs and cadmium at levels above ARAR and TBC drinking water standard/guidance values, indicating a potential health risk if the water were to be consumed. No potable water supply wells exist or are planned by the Navy in the potentially affected downgradient area. The Navy owns the land within the potentially affected area. Therefore, under existing and projected future land use conditions, no exposure pathway exists for human consumption of degraded ground water. The potential effect of ground water discharge on surface water quality is evaluated in Section 7.0.

Area A Wetland

Since daily human activity is not occurring within the wetland, exposure scenarios were not developed. The only possible activity which is associated with this site are the occasional visits by on-base children. Children who explore the streambeds within the North Lake recreational area might climb up the wooded slopes and investigate the perimeter of the wetland. This potential activity was developed into an exposure scenario.

TABLE 6-3
UTILITY WORKER REPAIRING STORM SEWERS IN AREA A LANDFILL

Exposure Scenario:	Utility Worker Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Storm Sewer Repair in Area A landfill
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	1	Estimate based Navy Subbase Stats
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-3 (continued)
UTILITY WORKER REPAIRING STORM SEWERS IN AREA A LANDFILL

Exposure Scenario:	Utility Worker Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Storm Sewer Repair in Area A landfill
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure groundwater is 8 ft below the surface
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-3 (continued)
UTILITY WORKER REPAIRING STORM SEWERS IN AREA A LANDFILL

Exposure Scenario:	Utility Worker Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Storm Sewer Repair in Area A landfill
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
[illegible]n Permeability Rate	(cm/hr)		

TABLE 6-4
WEAPONS CENTER PERSONNEL EXPOSED TO FUGITIVE DUST FROM AREA A LANDFILL

Exposure Scenario:	Worker Exposures to Fugitive Dust from Alpha Area Landfill
Case/Timing:	Current Site Conditions
Primary Activity:	Work in Weapons Center
Exposed People:	Weapons Center Personnel, 22 - 50 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	250	Will vary with each site: CHECK
Average Lifetime Exposure	years	35	Estimate from Bill Mansfield
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			No Potential Exposure
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-4 (continued)
WEAPONS CENTER PERSONNEL EXPOSED TO FUGITIVE DUST FROM AREA A LANDFILL

Exposure Scenario:	Worker Exposures to Fugitive Dust from Alpha Area Landfill
Case/Timing:	Current Site Conditions
Primary Activity:	Work in Weapons Center
Exposed People:	Weapons Center Personnel, 22 - 50 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	2.5	EPA, 1991, Default
PM10 Concentration	mg/m3	0.0043	Hanna et al, 1982
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-4 (continued)
WEAPONS CENTER PERSONNEL EXPOSED TO FUGITIVE DUST FROM AREA A LANDFILL

Exposure Scenario:	Worker Exposures to Fugitive Dust from Alpha Area Landfill
Case/Timing:	Current Site Conditions
Primary Activity:	Work in Weapons Center
Exposed People:	Weapons Center Personnel, 22 - 50 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-5
MILITARY SERVICEMEN MOVING PALETTES IN ALPHA AREA A STORAGE AREA

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Unloading pallettes in Alpha Area Landfill
Exposed People:	Transient Military servicemen

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	0.333	Estimate From Sr. Cheif Dregger
Exposure Duration	days/year	260	Estimate From Sr. Cheif Dregger
Average Lifetime Exposure	years	3	Estimate From Sr. Cheif Dregger
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-5 (continued)
MILITARY SERVICEMEN MOVING PALETTES IN ALPHA AREA A STORAGE AREA

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Unloading pallettes in Alpha Area Landfill
Exposed People:	Transient Military servicemen

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust and volatiles
Inhalation Rate	m3/hr	2.5	EPA, 1991 Default Commericial/Industrial
PM10 Concentration	mg/m3	0.018	EPA 1989 Air Quality for New England
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-5 (continued)
MILITARY SERVICEMEN MOVING PALETTES IN ALPHA AREA A STORAGE AREA

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Unloading pallettes in Alpha Area Landfill
Exposed People:	Transient Military servicemen

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-6
MILITARY SERVICEMEN EXPOSED TO FUGITIVE DUST WHILE ENGAGING IN NEARBY RECREATIONAL ACTIVITIES

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Playing tennis or jogging near Alpha Area
Exposed People:	Military servicemen, 18 - 65 years old

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	1	Assumed
Exposure Duration	days/year	120	Assumed 30 wks/year; 4 days/wk
Average Lifetime Exposure	years	6	Reassigned Tour of Duty
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Not Sufficient Exposure Pathway
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-6 (continued)
MILITARY SERVICEMEN EXPOSED TO FUGITIVE DUST WHILE ENGAGING IN NEARBY RECREATIONAL ACTIVITIES

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Playing tennis or jogging near Alpha Area
Exposed People:	Military servicemen, 18 - 65 years old

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	2.5	EPA, 1989a assuming moderate excercise
PM10 Concentration	mg/m3	0.00407	modeled
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-6 (continued)
MILITARY SERVICEMEN EXPOSED TO FUGITIVE DUST WHILE ENGAGING IN NEARBY RECREATIONAL ACTIVITIES

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Playing tennis or jogging near Alpha Area
Exposed People:	Military servicemen, 18 - 65 years old

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-7
GROTON/LEDYARD RESIDENTS EXPOSED TO FUGITIVE DUST

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Groton/Ledyard Residents

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	24	
Exposure Duration	days/year	350	EPA 1991 Default
Average Lifetime Exposure	years	30	upper bound at one residence
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			No Potential Exposure
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-7 (continued)
GROTON/LEDYARD RESIDENTS EXPOSED TO FUGITIVE DUST

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Groton/Ledyard Residents

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	0.8	Default, EPA 1991
PM10 Concentration	mg/m3	0.004	Hanna et al 1982
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			Not Associated with Site
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Not Associated with Site
Exposed Body Parts Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-7 (continued)
GROTON/LEDYARD RESIDENTS EXPOSED TO FUGITIVE DUST

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Groton/Ledyard Residents

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-8
CITIZENS ATTENDING CAR AUCTIONS IN DEPLOYED PARKING

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Public Car Auctions in Deployed Parking Areas
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	2.5	2hrs to preview;4 hrs actual auction
Exposure Duration	days/year	24	18dayspreview;6days/year actual auction
Average Lifetime Exposure	years	30	upper bound at one residence/employment
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Not Sufficient Exposure Pathway
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-8 (continued)
CITIZENS ATTENDING CAR AUCTIONS IN DEPLOYED PARKING

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Public Car Auctions in Deployed Parking Areas
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Inhalation of Air:			**Potential Exposure**
			fugitive dust
Inhalation Rate	m3/hr	2.5	EPA, 1989a assuming moderate excercise
PM10 Concentration	mg/m3	0.018	EPA, 1989 Air Quality in New England'
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-8 (continued)
CITIZENS ATTENDING CAR AUCTIONS IN DEPLOYED PARKING

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Public Car Auctions in Deployed Parking Areas
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

Area A Downstream Watercourses

The exposure scenarios for this site are presented in Tables 6-9 to 6-12 and include:

- Subase Children Exploring the Woods within Area A Wetland, Landfill and Downstream Watercourses;
- Subase Children Exploring Streambeds and Area A Wetland;
- Subase Children Swimming in North Lake;
- Utility Worker Repairing Utility lines in Area A Downstream Watercourses;

Young children living at NSB-NLON were selected for assessment of health risks associated with living and playing onsite. This population group is considered to be more sensitive than adults (their parents) and, thus, examining risks to children provides a conservative approach to assessing risks to onsite residents. The factors that make children more sensitive or vulnerable to risks include: 1) their activity patterns, and 2) smaller body size. Both factors will make them more likely to encounter contaminants and will result in larger doses on a per body weight basis. The six to nine year old age group represents the age group in the exposure scenarios that pertain to children. Junior officers and their families live on the Subase and the ages of their children would typically fall into this age group. A junior officer's tour of duty is three years, but at the request of the EPA Region I Superfund Health Risk Assessment Department, six years was used as the average lifetime exposure for Subase children in case their parents remained at the base. The six year estimate for the exposure period was also used for exposure scenarios pertaining to naval servicemen working on base.

An activity that has raised health concerns in this area involves the use of North Lake area for swimming and playing. Thus, an exposure scenario for this activity was developed for children that might use the area on a regular basis for swimming and playing. The frequency of this activity was determined through telephone conversation with Pat Russak, who is the Naval swimming manager.

Another exposure scenario within Area A Downstream is Subase children exploring the streambeds and ponds. These are the locations where the highest levels of pesticides were observed and, therefore, are treated separately in order to provide focus to potential risks associated with these conditions. An additional activity for children involves playing in the picnic area. This activity was not developed into a scenario because of lack of surface soil data in the area of interest. It is expected that exposure in this area would be less than in the other scenarios evaluated for children playing in the woods, stream beds, or ponds.

Utility lines are located six feet below the surface on this site, and, therefore, the potential exposure of utility maintenance workers was evaluated. The height of ground water table ranges between two to ten feet below the ground. Utility workers might be exposed to ground water during excavation.

TABLE 6-9
SUBASE CHILDREN EXPLORING THE WOODS

Exposure Scenario:	Exposures to Surface Soil
Case/Timing:	*Current Site Conditions*
Primary Activity:	Exploring in woods (North Lake, Area A Landfill, Wetlands)
Exposed People:	Young children from 6-9 years old living on subase

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	25	EPA, 1989a mean age 7<8 years
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	930	EPA, 1989a mean age 6<9 years
Total Exposure Duration:			
Daily Exposure Period	hours/day	2	Assumed
Exposure Duration	days/year	56	Assumed 7 months/yr: 2 days/wk
Average Lifetime Exposure	years	6	Assume Reassigned Tour of Duty
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	200	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.3	EPA, 1989a age 9< 10 years
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-9 (continued)
SUBASE CHILDREN EXPLORING THE WOODS

Exposure Scenario:	Exposures to Surface Soil
Case/Timing:	Current Site Conditions
Primary Activity:	Exploring in woods (North Lake, Area A Landfill, Wetlands)
Exposed People:	Young children from 6-9 years old living on subase

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure (fugitive dust)
Inhalation Rate	m3/hr	3.2	EPA, 1989a age 10 moderate activity
PM10 Concentration	mg/m3	0.018	EPA 1989 Air Quality in New England
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-9 (continued)
SUBASE CHILDREN EXPLORING THE WOODS

Exposure Scenario:	Exposures to Surface Soil
Case/Timing:	Current Site Conditions
Primary Activity:	Exploring in woods (North Lake, Area A Landfill, Wetlands)
Exposed People:	Young children from 6-9 years old living on subase

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-10
SUBASE CHILDREN EXPLORING STREAMBEDS AND AREA A WETLAND

Exposure Scenario:	Exposures to Sediments
Case/Timing:	Current Site Conditions
Primary Activity:	Exploring streambds and Area A wetland
Exposed People:	Young children from 6-9 years old living on subbase

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	25	EPA, 1989a mean age 7<8 years
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	930	EPA, 1989a mean age 6<9 years
Total Exposure Duration:			
Daily Exposure Period	hours/day	2	Assumed
Exposure Duration	days/year	28	Assumed 7 months/yr:1 days/wk
Average Lifetime Exposure	years	6	Assume Reassigned Tour of Duty
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			No Potential Exposure
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-10 (continued)
SUBASE CHILDREN EXPLORING STREAMBEDS AND AREA A WETLAND

Exposure Scenario:	Exposures to Sediments
Case/Timing:	Current Site Conditions
Primary Activity:	Exploring streambds and Area A wetland
Exposed People:	Young children from 6-9 years old living on subbase

Variable	Units	Values	Notes & References
Inhalation of Air:			No Potential Exposure
Inhalation Rate	m3/hr	0	
PM10 Concentration	mg/m3	0	
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-10 (continued)
SUBASE CHILDREN EXPLORING STREAMBEDS AND AREA A WETLAND

Exposure Scenario:	Exposures to Sediments
Case/Timing:	Current Site Conditions
Primary Activity:	Exploring streambds and Area A wetland
Exposed People:	Young children from 6-9 years old living on subbase

Variable	Units	Values	Notes & References
Ingestion of Sediments:			Potential Exposure
Ingestion Rate	mg/day	200	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			Potential Exposure
Sediment Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			entire body
Fraction of Skin Area Exposed	(fraction)	1	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			Not Sufficient Exposure Pathway
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			Not Sufficient Exposure Pathway
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-11
SUBASE CHILDREN SWIMMING IN NORTH LAKE

Exposure Scenario:	Exposure to North Lake Surface Water and Sediment
Case/Timing:	Current Site Conditions
Primary Activity:	Swimming in North Lake
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	25	EPA, 1989a mean age 7<8 years
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	930	EPA, 1989a mean age 6<9 years
Total Exposure Duration:			
Daily Exposure Period	hours/day	4	Assumed
Exposure Duration	days/year	55	Assumed 11 wks/yr:5 days/wk
Average Lifetime Exposure	years	6	Assume Reassigned Tour of Duty
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			No Potential Exposure
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-11 (continued)
SUBASE CHILDREN SWIMMING IN NORTH LAKE

Exposure Scenario:	Exposure to North Lake Surface Water and Sediment
Case/Timing:	Current Site Conditions
Primary Activity:	Swimming in North Lake
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Inhalation of Air:			No Potential Exposure
Inhalation Rate	m3/hr	0	
PM10 Concentration	mg/m3	0	
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-11 (continued)
SUBASE CHILDREN SWIMMING IN NORTH LAKE

Exposure Scenario:	Exposure to North Lake Surface Water and Sediment
Case/Timing:	Current Site Conditions
Primary Activity:	Swimming in North Lake
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Ingestion of Sediments:			Potential Exposure (includes beach sand & North Lake sediment)
Ingestion Rate	mg/day	200	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			Potential Exposure
Sediment Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			entire body
Fraction of Skin Area Exposed	(fraction)	1	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			Potential Exposure
Ingestion Rate	l/day	1.2	EPA, 1989 50ml/hr
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			Potential Exposure
Exposed Body Parts			EPA, 1989a
Fraction of Total	(fraction)	1	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-12
UTILITY WORKER REPAIRING UTILITY LINES IN AREA A DOWNSTREAM WATERCOURSES

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in Area A Downstream Watercourses
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	1	Estimate from Navy Subbase Stats
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-12 (continued)
UTILITY WORKER REPAIRING UTILITY LINES IN AREA A DOWNSTREAM WATERCOURSES

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in Area A Downstream Watercourses
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			Not Sufficient Exposure Pathway
Ingestion Rate	l/day	0	Assumed
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-12 (continued)
UTILITY WORKER REPAIRING UTILITY LINES IN AREA A DOWNSTREAM WATERCOURSES

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in Area A Downstream Watercourses
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			Considered in the Exposure to Soils
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults: EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			Considered in the Exposure to Soils
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

Defense Reutilization and Marketing Office (DRMO)

The following exposure scenarios have been developed for this site and are provided in Tables 6-13 to 6-20:

- Citizens Attending Monthly Public Auctions at DRMO;
- Citizens Attending Weekly Public Sales at DRMO;
- Navy Employees Sorting Scrap Metal;
- Utility Worker Exposed to Soils and Ground Water in DRMO Under Current Conditions;
- Utility Worker Exposed to Soils and Ground Water in DRMO Under Future Conditions;
- Future Construction of Hazardous Waste Storage Facility;
- Ledyard Residents Inhaling Fugitive Dust from DRMO;
- Subase Children Exposed to Fugitive Dust from DRMO and Area A Landfill.

The migration of VOCs into the buildings within DRMO site was evaluated as a potential exposure pathway for employees working in the buildings. This was not considered to be an important exposure route under current conditions based on the results of soil, ground water, and soil gas sampling, therefore, an exposure scenario was not developed.

The DRMO site is visited on a weekly basis by delivery people. State and federal agency representatives visit on a more frequent basis. The health risks associated with these visits were judged to be small compared to the other DRMO site exposure scenarios evaluated in this risk assessment. Therefore, health risks were not quantified for delivery people and state and federal representatives.

Utility lines are buried four to six feet below the surface. Depth of ground water ranges from approximately four to eleven feet below the surface. Navy Public Works employees, or construction workers may come into contact with soil and ground water through soil excavation. Residents close to the DRMO site include Subase children and individuals living near the site. They could come into contact with onsite contaminants via transport of fugitive dust generated from DRMO as well as from other onsite locations.

Lower Subase

Three exposure scenarios involving contact with subsurface soil were developed for the Lower Subase (Tables 6-21 to 6-23):

TABLE 6-13
CITIZENS ATTENDING MONTHLY PUBLIC AUCTIONS AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Monthly Public Auctions at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	2.5	2 hrs per preview/4 hrs per auction
Exposure Duration	days/year	24	18 days preview; 6 days/yr auction
Average Lifetime Exposure	years	30	upper bound at one residence
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Not Significant Exposure Pathway
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-13 (continued)
CITIZENS ATTENDING MONTHLY PUBLIC AUCTIONS AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Monthly Public Auctions at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	2.5	EPA, 1989a, moderate excerise
PM10 Concentration	mg/m3	0.018	EPA, 1989 Air Quality in New England
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-13 (continued)
CITIZENS ATTENDING MONTHLY PUBLIC AUCTIONS AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Monthly Public Auctions at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-14
CITIZENS ATTENDING WEEKLY PUBLIC SALES AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Weekly Public Sales at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	2	Schedule from DRMO
Exposure Duration	days/year	26	Schedule from DRMO
Average Lifetime Exposure	years	30	upper bound at one residence
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Not Sufficient Exposure Pathway
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-14 (continued)
CITIZENS ATTENDING WEEKLY PUBLIC SALES AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Weekly Public Sales at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	2.5	EPA, 1989a assuming moderate excercise
PM10 Concentration	mg/m3	0.018	EPA, 1989 Air Quality in New England
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-14 (continued)
CITIZENS ATTENDING WEEKLY PUBLIC SALES AT DRMO

Exposure Scenario:	Exposures to Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Attending Weekly Public Sales at DRMO
Exposed People:	Citizens

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-15
DEPARTMENT OF DEFENSE WORKERS SORTING SCRAP METAL

Exposure Scenario:	Worker Exposures to Surface Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Sorting Scrap Metals
Exposed People:	D.O.D Workers, 18 to 65 years old

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	180	Estimate from Linda McCord
Average Lifetime Exposure	years	35	Estimate from Linda McCord
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-15 (continued)
DEPARTMENT OF DEFENSE WORKERS SORTING SCRAP METAL

Exposure Scenario:	Worker Exposures to Surface Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Sorting Scrap Metals
Exposed People:	D.O.D Workers, 18 to 65 years old

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	2.5	EPA 1991 Default Agriculture setting
PM10 Concentration	mg/m3	0.018	EPA 1989 Air Quality in New England value from Waterford, CT.
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-15 (continued)
DEPARTMENT OF DEFENSE WORKERS SORTING SCRAP METAL

Exposure Scenario:	Worker Exposures to Surface Soil and Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Sorting Scrap Metals
Exposed People:	D.O.D Workers, 18 to 65 years old

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-16
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER CURRENT CONDITIONS

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundwa
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	1	Will vary with each site: CHECK
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-16 (continued)
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER CURRENT CONDITIONS

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundwa
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure
			fugitive dust and volatiles
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-16 (continued)
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER CURRENT CONDITIONS

Exposure Scenario:	Utility Worker Exposures to Soil, Fugitive Dust and Groundw
Case/Timing:	Current Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-17
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER FUTURE CONDITIONS

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	1	Will vary with each site: CHECK
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-17 (continued)
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER FUTURE CONDITIONS

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust and volatiles
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-17 (continued)
UTILITY WORKER EXPOSED TO SOILS AND GROUND WATER IN DRMO UNDER FUTURE CONDITIONS

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Underground Utility Repair in DRMO
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-18
FUTURE CONSTRUCTION OF HAZARDOUS WASTE STORAGE FACILITY

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Construction of Hazardous Waste Storage Facility
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	80	5 days/wk for 6 months
Average Lifetime Exposure	years	1.5	Estimate given from the Shore Planner
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-18 (continued)
FUTURE CONSTRUCTION OF HAZARDOUS WASTE STORAGE FACILITY

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Construction of Hazardous Waste Storage Facility
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure
			fugitive dust
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excer.
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-18 (continued)
FUTURE CONSTRUCTION OF HAZARDOUS WASTE STORAGE FACILITY

Exposure Scenario:	Worker Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Site Conditions
Primary Activity:	Construction of Hazardous Waste Storage Facility
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-19
LEDYARD RESIDENTS INHALING FUGITIVE DUST FROM DRMO

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Ledyard Residents

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	24	
Exposure Duration	days/year	350	EPA 1991 Default
Average Lifetime Exposure	years	30	upper bound at one residence
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			No Potential Exposure
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-19 (continued)
LEDYARD RESIDENTS INHALING FUGITIVE DUST FROM DRMO

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Ledyard Residents

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	0.8	EPA, 1989 Default
PM10 Concentration	mg/m3	0.0006	Hanna et al. 1982
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			Not Associated with Site
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Not Associated with Site
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-19 (continued)
LEDYARD RESIDENTS INHALING FUGITIVE DUST FROM DRMO

Exposure Scenario:	Exposures to Fugitive Dust
Case/Timing:	Current Site Conditions
Primary Activity:	Living in Area
Exposed People:	Ledyard Residents

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-20
SUBASE CHILDREN EXPOSED TO FUGITIVE DUST FROM DRMO AND AREA A LANDFILL

Exposure Scenario:	Exposure to Fugitive Dust from DRMO & Area A Landfill
Case/Timing:	*Current Site Conditions*
Primary Activity:	Subase Children living in Base Housing
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	25	EPA, 1989a mean age 7<8 years
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	930	EPA, 1989a mean age 6<9 years
Total Exposure Duration:			
Daily Exposure Period	hours/day	24	Assumed
Exposure Duration	days/year	350	EPA 1991 Default
Average Lifetime Exposure	years	6	Assume Reassigned Tour of Duty
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Not considered as Step II site
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Not considered as Step II site
Soil Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-20 (continued)
SUBASE CHILDREN EXPOSED TO FUGITIVE DUST FROM DRMO AND AREA A LANDFILL

Exposure Scenario:	Exposure to Fugitive Dust from DRMO & Area A Landfill
Case/Timing:	Current Site Conditions
Primary Activity:	Subase Children living in Base Housing
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure
Inhalation Rate	m3/hr	0.8	EPA, 1991 Default
PM10 Concentration	mg/m3	4.07E-06	Modeled
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-20 (continued)
SUBASE CHILDREN EXPOSED TO FUGITIVE DUST FROM DRMO AND AREA A LANDFILL

Exposure Scenario:	Exposure to Fugitive Dust from DRMO & Area A Landfill
Case/Timing:	Current Site Conditions
Primary Activity:	Subase Children living in Base Housing
Exposed People:	Young children from 6-9 years old living on Subase

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.5	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate			

TABLE 6-21
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE VAULTS

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase vaults
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	3.5	Estimate for Naval Subase Stats
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-21 (continued)
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE VAULTS

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase vaults
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			No Potential Exposure *VOCs were not detected in soil gas*
Inhalation Rate	m3/hr	0	
PM10 Concentration	mg/m3	0	
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			Not Sufficient Exposure Pathway
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure leakage through walls of some vaults
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-21 (continued)
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE VAULTS

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase vaults
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-22
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	3.5	Estimate from Naval Subase Stats
Average Lifetime Exposure	years	20	Assumed for Naval Public Works employee
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-22 (continued)
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-22 (continued)
UTILITY WORKER EXPOSURES TO SOILS AND GROUND WATER IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Current Site Conditions
Primary Activity:	Utility Repair in Lower Subase
Exposed People:	Naval Public Works Employees 18-65 years

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

TABLE 6-23
FUTURE CONSTRUCTION OF BUILDINGS IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Conditions
Primary Activity:	Construction of Buildings
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Physical Attributes of Population:			
Average Bodyweight	kg	70	EPA, 1989a
Average Lifetime	years	70	Assumed
Total Skin Area	cm2	19400	EPA, 1989a
Total Exposure Duration:			
Daily Exposure Period	hours/day	8	Assumed
Exposure Duration	days/year	80	5 days/wk for 6 months
Average Lifetime Exposure	years	1.5	Estimate given from the Shore Planner
Yearly Averaging Period	days	365	Standard
Ingestion of Soil:			Potential Exposure
Ingestion Rate	mg/day	100	EPA, 1989b
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Soil:			Potential Exposure
Soil Adherence	mg/cm2	0.5	EPA, 1989b
Exposed Body Parts			arms, hands, head
Fraction of Skin Area Exposed	(fraction)	0.19	EPA, 1989a
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b

TABLE 6-23 (continued)
FUTURE CONSTRUCTION OF BUILDINGS IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Conditions
Primary Activity:	Construction of Buildings
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Inhalation of Air:			Potential Exposure fugitive dust
Inhalation Rate	m3/hr	3.9	EPA, 1989a assuming heavy excercise
PM10 Concentration	mg/m3	0.09	GRI, 1987
Absorption Factor			
VOCs, SVOCs	(fraction)	1	EPA, 1989b
Lead	(fraction)	0.42	EPA, 1989c
Other Inorganics	(fraction)	1	EPA, 1989b
Ingestion of Groundwater:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Groundwater:			Potential Exposure
Exposed Body Parts			head, arms. hands
Fraction of Total	(fraction)	0.19	EPA, 1989a
Skin Permeability Rate	(cm/hr)		

TABLE 6-23 (continued)
FUTURE CONSTRUCTION OF BUILDINGS IN LOWER SUBASE

Exposure Scenario:	Exposures to Soil, Fugitive Dust and Groundwater
Case/Timing:	Future Conditions
Primary Activity:	Construction of Buildings
Exposed People:	Contracted Construction Worker

Variable	Units	Values	Notes & References
Ingestion of Sediments:			No Potential Exposure
Ingestion Rate	mg/day	0	
Absorption Factor			
VOCs, PAHs	(fraction)	1	EPA, 1989b
Other SVOCs	(fraction)	0.3	EPA, 1989b
Lead	(fraction)	0.3	Value for Adults; EPA, 1989b
Other Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Sediments:			No Potential Exposure
Sediment Adherence	mg/cm2	0	
Exposed Body Parts			
Fraction of Skin Area Exposed	(fraction)	0	
Absorption Factor			
VOCs	(fraction)	0.50	EPA, 1989b
SVOCs	(fraction)	0.05	EPA, 1989b
Inorganics	(fraction)	0.01	Negligible; EPA, 1989b
Ingestion of Surface Water:			No Potential Exposure
Ingestion Rate	l/day	0	
Absorption Factor			
VOCs	(fraction)	1	EPA, 1989b
SVOCs	(fraction)	1	EPA, 1989b
Inorganics	(fraction)	1	EPA, 1989b
Dermal Absorption of Surface Water:			No Potential Exposure
Exposed Body Parts			
Fraction of Total	(fraction)	0	
Skin Permeability Rate	(cm/hr)		

- Utility Worker Exposures to Soils and Ground Water in Lower Subase Vaults;
- Utility Worker Exposures to Soils and Ground Water in Lower Subase;
- Future Construction of Buildings in Lower Subase.

Utility maintenance is an ongoing activity within the Lower Subase. During manhole inspection, visible oil was observed in some incidences. Enclosed trenches (concrete vaults) contain fuel lines, and steam condensate lines. The average depth of trenches are three feet, but some of the trenches are seven feet deep. Sediment or water was sometimes observed in the concrete vaults. Evidence of water suggests cracks within vaults allowing either seawater or ground water intrusion. Some of the utility lines are buried just inches below the ground surface, but others are 15 feet deep. The ground water table is present between six to ten feet below the surface. Therefore, contact with subsurface soil and ground water at depths of 15 feet is possible during utility repair and construction.

A full-time military staff occupies the Lower Subase. Therefore, the possibility of VOCs intruding into the buildings and concrete vaults was examined. A soil gas survey was performed to confirm the low detection of VOCs in subsurface soil and ground water (Section 4.0). More than half of the samples did not detect VOCs, and in most cases only trace to low levels of VOCs were found. Based on these findings, inhalation of VOCs by military administrative staff or laborers was not considered a potential exposure route and has not been included in the exposure scenarios for the Lower Subase.

Fishing or Shellfishing in Thames River

Potential risks to individuals who may recreationally fish or shellfish in the Thames River are not explicitly considered in this assessment. Information presented elsewhere in this document suggests the site may discharge chemicals in ground water and via streams draining the Area A region of the site. In general, it is anticipated that these discharges will be diluted greatly by tidal mixing in the river. Estimates of nearfield dilution suggest that exposure concentrations will be quite small.

In order to establish if compounds of interest are being bioaccumulated in marine animals that might be ingested by humans, it is recommended that this potential exposure route be examined directly rather than speculating on the potential for such bioaccumulation.

The water quality sampling in the river did indicate the presence of elevated manganese levels within the Thames River at the outlet of Area A watercourses. The manganese concentrations at surface water sample locations (2DSW12 and 2DSW13) within Thames River exceeded the EPA Water Quality Criterion for Manganese (100 ug/l). This human health criterion is for the protection of human consumption of marine shellfish. In Section 4.0, the manganese concentration at 2DSW12 was detected at 115 ug/l which is slightly above the criterion. At 2DSW13 manganese was detected at 589 ug/l. These surface water sample locations are approximately ten feet away from the discharge points (outfalls) of the Area A Downstream Watercourses. Upstream surface water samples in the river, 6SW1 and 8SW1, did not contain elevated manganese levels. Periodic or continuous discharges from the outfalls may

be responsible for the localized elevated manganese levels at 2DSW12 and 2DSW13. The human health criterion of 100 ug/l was exceed for 13 out of 15 surface water samples within Area A Downstream Watercourses as stated in Section 4.0. Further seasonal sampling is suggested at 2DSW12 and 2DSW13 to identify the source of manganese and verify if a potential health risk is apparent. Discussion of the possible source of manganese is presented in Section 4.0.

6.2.3 Quantification of Exposure

6.2.3.1 Step I Sites

Data on chemical concentrations in Step I sites are reviewed to provide a qualitative basis for evaluating exposure.

Construction Battalion Unit (CBU) Drum Storage Area

Concentrations of compounds at this site do not indicate the presence of contamination that might result in exposure.

Rubble Fill at Bunker A-86

The semi-volatile analysis of a surface soil composite sample revealed elevated PAH concentrations. The detected PAH concentrations were significantly above ambient PAH levels in urban soils (Menzie et al., 1991). The same composited surface soil sample contained a high concentration of arsenic (127 ppm); a moderate contamination of methoxychlor (370 ppb) and a low concentration of Delta-BHC (42 ppb). However, the detected pesticides are different than those pesticides which have been detected at NSB-NLON. These levels of contaminants might indicate localized contamination or contamination over a more widespread area. Thus there is potential for exposure to contaminants at this site.

Torpedo Shops

The Torpedo Shop buildings are not part of the study area. Sampling was limited to septic system leaching field. Methylene chloride, acetone and 2-butanone were detected in the subsurface soil at this location. These compounds are typically used as solvents and their presence could be associated with torpedo maintenance work. Benzene was detected at a very low level (4 ppb) in one subsurface soil sample. Generally low levels of VOCs were detected by soil gas measurements within the septic system, except for one location where elevated level were recorded.

Low levels of PCBs and DDE were detected in two separate locations. Low concentrations of VOCs, semi-volatiles and antimony, were detected in subsurface soils near the septic systems which are at remote locations with respect to the torpedo shops. Antimony was detected above established background levels.

Only one surface soil sample (well location 7MW1 from a depth of 0-2 feet) was collected in the former septic leaching field. Surface runoff from the site flows southwest to

drainage swales and storm sewers located on the south side of Buildings 325 and 450.

Antimony exceeded USEPA health advisory by 20 times within one ground water monitoring well. Several VOCs were detected in the overburden ground water system, but at levels below drinking water standards. Their source has not yet been identified. Chlorinated compounds were absent in an upgradient bedrock monitoring well (7MW1).

Utility lines are buried five to six feet below the surface. Therefore, during outside utility repair work, exposures to subsurface soil and ground water contaminants are possible. The ground water table is approximately five to six feet below the ground surface.

Goss Cove Landfill

VOCs were detected in soils and they included toluene (18,000 ppb maximum) and xylene (23,000 ppb maximum). None of the test boring or monitoring well locations were directly adjacent to the Nautilus museum, but VOCs were detected in landfill material and shallow ground water within the parking lot area. VOC constituents detected in ground water included vinyl chloride (5 ppb), xylene, ethylbenzene, and toluene. The presence of VOCs in landfill material and ground water suggests the potential for the lateral migration of vapors towards the museum.

Pesticides, 4,4'DDE (11,000 ppb maximum) and 4,4 DDT (34,000 ppb maximum) were found at elevated levels. Elevated levels of arsenic, silver, lead, cadmium, chromium, and mercury were detected in one sample from test boring (8TB1). PAHs were observed at higher concentrations in soil than any other site at NSB-NLON. PAH concentrations could be related to the landfill material or presence of petroleum contamination. The presence of sub-surface contamination indicates the potential for exposure at this site during excavation or construction activities.

The sediment and surface water within Goss Cove has not been sampled.

Over Bank Disposal Area Northeast (OBDANE)

Naturally occurring chemicals were observed at ambient levels. Anthropogenic chemicals were not found. The potential for exposure seems limited in this area.

Spent Acid Storage and Disposal Area

Since the site is paved, the only medium sampled was subsurface soil. Lead contamination was found in subsurface soil. Below four feet from the surface, lead levels decrease with depth. The lateral extent of contamination is not well characterized. Based on current laboratory data, soil in this area would need to be handled as hazardous waste.

There is a potential for exposure at this site during soil excavation or construction activities.

Former Gasoline Station

No chemical constituents were detected at significant concentrations; all were detected below ARAR/TBC values. Since the site is paved, the only activity which offers the potential for exposures to subsurface soil is utility work.

6.2.3.2 Step II Sites

Analytical data for the Area A Landfill, Over the Bank Disposal Area, DRMO, and the Lower Subase were used to develop exposure point concentrations (EPCs) for quantitative risk assessment for the scenarios identified in Section 6.2.2. To estimate the range of EPCs corresponding to an exposure route, the arithmetic average exposure point concentration of a compound of interest within a particular medium was used to represent the nominal case while the maximum exposure point concentration was used as an upper bound. Using the average and maximum exposure point concentrations, the daily doses through an exposure route were estimated. Values reported as non-detected were included in the calculation of the mean concentrations as discussed in Section 6.1.

The EPCs used in the quantitative risk assessment are presented in tables in Appendix E. In most cases the concentrations are based on measured values in soil, sediment, or water. However, in some cases, values are derived by modeling one or more exposure pathways. Special data handling issues or the use of models are described below.

EPCs for Children Swimming at North Lake

During sampling conducted on April 24, 1990 by the Navy, an elevated level of mercury was detected in the beach sand of North Lake. However, the presence of mercury was detected only once and more recent analyses of the beach sand have not detected mercury. Past sampling is discussed in Section 1.0. Table 1-6 presents North Lake surface water and sediment/beach sand analytical data.

One surface water and one sediment sample (2DSD/SW10) within North Lake were collected during the most recent sampling round. Surface soil in picnic area, and beach sand were not tested around North Lake as part of our sampling effort. Thus, an evaluation of risks is based on historical data not collected or analyzed under strict CLP protocols. Tables in Appendix E, entitled Historical North Lake Laboratory data, present the results used to derive the surface water and sediment exposure point concentrations. Because historical data have been used, the EPCs may not reflect current conditions.

EPCs for PAHs in Soils of the Lower Subase

Semi-volatile compounds were not analyzed for soils of the Lower Subase. Therefore, possible PAH content in the soil was estimated using the total petroleum hydrocarbon and fluorescence spectroscopy data (refer to Tables 4-53 & 4-54). Because PAHs are present within petroleum products and because oil sheens, visible product and petroleum odors have been observed in some manholes along with confirmatory TPH detection in surrounding soil, it is reasonable to expect that PAHs are present in the soils. Petroleum product in the soil has been

characterized as No. 2 and No. 6 fuel oils. Discussion of nature of the petroleum contamination is presented in Section 4.13. PAH concentrations in subsurface soil were estimated by applying known PAH percentages in No. 6 and No. 2 fuel oils and assuming that the volatile portion of the fuel oils is absent (Tables 6-24 to 6-26). The latter assumption is based on very low levels of VOCs detected in subsurface soil.

EPCs in Soil via Fugitive Dust

Analytical models were used to estimate concentrations of fugitive dusts. These models incorporate simplifying assumptions to estimate the EPCs for contaminants associated with suspended dusts in air.

EPCs for Activities Involving Excavation

Fugitive dust levels to which the base personnel and independent construction workers are exposed were estimated by multiplying an estimated PM10 concentration (0.09 mg/m^3) by the mean of the soil EPC for the nominal case and by the maximum soil EPC for the upper bound case. Only surface soil samples (0 - 2 feet) were used in the calculation of fugitive dust EPCs. The PM10 designation is defined as the airborne particulate matter that is less than 10 um in diameter. The PM10 measurement is the airborne particulate concentration expressed in mg/m^3. A PM10 value of 0.09 mg/m^3 is used for the soil excavation activities because it is about twice the annual average maximum recorded in New England and is also a conservative estimate for a site with limited excavation (GRI, 1987).

EPCs Under Ambient Conditions

To assess fugitive dust exposures under ambient conditions an ambient particulate concentration (PM10) was chosen from data presented in a recent USEPA Region I document produced by the Ambient Air and Emissions Monitoring Section (1989 Annual Report on Air Quality in New England). The nearest air quality monitoring station to NSB-NLON is located in Waterford, Connecticut in New London County. The 1989 mean PM10 concentration at this station was 0.018 mg/m^3. By using this PM10 value, an overly conservative estimate is derived for the site if we assume that all fugitive dust is generated on the site. The estimate is conservative because some of the suspended particulate is generated off the Subase and represents the background level. Therefore the actual PM10 concentration attributed to routine conditions at the site is less than 0.018 mg/m^3.

Modeled EPCs at Locations Distant from Sites

At locations away from the Step II sites, analytical models were used and applied on a site-specific basis. These models incorporate wind rose data for the coastal region of Connecticut. A wind rose is a pie chart which displays wind data in terms of percent frequency for direction and velocity. Annual wind roses representing the years 1986, 1987 and 1988 at Sikorsky Memorial Airport in Stratford, Connecticut were obtained from the Connecticut DEP Air Modeling Division. CTDEP air modelers suggested these wind roses as appropriate because this site is coastal.

TABLE 6-24
FRESH AND ESTIMATED WEATHERED COMPOSITION OF NO. 2 FUEL OIL

			Fresh Material (1)	Nonvolatile Material (2)
			Percent Composition by Weight	
Saturated Compounds		*individual*	61.80%	68.90%
n-paraffins		*compounds*		
	C10+C11	*1.26%*		
	C12	*0.84%*		
	C13	0.96%		1.070%
	C14	1.03%		1.148%
	C15	1.13%		1.260%
	C16	1.05%		1.171%
	C17	0.65%		0.725%
	C18	0.55%		0.613%
	C19	0.33%		0.368%
	C20	0.18%		0.201%
	C21	0.09%		0.100%
	C22	0.00%		0.000%
	C23	0.00%		0.000%
	C24	0.00%		0.000%
	C25	0.00%		0.000%
	C26	0.00%		0.000%
	C27	0.00%		0.000%
	C28	0.00%		0.000%
	C29	0.00%		0.000%
	C30	0.00%		0.000%
	C31	0.00%		0.000%
	C32	0.00%		0.000%
	Isoparaffins	22.30%		24.861%
	1-ring cycloparaffins	17.50%		19.509%
	2-ring cycloparaffins	9.40%		10.479%
	3-ring cycloparaffins	4.50%		5.017%
	4-ring cycloparaffins	0.00%		0.000%
	5-ring cycloparaffins	0.00%		0.000%
	6-ring cycloparaffins	0.00%		0.000%
Aromatics			38.20%	42.59%
Benzenes		10.30%		
Indanes and tetralins		7.30%		8.14%
Dinaphthenobenzenes		4.60%		5.13%
Naphthalenes		0.20%		0.22%
Methylnaphthalenes		2.10%		2.34%
Dimethylnaphthalenes		3.20%		3.57%
Other napthalenes		0.40%		0.45%
Acenaphthenes		3.80%		4.24%
Acenaphthalenes		5.40%		6.02%
Phenanthrenes		0.00%		0.00%
Pyrenes		0.004%		0.00%
Fluoranthene		0.004%		0.0041%
Benzanthracene		0.000%		0.0001%
Chrysene		0.000%		0.0002%
Benzo(a)pyrene		0.000%		0.0001%
Benzo(e)pyrene		0.000%		0.0000%
Benzothiophenes		0.90%		1.00%
Dibenzothiophenes		0.00%		0.00%
Total semivolatile aromatics =		27.90%		
Polar Materials			0.000%	0.000% (3)
Insolubles			0.000%	0.000%
		Total =	100.00%	
Volatile Aromatic portion =			10.30%	
Total assuming volatiles aromatics are absent =			89.70%	

(1) Fresh composition is taken from Oil in the Sea (NAS, 1985)
(2) Assuming the 2# Fuel Oil in the soil is weathered and does not contain volatile fraction (BTX).
(3) Assuming polar material fraction is not volatile

TABLE 6-25
FRESH AND ESTIMATED WEATHERED COMPOSITION OF NO. 6 FUEL OIL

			Fresh Material (1)	Weathered Material (2)
			Percent Composition by Weight	
Saturated Compounds		*individual*	21.10%	21.96%
n-paraffins		*compounds*		
	C13	0.07%		0.073%
	C14	0.11%		0.114%
	C15	0.12%		0.125%
	C16	0.14%		0.146%
	C17	0.15%		0.156%
	C18	0.12%		0.125%
	C19	0.14%		0.146%
	C20	0.12%		0.125%
	C21	0.11%		0.114%
	C22	0.10%		0.104%
	C23	0.09%		0.094%
	C24	0.08%		0.083%
	C25	0.07%		0.073%
	C26	0.05%		0.052%
	C27	0.04%		0.042%
	C28	0.05%		0.052%
	C29	0.04%		0.042%
	C30	0.04%		0.042%
	C31	0.04%		0.042%
	C32	0.05%		0.052%
	Isoparaffins	5.00%		5.203%
	1-ring cycloparaffins	3.90%		4.058%
	2-ring cycloparaffins	3.40%		3.538%
	3-ring cycloparaffins	2.90%		3.018%
	4-ring cycloparaffins	2.70%		2.810%
	5-ring cycloparaffins	1.90%		1.977%
	6-ring cycloparaffins	0.40%		0.416%
Aromatics			34.20%	35.59%
Benzenes		1.90%		
Indanes and tetralins		2.10%		2.19%
Dinaphthenobenzenes		2.00%		2.08%
Methylnaphthalenes		2.60%		2.71%
Acenaphthenes		3.10%		3.23%
Acenaphthalenes		7.00%		7.28%
Phenanthrenes		11.60%		12.07%
Pyrenes		1.70%		1.77%
Fluoranthene		0.02%		0.0250%
Benzanthracene		0.009%		0.0094%
Chrysene		0.020%		0.0204%
Benzo(a)pyrene		0.004%		0.0046%
Benzo(e)pyrene		0.001%		0.0010%
Benzothiophenes		1.50%		1.56%
Dibenzothiophenes		0.70%		0.73%
Total semivolatile aromatics =		30.30%		
Polar Materials			30.30%	31.53% '(3)
Insolubles			14.40%	14.98%
		Total =	100.00%	
Volatile Aromatic portion =			3.90%	
Total assuming volatiles aromatics are absent =			96.10%	

(1) Fresh composition is taken from Oil in the Sea (NAS, 1985)

(2) Assuming the 6# Fuel Oil in the soil is weathered and does not contain volatile fraction (BTX).

(3) Assuming polar material fraction is not volatile

TABLE 6-26
ESTIMATED PAH ASSOCIATED WITH FUEL OIL CONTAMINATION IN THE LOWER SUBASE
(Percent Composition by Weight)

PAH Composition	Fuel 6#	Fuel 2#	Average %	Estimated Concentrations (ppm)
Dinaphthenobenzenes	2.081	5.128	3.605	114.86
Naphthalenes		0.223	0.223	7.10
Methylnaphthalenes	2.706	2.341	2.523	80.40
Dimethylnaphthalenes		3.567	3.567	113.67
Other Napthalenes		0.446	0.446	14.21
Acenapththenes	3.226	4.236	3.931	118.89
Acenaphthalenes	7.284	6.020	6.652	211.96
Phenanthrenes	12.071		12.071	384.63
Pyrenes	1.769	0.005	0.887	28.26
Fluoranthene	0.025	0.004	0.015	0.46
Benzanthracene	0.009	0.000	0.005	0.15
Chrysene	0.020	0.000	0.010	0.33
Benzo(a)pyrene	0.005	0.000	0.002	0.07
Benzo(e)pyrene	0.001	0.000	0.001	0.02
Benzothiophenes	1.561	1.003	1.282	40.85
Dibenzothiophenes	0.728		0.728	23.21
		Total PAH %	35.75	
		Total Estimated PAH Concentration		1139 ppm
		Estimated Carcinogenic PAH Concentration		1 ppm
		Estimated Insolubles and Hydrocarbon Concentration		2047 ppm
		Total		3186 ppm
		Actual Mean TPH Concentration		3186 ppm

The sector averaged zero stack height model (Hanna et al., 1982) was used to estimate fugitive dust concentrations at various distances and directions from Step II sites where the potential for dust generation was present. The model is obtained from a Gaussian plume equation by integrating to obtain the total mass horizontally across the plume and then distributing the mass entirely within one of the sixteen wind directions. The concentration, which is averaged over a sector, is weighted by the frequency with which the wind blows in that direction. Modeling parameters used in the fugitive dust calculations and the results are provided in Table 6-27, and calculations using the model are provided in Appendix E.

TABLE 6-27
MODELING PARAMETERS FOR FUGITIVE DUST EXPOSURES

Source	Receptor	Source Area (sq. mile)	Source-to-Receptor Direction	% of Time Wind Blowing Toward Receptor	Mean Annual Wind Speed in Receptor Direction (m/sec)	Source-to-Receptor Distance (miles)
DRMO	Subase Residents	3,181	South	5.13%	4.65	915
Area A Landfill	Subase Residents	22,259	Southwest	9.47%	5.40	490
DRMO	Offsite Residents	3,181	North	10.37%	5.47	485
Area A Landfill	Offsite Residents Along Route 12	22,259	East	6.73%	5.69	425
Area A Landfill	Weapons Center	22,259	Northwest	6.63%	6.16	240

6.2.4 Estimating Average Daily Doses

6.2.4.1 Selecting Reference Values for Exposed Populations

Generally accepted reference values for inhalation rates, body size etc. were used to make estimates of dose and to place these estimates on a per unit weight basis. Because these reference values are generally accepted they can be helpful when site-specific information is not available. In subsequent subsections such information will be provided. Among the most basic reference standards used are those for total skin area and body weight.

All reference values are presented in the exposure scenario tables (Tables 6-3 to 6-23) along with citations.

6.2.4.2 Equations Used to Estimate Average Daily Doses (ADDs)

Estimates of doses are presented as Average Daily Doses (ADDs) in tables in Appendix E corresponding to the exposure scenarios. The word "dose" has several meanings in toxicology and risk assessment. The three most commonly used meanings are:

- exposure dose - the total amount of a compound that may enter the body via ingestion, inhalation, or dermal contact; this dose may also be referred to as

the administered dose; and it includes material that may be excreted or exhaled rapidly.

- delivered dose - this is the quantity of a compound that reaches a target organ (e.g., liver).

- biologically effective dose - this is the quantity of a compound that results in an effect at the site of the effect.

In this document, the meaning of "dose" is the "exposure dose". Estimating doses involves converting estimated exposure point concentrations in the environmental medium to annual average doses in units of milligram of compound per day per kilogram of body weight (mg/kg/day).

Equations (i.e., exposure models) were used to estimate the chronic dose of each Compound of Interest, averaged over a year. The information presented in the following subsections generally assumes that the concentrations of compounds of interest will remain constant over the exposure period, in some cases a lifetime. In the case of organic compounds and many of the inorganics, this is a highly conservative assumption. It is well known that the organic compounds will biodegrade with time in the soil. (Refer to Section 5 Contaminant Fate and Transport.) The concentration of a compound decreases with time as expressed by the measured or estimated half-life. The dose in such cases would be the integral of the concentration with time curve for the period of interest. Other loss mechanisms that might occur include volatilization and photolysis.

Average Daily Doses (ADDs) of the chemicals from each exposure route and exposure point were estimated using standard chemical intake equations and a combination of standard and site-specific exposure assumptions. The exposure routes and specific exposure assumptions are provided in each exposure scenario table.

The general form of the ADD equation is as follows:

$$\text{ADD} = \frac{\text{(Total Amount of Chemical Taken In)}}{\text{(Body Weight) (Averaging Period)}}$$

Two ADDs were calculated for each exposure route: the ADD (year) and the ADD (life). The ADD (year) was used to evaluate non-carcinogenic effects. It represents the chemical intake during the course of a yearly exposure period and was calculated as the average daily dose over a 365-day period. The ADD (life) was used to evaluate carcinogenic effects. It represents the chemical intake averaged over a lifetime and was calculated as the average daily dose over a 70 year lifetime. All doses are estimated in units of mg/kg/day.

Averaging time refers to the exposure period over which a dose level is estimated. The exposure period becomes an important consideration because different effects may be manifested at different dose levels and over different periods. The issue of averaging time applies primarily to those effects for which there may be thresholds. These include non-carcinogenic effects.

Because potential carcinogens are not considered to have thresholds, any exposure would involve some risk. Thus, exposures to potential carcinogens can be expressed as an average lifetime dose.

The EPA has su[illegible]ted that, "for assessment of other (than carcinogenic) chronic health risks, the long-term co[illegible]ntrations (LTCs) should not necessarily be averaged over a 70-year period and for some c[illegible]icals it would clearly be incorrect to do so." Our approach was to average LTCs over a one year period for the assessment of non-carcinogenic effects and not to substantially reduce an LTC value by averaging over a full lifetime.

Estimates of ADD are presented in spreadsheet format for each of the exposure scenarios, exposure routes, and compounds of interest in tables in Appendix E.

6.2.5 Uncertainty in Exposure Estimates

Information presented below depicts sources of uncertainty:

- sources of variability in sampling data used to estimate exposures;
- assumptions that have been made in estimating exposure point concentrations; and
- limitations and sources of uncertainty associated with fate and transport models that were used, for example, fugitive dust, soil gas and ground water flow models.

Based on experience, the following exposure conditions tend to have large degrees of uncertainty associated with them.

- Intrusion of soil gas from surrounding soils into buildings.
- Transport of fugitive dusts from contaminated sites to offsite or onsite receptors near the sites.
- Transport of compounds of interest via ground water to adjacent offsite receptor wells, volatilization into buildings or discharge to surface water bodies.
- Incidental ingestion of soil by site workers and children.
- Release of vapors during excavations on site.
- Migration of non-aqueous phase liquids (petroleum) and gasses.
- Biodegradation of PAH compounds in shallow and deep soil layers.

6.3 Toxicity Assessment

This section of the document identifies and organizes information on the health effects of site-specific compounds of interest. Dose-response assessment provides one of two major bodies of information needed to characterize risks. Information developed in the dose-response assessment is combined with information developed in the exposure assessment to estimate risks.

Evaluation of a compound's potential for toxicity involves the examination of available data that relate its observed toxic effects to doses at which they occur. Generally, there are three categories of information that are considered in this part of a quantitative human health risk assessment:

1. Information on the potential for compounds to initiate or promote cancers.

2. Information on the potential acute or chronic non-cancer effects of compounds.

3. Information on applicable air, surface water, and ground water standards.

Information that will be utilized to characterize human health risks at a site is summarized in Table 6-2. Brief summaries of such information given below make it clear which values (cancer potency, reference dose) are being used for the purpose of the risk assessment.

6.3.1 Toxicity Assessment for Noncarcinogenic Effects

Assessment for Non-Carcinogens

This sub-section provides identifies and organizes information for assessing the non-carcinogenic health effects of compounds of interest. All the compounds of interest have the potential for effects that are non-carcinogenic in nature. Therefore, when evaluating such effects potential carcinogens should be included along with compounds that are typically considered to be non-carcinogens.

The assessment of non-carcinogenic effects is complex. There is a broad interaction of time scales (acute, subchronic, and chronic) with kinds of effects. In various risk assessment guidance documents, most of the attention has focused on evaluating the consequences of chronic (long term) exposure to various compounds. Efforts here have been directed at establishing Risk Reference Doses (RfDs) for compounds.

Acute Effects

Acute effects are those that occur as a result of short-term exposure to compounds of interest. "Short-term" is here defined as exposure periods ranging from less than a day to a few days. Naturally, such effects might also be manifested if individuals were exposed on a continual basis if the exposure concentration was high enough to result in acute effects.

Acute exposures and associated effects might occur as a result of the releases of gases or dusts during excavation of contaminated soils or waste deposits. Such excavations may be part of planned maintenance activities, remedial investigations, or restoration activities. If compounds are in sufficiently high concentrations to cause acute effects upon general public exposure, then immediate restoration activities should be evaluated. Such an occurrence would be considered to constitute an imminent hazard.

In most cases, acute effects could result from skin or eye contact with "high" levels of vapors or with direct contact with raw or highly concentrated materials. There is little data available to relate acute toxic effects to specific doses of compound mixtures.

Subchronic and Chronic Effects

This sub-section provides information that is used to assess the potential subchronic and chronic health effects associated with the presence of compounds of interest at these sites. Information presented here can be used to estimate risks using the equations and methods outlined in Section 6.2 and 6.4 of this document. The subchronic and chronic effects of compounds of interest can be evaluated by reference to:

- Reference Dose (RfD) values for subchronic and chronic exposures on the order of years.

These values serve as benchmarks for assessing the potential for non-carcinogenic health effects. They represent "threshold" health effects values below which no effects are expected. To ensure that these benchmarks are set low enough, uncertainty in the supporting data base is taken into account through the application of uncertainty or safety factors.

The USEPA has published RfD values for some of the compounds of interest. Table 6-28 provides a summary of these values. The RfD values presented in this table are used in the equations for calculating risks in Section 6.4. A RfD is defined in the Integrated Risk Information System (IRIS) as an estimate (uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population, including sensitive subgroups, that is likely to be without an appreciable risk of deleterious effects during a lifetime. A critical effect refers to the health endpoint upon which the reference dose is based. The uncertainty factor contributes as a divisor to the dose associated with the critical effect, which is usually a No-Observed-Adverse-Effect-Level (NOAEL) or a Lowest-Observed-Adverse-Effect Level (LOAEL). Most uncertainty factors are standardized and include:

- 10-fold factor for extrapolation from animals to humans;
- 10-fold factor for variability in the human population;
- 10-fold factor for use of a less-than-chronic study; and
- 1 to 10-fold factor for extrapolation from a LOAEL.

TABLE 6-28
TOXICITY VALUES USED FOR RISK ASSESSMENT

COMPOUND	SUBCHRONIC RFDs INHALATION (mg/kg/day)		SUBCHRONIC RFDs INGESTION (mg/kg/day)		CHRONIC RFDs INHALATION (mg/kg/day)		CHRONIC RFDs INGESTION (mg/kg/day)	
VOLATILE ORGANIC COMPOUNDS								
Nonchlorinated Aromatics								
Benzene	9E-02	c	2E-01	c	2E-01	c	1E-01	c
Ethylbenzene	3E-01	a	1E+00	a	3E+01	a	1E-01	a
Toluene	6E-01	a	2E-01	a	6E-01	a	2E-01	a
Xylene (total)	9E-02	a	4E+00	a	2E-01	a	2E+00	a
Chlorinated Compounds								
Chloromethane								
1,1-Dichloroethane	1E+00	a	1E+00	a	1E-01	a	1E-01	a
1,2-Dichloroethane	1E+00	d	1E+00	d	1E-01	d	1E-01	d
1,1-Dichloroethene	1E+00	e	9E-03	a	1E-01	e	9E-03	a
Cis-1,2-Dichloroethene (represents trans	1E+00	e	1E-01	a	1E-01	e	1E-02	a
Methylene Chloride	9E-01	a	6E-02	a	9E-01	a	6E-02	a
1,1,2,2 Tetrachloroethane	1E+00	e	1E-01	e	1E-01	e	1E-02	e
Tetrachloroethene	1E+00	e	1E-01	a	1E-01	e	1E-02	a
Trichloroethene	1E+00	e	1E-01	e	1E-01	e	1E-02	e
1,1,1-Trichloroethane	3E+00	a	9E-01	a	3E-01	a	9E-02	a
1,1,2-Trichloroethane	1E+00	e	4E-02	a	1E-01	e	4E-03	a
Vinyl Chloride	1E+00	e	1E-01	e	1E-01	e	1E-02	e
Other VOCs								
Acetone	1E+00	g	1E+00	a	1E-01	g	1E-01	a
2-Butanone	9E-01	a	5E-01	a	9E-02	a	5E-02	a
4-Methyl-2-Pentanone	9E-01	f	5E-01	f	9E-02	f	5E-02	f
Carbon Disulfide	3E-03	a	1E-01	a	3E-03	a	1E-01	a
SEMIVOLATILE COMPOUNDS								
Noncarcinogenic PAHs								
Acenaphthene	6E-01	j	6E-01	a	6E-02	j	6E-02	a
Acenaphthylene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Anthracene	3E+00	j	3E+00	a	3E-01	j	3E-01	a
Fluoranthene	4E-01	j	4E-01	a	4E-02	j	4E-02	a
Fluorene	4E-01	j	4E-01	a	4E-02	j	4E-02	a
2-Methylnaphthalene	4E-02	i	4E-02	i	4E-03	i	4E-03	i
Naphthalene	4E-02	i	4E-02	a	4E-03	i	4E-03	a
Phenanthrene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Pyrene	3E-01	j	3E-01	a	3E-02	j	3E-02	a
Carcinogenic PAHs								
Benzo(a)Anthracene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Benzo(a)Pyrene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Benzo(b)Fluoranthene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Benzo(g,h,i)Perylene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Benzo(k)Fluoranthene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Chrysene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Dibenz(a,h)Anthracene	5E-01	h	5E-01	h	5E-02	h	5E-02	h
Indeno(1,2,3-cd)Pyrene	5E-01	h	5E-01	h	5E-02	h	5E-02	h

TABLE 6-28 (continued)
TOXICITY VALUES USED FOR RISK ASSESSMENT

COMPOUND	SUBCHRONIC RFDs INHALATION (mg/kg/day)		SUBCHRONIC RFDs INGESTION (mg/kg/day)		CHRONIC RFDs INHALATION (mg/kg/day)		CHRONIC RFDs INGESTION (mg/kg/day)	
Other Semi-Volatile Compounds								
bis(2-Ethylhexyl)Phthalate	2E-02	j	2E-02	a	2E-02	j	2E-02	a
Di-n-Butylphthalate	2E-02	k	2E-02	k	2E-02	k	2E-02	k
2,4-Dimethylphenol	2E-01	j	2E-01	a	2E-02	j	2E-02	a
4,6-Dinitro-2-methylphenol	5E-01	l	5E-01	l	5E-02	l	5E-02	l
2-Methylphenol	5E-01	j	5E-01	a	5E-02	j	5E-02	a
4-Methylphenol	5E-01	j	5E-01	a	5E-02	j	5E-02	a
Phenol	6E-01	j	6E-01	a	6E-01	j	6E-01	a
Benzoic Acid	4E+00	j	4E+00	a	4E+00	j	4E+00	a
4-Chloroaniline	4E-03	j	4E-03	a	4E-03	j	4E-03	a
Dibenzofuran								
2-Nitroaniline	4E-03	m	4E-03	m	4E-03	m	4E-03	m
N-Nitrosodiphenylamine (1)	1E-02	o	1E-02	o	1E-03	o	1E-03	o
PESTICIDES								
4,4' DDE	5E-04	n	5E-04	n	5E-04	n	5E-04	n
4,4' DDD	5E-04	n	5E-04	n	5E-04	n	5E-04	n
4,4'-DDT	5E-04	j	5E-04	a	5E-04	j	5E-04	a
Beta-BHC	3E-03	j	3E-03	p	3E-04	j	3E-04	p
Endrin	5E-04	j	5E-04	a	3E-04	j	3E-04	a
Endrin Ketone								
Methoxychlor	5E-03	j	5E-03	a	5E-03	j	5E-03	
PCBs								
Aroclor 1260	1E-03	o	1E-03	o	1E-03	o	1E-03	o
Aroclor 1254	1E-03	o	1E-03	o	1E-03	o	1E-03	o
INORGANICS								
Metals								
Aluminum								
Antimony	4E-04	j	4E-04	a	4E-04	j	4E-04	a
Arsenic	1E-03	j	1E-03	a	1E-03	j	1E-03	a
Beryllium	5E-03	j	5E-03	a	5E-03	j	5E-03	a
Boron	9E-02	j	9E-02	a	9E-02	j	9E-02	a
Cadmium	5E-04	j	5E-04	r	5E-04	j	5E-04	a
Copper	4E-02	j	4E-02	a	4E-02	j	4E-02	a
Iron								
Lead	5E-04	q	5E-04	q	5E-04	q	5E-04	q
Manganese	1E-04	a	1E-01	a	1E-04	a	1E-01	a
Mercury	9E-05	a	3E-04	a	9E-05	a	3E-04	a
Nickel	2E-02	j	2E-02	a	2E-02	j	2E-02	a
Selenium								
Zinc	2E-01	j	2E-01	a	2E-01	j	2E-01	a

TABLE 6-28 (continued)
TOXICITY VALUES USED FOR RISK ASSESSMENT

COMPOUND	WEIGHT OF EVIDENCE CLASSIFICATION INHALATION	WEIGHT OF EVIDENCE CLASSIFICATION INGESTION	CARCINOGENIC POTENCY FACTORS INHALATION (mg/kg/day)-1		CARCINOGENIC POTENCY FACTORS INGESTION (mg/kg/day)-1	
VOLATILE ORGANIC COMPOUNDS						
Nonchlorinated Aromatics						
Benzene	A	A	2.9E-02	a	2.9E-02	a
Ethylbenzene						
Toluene						
Xylene (total)						
Chlorinated Compounds						
Chloromethane	C	C	6.3E-03	a	1.3E-02	a
1,1-Dichloroethane	C	C	ND	a	ND	a
1,2-Dichloroethane	B2	B2	9.1E-02	a	9.1E-02	a
1,1-Dichloroethene	C	C	1.2E+00	a	6E-01	a
Cis-1,2-Dichloroethene (represents trans)						
Methylene Chloride	B2	B2	1.6E-03	a	7.5E-03	a
1,1,2,2 Tetrachloroethane	C	C	2.0E-01	a	2.0E-01	a
Tetrachloroethene	B2	B2	1.8E-03	a	5.1E-02	a
Trichloroethene	B2	B2	1.7E-02	a	1.1E-02	a
1,1,1-Trichloroethane						
1,1,2-Trichloroethane	C	C	5.7E-02	a	5.7E-02	a
Vinyl Chloride	A	A	2.9E-01	a	1.9E+00	a
Other VOCs						
Acetone						
2-Butanone						
4-Methyl-2-Pentanone						
Carbon Disulfide						
SEMIVOLATILE COMPOUNDS						
Noncarcinogenic PAHs						
Acenaphthene						
Acenaphthylene						
Anthracene						
Fluoranthene						
Fluorene						
2-Methylnaphthalene						
Naphthalene						
Phenanthrene						
Pyrene						
Carcinogenic PAHs						
Benzo(a)Anthracene	B2	B2	1.7E+00	b	8.8E-01	b
Benzo(a)Pyrene	B2	B2	6.1E+00	a	1.1E+01	a
Benzo(b)Fluoranthene	B2	B2	1.6E+00	b	8.5E-01	b
Benzo(g,h,i)Perylene	D	D	2.5E-01	b	1.3E-01	b
Benzo(k)Fluoranthene	B2	B2	1.6E+00	b	8.5E-01	b
Chrysene	B2	B2	5.1E-02	b	2.7E-02	b
Dibenz(a,h)Anthracene	B2	B2	1.3E+01	b	6.8E+00	b
Indeno(1,2,3-cd)Pyrene	B2	B2	2.7E+00	b	2.7E+00	b

TABLE 6-28 (continued)
TOXICITY VALUES USED FOR RISK ASSESSMENT

COMPOUND	WEIGHT OF EVIDENCE CLASSIFICATION		CARCINOGENIC POTENCY FACTORS			
	INHALATION	INGESTION	INHALATION (mg/kg/day)-1		INGESTION (mg/kg/day)-1	
Other Semi-Volatile Compounds						
bis(2-Ethylhexyl)Phthalate	B2	B2	1.4E-02	j	1.4E-02	a
Di-n-Butylphthalate						
2,4-Dimethylphenol						
4,6-Dinitro-2-methylphenol						
2-Methylphenol						
4-Methylphenol						
Phenol						
Benzoic Acid						
4-Chloroaniline						
Dibenzofuran						
2-Nitroaniline						
N-Nitrosodiphenylamine (1)	B2	B2	4.9E-03	j	4.9E-03	a
PESTICIDES						
4,4' DDE	B2	B2	3.4E-01	j	3.4E-01	a
4,4' DDD		B2	3.4E-01	j	2.4E-01	a
4,4'-DDT	B2	B2	3.4E-01	a	3.4E-01	a
Beta-BHC						
Endrin						
Endrin Ketone						
Methoxychlor						
PCBs						
Aroclor 1260	B2	B2	7.7E+00	j	7.7E+00	a
Aroclor 1254	B2	B2	7.7E+00	j	7.7E+00	a
INORGANICS						
Metals						
Aluminum						
Antimony						
Arsenic	A	A	5.0E+01	a	NA	a
Beryllium	B2	B2	8.4E+00	a	4.3E+00	a
Boron						
Cadmium	B1	ND	6.1E+00	a	ND	a
Copper						
Iron						
Lead	B2	B2	ND	a	ND	a
Manganese						
Mercury						
Nickel	A	ND	8.4E-01	a	ND	a
Selenium						
Zinc						

TABLE 6-28 (continued)
TOXICITY VALUES USED FOR RISK ASSESSMENT

NOTES

a Toxicity values taken directly or derived from values provided in: Health Effects Assessment Summary Tables, U.S EPA, 1990.

b CPFs for PAHs were developed using the CPFs for benzo(a)pyrene and the relative potency factors developed by ICF-Clement and Associates, Inc. 1987.

c RfD values for benzene were selected to reflect the most toxic values for other non-chlorinated aromatic compounds.

d 1,2-Dichloroethene was assumed to have non-carcinogenic effects similar to those of 1,1-dichloroethene.

e RfD values were selected for compounds and routes of exposure based on data for other chlorinated volatile compounds.

f The ketone 4-methyl-2-pentanone was assumed to have non-carcinogenic effects similar to those of the ketone 2-butanone.

g The inhalation RfD for acetone was assumed to the same as the ingestion RfD.

h RfD values for three-ring and higher molecular weight PAH compounds were estimated from GRI, 1987 and from available RfD values.

i RfD values for compounds and routes of exposure were assumed to be the same as the RfD values for naphthalene.

j RfD values for inhalation were assumed to the same as for ingestion.

k RfD values for di-n-butyl phthalate were assumed to the same as those for bis(2-ethyl hexyl) phthalate.

l 4,6-dinitro-2-methylphenol was assumed to have noncarcinogenic effects similar to those of other methyl phenols.

m 2-nitroanaline was assumed to be as toxic as 4-chloroanaline.

n RfD values for DDE and DDD were assumed to the same as those for DDT.

o RfD values were selected based on a review of data presented in the ATSDR toxicological profiles; values were selected by applying an uncertainty factor of 100 or more to values developed from available animal data.

p Beta-BHC was assumed to have toxicity similar to gamma-BHC (lindane).

q An RfD value for lead was developed from the drinking water standard.

r The subchronic RfD for chromium was assumed to be equal to the chronic RfD.

The use of ten fold uncertainty factors is traditional. However, there may be situations where data support the application of smaller uncertainty factors. There is ongoing research directed at the use of physiologically based pharmacokinetics modeling for interspecies extrapolation. However, at this time, no specific guidance can be provided on the use of this method for developing better extrapolation (from animal to human) values for application to compounds of interest.

Modifying factors also contribute as divisors to the NOAEL or LOAEL and are usually one; however, in certain instances, the IRIS review group uses, based on collective professional judgment, a modifying factor to further adjust the reference dose. Confidence in the reference dose refers to a qualitative judgment of the confidence that the EPA review group had in the quality of the critical study, the supporting database, and the reference dose. A "low" confidence designation suggests that the reference dose is likely to change as new information becomes available.

The result of applying various multiples of 10 is that for many compounds the RfD is calculated to be a factor of 100 less than the NOAEL and for some (ethylbenzene) as much as a factor of 1000 less.

6.3.2 Toxicity Assessment for Carcinogenic Effects

This sub-section provides information that can be used to characterize the carcinogenic potencies of compounds of interest. Values for cancer potencies presented in Table 6-28, when combined with data on exposure, are used to make quantitative estimates of risk. The EPA's Cancer Assessment Group (CAG) in Washington D.C. is the primary source of information on the cancer potencies of selected compounds.

Cancer Potency Factors Used in Risk Assessment

A summary of the cancer potency factors that are used in the quantitative risk assessment is given in Table 6-28. The values provided in this table are used in the equations provided in Section 6.4 for estimating risk.

As a matter of EPA policy, estimates of the carcinogenic potency of compounds are based on the assumption that there are no threshold levels and that the response is linear with dose at low levels (at those encountered in the environment). Thus, there is always some calculable level of risk at every exposure concentration.

The "weight of evidence" regarding the potential carcinogenicity of a compound varies as a result of variations in the available test data, adequacy of studies, kinds of studies, and observed responses. The EPA has established weight-of-evidence categories for characterizing compounds (Table 6-29) and these are indicated in Table 6-28. In the subsequent discussion, the weight of evidence will be presented for selected compounds of interest.

TABLE 6-29 EPA WEIGHT-OF-EVIDENCE CATEGORIES FOR POTENTIAL CARCINOGENS		
EPA Category	**Description of Group**	**Description of Evidence**
Group A	Human Carcinogen	Sufficient evidence from epidemiologic studies to support a causal association between exposure and human cancer.
Group B1	Probable Human	Limited evidence of carcinogenicity in humans from epidemiologic studies.
Group B2	Probable Human	Sufficient evidence of carcinogenicity in animals, inadequate evidence of carcinogenicity in humans.
Group C	Possible Human	Limited evidence of carcinogenicity in animals; no data for humans.
Group D	Not Classified	Inadequate evidence of carcinogenicity in animals.
Group E	No Evidence of	No evidence for carcinogenicity in at least two adequate animal tests or in both epidemiologic and animal studies.

The carcinogenic potency of a compound can be expressed in a variety of ways. In this document, the potency is expressed as a "potency factor". The potency factor as calculated by the EPA CAG is usually the 95% statistical upper bound on the slope of the dose-response curve in the low-dose linear portion as estimated by the multistage linearized model. The response is the lifetime risk of cancer in humans as a function of an average daily exposure level (mg/kg/day) occurring throughout that lifetime. The slope or potency factor is expressed in units of $(mg/kg/day)^{-1}$. Cancer potency factors for some of the compounds of interest have been estimated by EPA's Cancer Assessment Group (CAG) and are available in EPA's Health Effects Summary document.

6.3.3 Uncertainties Related to Toxicity Information

One of the difficulties in carrying out dose-response assessments is that the compounds of interest occur as complex mixtures with varying composition within and among sites. Information on the health effects of individual compounds may not be directly applicable to that compound as it exists as part of a complex mixture. However, in the absence of information to the contrary the compound-specific information is generally used.

It is suggested that until methods are developed to directly assess the toxicity of mixtures or until information is available on synergy and antagonism among compounds, the toxicity of compound mixtures be based on the additive toxicities of the individual compounds. This was done for the present analyses.

Matrix Effects

Many compounds are known to be strongly adsorbed to the soils or, in the case of metals, may be complexed. The "bioavailability" of the compounds in these complex soil media is quite different from that for these same compounds when administered in health studies (such

as laboratory animal research). In many health studies, the pure compound may be fed to the test animal in feed or as an oil; in other studies solvent extractions of the compounds may be applied to the skin.

The point is that experimental applications of compounds in laboratory studies do not mimic the conditions that occur on sites. Therefore, the "potency" or RfD values that are obtained from experimental studies are likely to overestimate the potential health effects of a compound as it occurs in a soil medium. The difference between experimental applications and those that occur in real world exposures is referred to here as a "matrix effect".

The greatest potential for overestimation of health effects involves potential exposure to contaminated soils. Health effects associated with direct contact or incidental ingestion of contaminated soil is likely to be overestimated if matrix effects are not taken into account.

Interpretation of RfD

Because of the margin of safety built into the RfD value, exceedence of the number has no immediate meaning with regard to specific health effects, the frequency of effects, or the magnitude of effects. However, exceedence of the number should serve as an indicator that the potential for unacceptable exposure does exist and precautions should be taken to limit exposure.

Form of The Compound

The toxicity of a compound (e.g., chromium) varies depending on the "form" or valence state of the compound. Therefore, it may be important that the risk assessor have information on the form of the compound present. However, this is very seldom the case because most analytical results are presented by reporting only total detected quantity of the compound present not its chemical state. Typically, chromium may occur in one of two forms: Cr III and Cr VI. The Cr VI state may be carcinogenic via the inhalation route. Exposure point concentrations do not identify the form of the compound and are based on only the presence of compound. The worst case was used in this risk assessment because the most toxic form of a compound of interest was assumed present if detected.

6.4 Risk Characterization

Risk characterization involves the integration of health effects information developed as part of the toxicity assessment (Section 6.3) with estimates of exposure developed as part of the exposure assessment (Section 6.2) to provide an estimate of risk. Qualitative estimates are provided for Step I sites. Quantitative estimates are usually presented either in probabilistic terms (e.g., one in a million) or with reference to specific benchmark or threshold levels. An important component of risk characterization is an assessment of the sources of uncertainty associated with the estimate. Because risk estimates tend to be "soft" and based on a combination of measurements and assumptions, it is important that information on sources of uncertainty be provided. The key elements of risk characterization are:

- estimation of human dose;
- estimation of risk;

- presentation of risk; and
- uncertainty analysis.

Qualitative assessment is provided for Step I sites and quantitative assessment for Step II sites in the following sections.

6.4.1 Step I Sites

Qualitative assessments for Step I sites are provided below.

Construction Battalion Unit (CBU) Drum Storage Area

Risks appear to be negligible because there is limited activity in this area and chemical concentrations are low.

Rubble Fill at Bunker A-86

Activity in this area is negligible. However, the site exhibits elevated levels of PAHs and arsenic which could cause a potential health risk if exposure were to occur under some future use condition. If site conditions change in the future, there may be some risk associated with the contaminants present.

Torpedo Shops

The potential exposure scenario relates to utility repair/installation within the former septic system area. Based on the relatively low levels of chemicals present at the site, and the health risk calculations made for utility workers at other sites (e.g., Area A landfill, Lower Subase), the health risks associated with this exposure scenario are qualitatively predicted to be negligible. The risk due to ground water quality degradation was previously discussed. A recommendation has been made to expand the investigation at this site to identify a potential source near the Torpedo Shop buildings. Further health risk assessment would be required.

Goss Cove Landfill

Future construction and excavation activities in the parking lot could result in some risk to workers. There is some potential that vapors from within the landfill could enter the museum building; however, this possibility has not been investigated. There is also a possibility that children could come in contact with sediments in Goss Cove. At present there are no data on the levels of contaminants in these sediments.

Over Bank Disposal Area Northeast (OBDANE)

This site appears to pose a negligible risk based on the lack of activity and the low concentrations of chemicals.

Spent Acid Storage and Disposal Area

There may be some risk to construction or utility maintenance personnel associated with contact with contaminated subsurface soils if they do not follow appropriate health and safety procedures. Based on similar levels of lead at DRMO, and the associated risk for construction workers in that area (Hazardous Waste Storage Building Construction), the risk to construction workers at this site could be above acceptable levels. Appropriate health and safety precautions should be followed during tank removal to confirm that no contamination is present.

Former Gasoline Station

No risks are identified under existing conditions based on available data. Appropriate health and safety precautions should be followed during tank removal to confirm that no contamination is present.

6.4.2 Estimation of Risk at Step II Sites

Estimates of risks are developed for individual carcinogens and non-carcinogens as well as for mixtures. The quantification of potential risks is based on the guidance published by the EPA on estimating risks of carcinogenic and non-carcinogenic mixtures (50 FR 1170 et seq., 9 January 1985). Risk estimates for compound mixtures are based on the assumption of additivity unless there is information to the contrary.

In accordance with current EPA guidance, the assumption of additive effects is made for non-carcinogens in order to calculate a Hazard Index Ratio, i.e., the ratio of exposure dose to RfD value as appropriate. However it is also recognized, as stated in the EPA's guidance, that this may not be a good assumption because of differences in target organs, application of uncertainty factors, and differences in modes of actions of compounds. However, the Hazard Index Ratio is currently identified in EPA guidance as a means of identifying situations where additional attention should be given.

6.4.2.1 Risk Estimation for Potential Carcinogens

The equation for estimating "Incremental Lifetime Risk" from exposure to carcinogens, by compound and by pathway, is:

Risk = Cancer Potency Factor X ADD (life)

where:

Risk (Incremental Lifetime Risk) = Probability that person will manifest cancer, during lifetime, from the particular exposure condition;

Cancer Potency Factor (CPF) for a compound is the slope of the dose/response curve for cancers estimated for the specific Compound of Interest [(mg/kg/day)-1]; different CPF values may be estimated for ingestion and inhalation.

The "total" risk posed by a mixture of carcinogens is estimated as the sum of the risks for the individual compounds. Cancer potency factors may differ for oral and inhalation routes of exposure. Thus, the calculations of risk must be made for the different exposure routes first and then combined. Cancer potency factors have not been published by EPA for dermal uptake. Generally, the potency factor associated with oral route has been used for exposure via dermal contact. It is reasoned that the pharmacokinetics associated with dermal uptake would be more similar to uptake via the gut than via the lung. However, dermal uptake is probably quite different than either uptake via the gut or the lung.

6.4.2.2 Risk Estimation for Non-Carcinogenic Effects

As stated previously, non-carcinogenic effects are evaluated by using the Hazard Index Ratio. The equation for estimating Hazard Index Ratios for exposure to non-carcinogens, by compound and by pathway, is:

Ratio = ADD(time)/RfD

where:

Ratio = Average Daily Dose for a specified averaging time (a year) relative to the Reference Dose (RfD); depending on the nature of the effect and the exposure period being considered.

The RfD value used for chronic exposures was used for exposure situations of seven years or more and RfD value for subchronic exposures was applied to exposure periods less than seven years.

In the absence of specific information on possible synergy or antagonism between or among compounds, a total Hazard Index Ratio is estimated by summing the ratios for each compound. Individual or summed ratio values in excess of "1" are considered as benchmarks for indicating the potential for some, generally sublethal, health effects. However, since by definition a ratio of 1 is acceptable, the question always remains, "At what point does the exposure become unacceptable or what are the real risks associated with hazard ratio indices in excess of "1"? Estimates of risk were calculated using computer-based spreadsheets.

6.4.3 Presentation of Risk

All calculations of risks are presented with summary tables in Appendix E. In the case of human health effects associated with exposure to potential carcinogens, risk estimates are expressed as the lifetime probability of excess cancer associated with the given exposure (e.g., a lifetime incremental risk of one in ten thousand).

Incremental cancer risk estimates are illustrated using simple bar charts (Figures 6-2 to 6-5). These figures include horizontal lines at the 1.0E-4 (one in ten thousand) and 1.0E-6 (one in the million) levels. Risks above 1.0E-4 are described here as "generally unacceptable for environmental risk to humans, and risks below 1.0E-6 are described here as generally considered de minimus for environmental risk to humans. The word "environmental" is underscored

Figure 6-2 Lifetime Cancer Risks Utility or Construction Workers

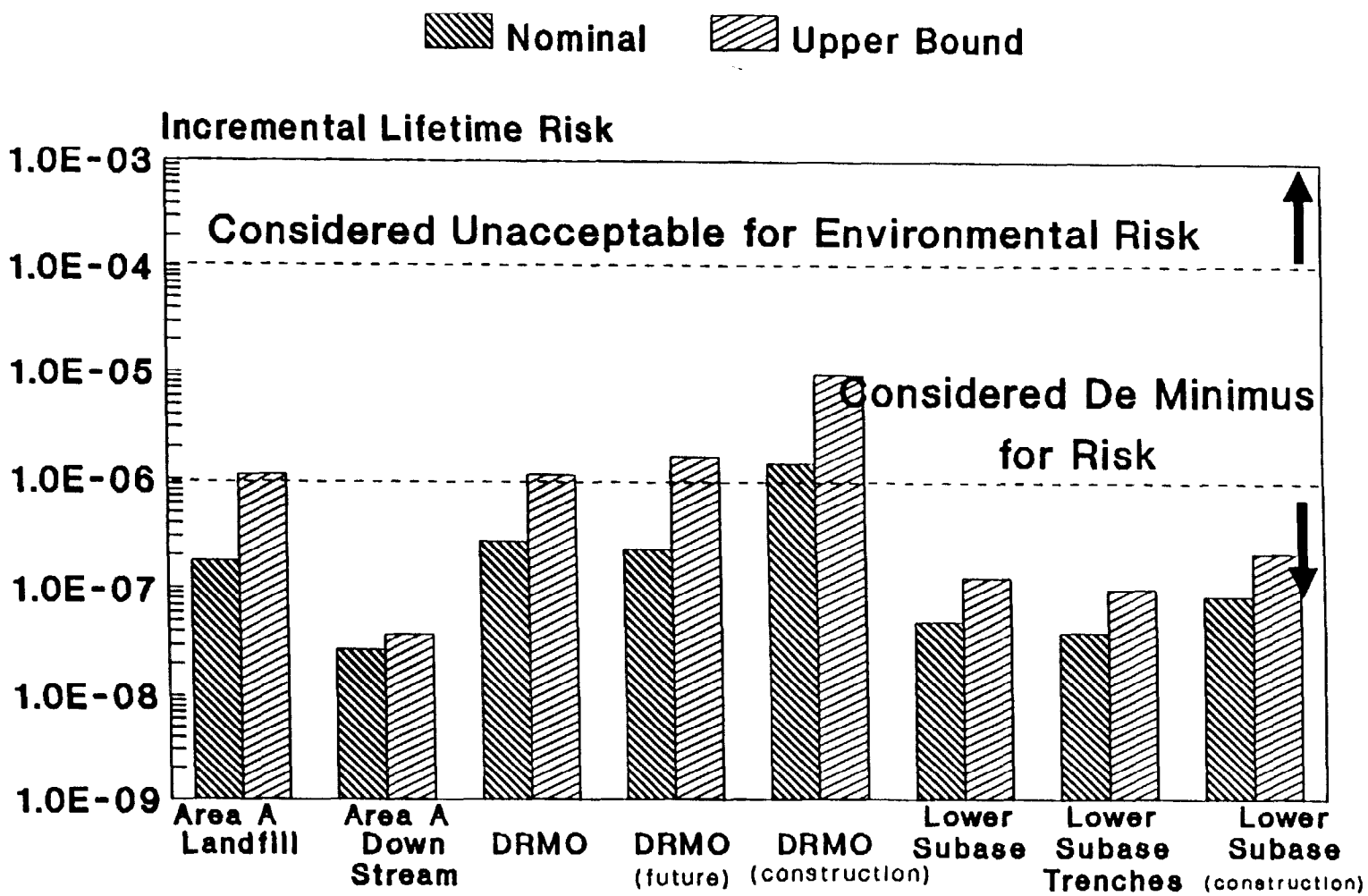


Figure 6-3 Lifetime Cancer Risks Subase Children

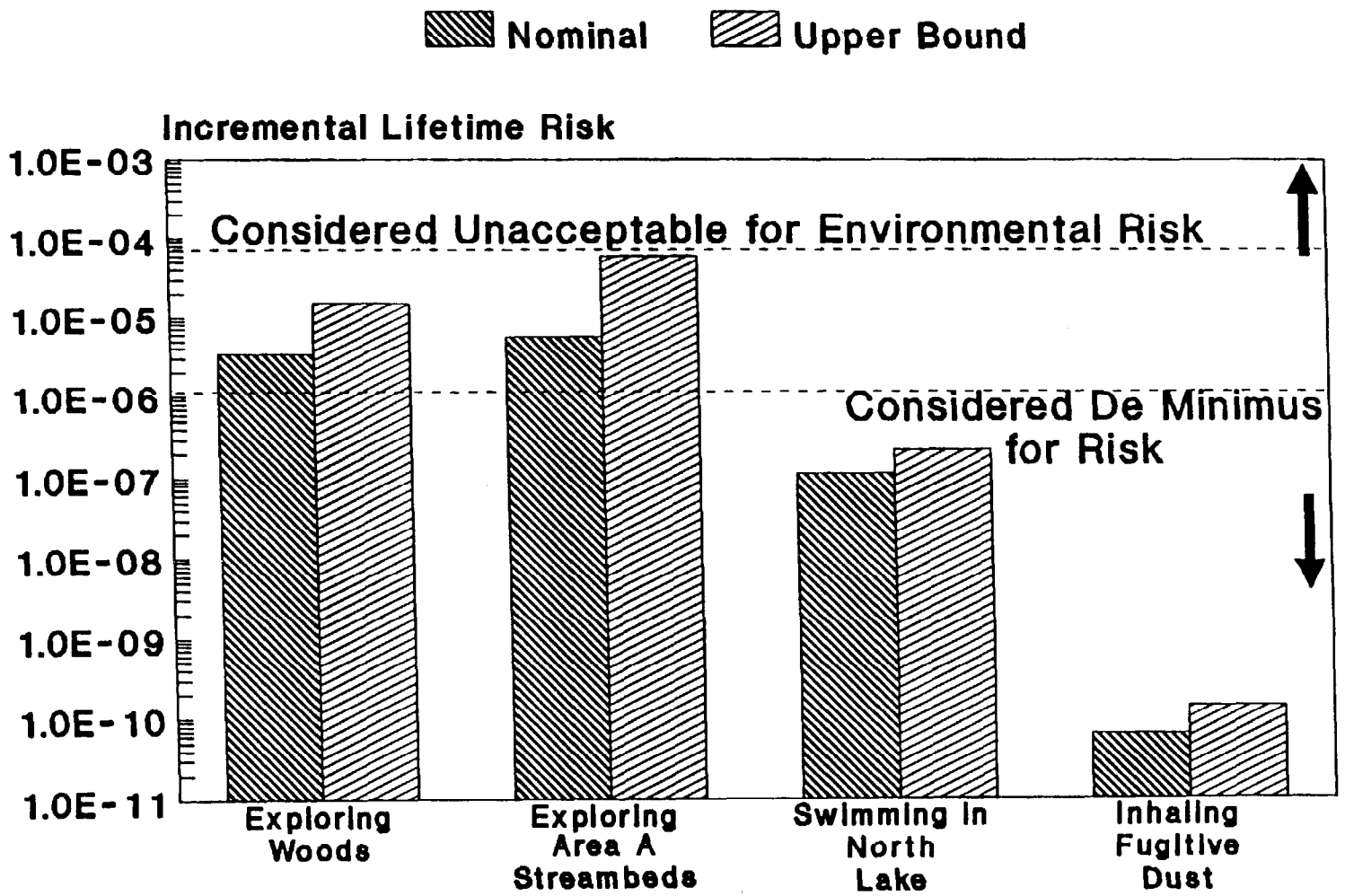


Figure 6-4 Lifetime Cancer Risks Offsite Receptors

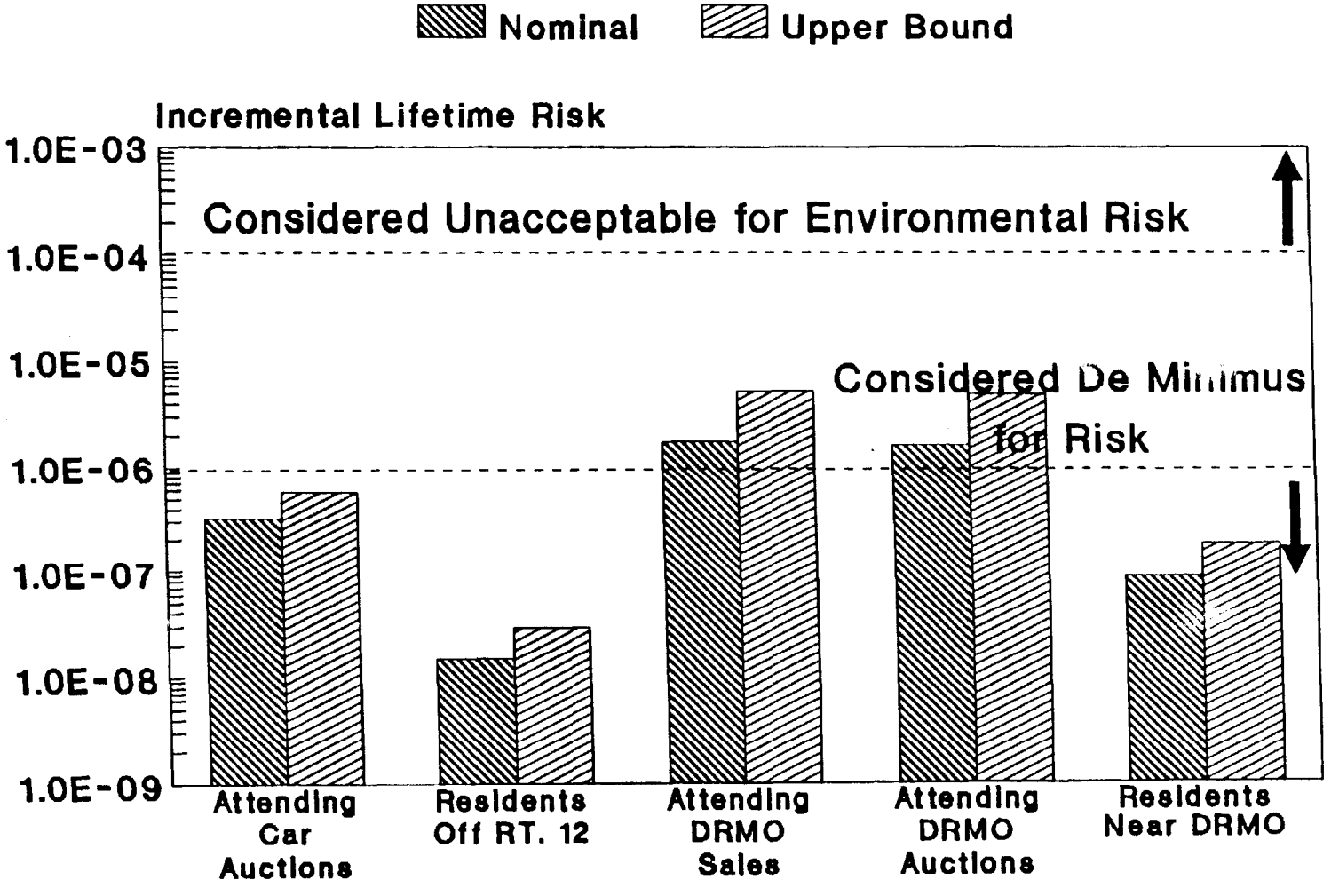
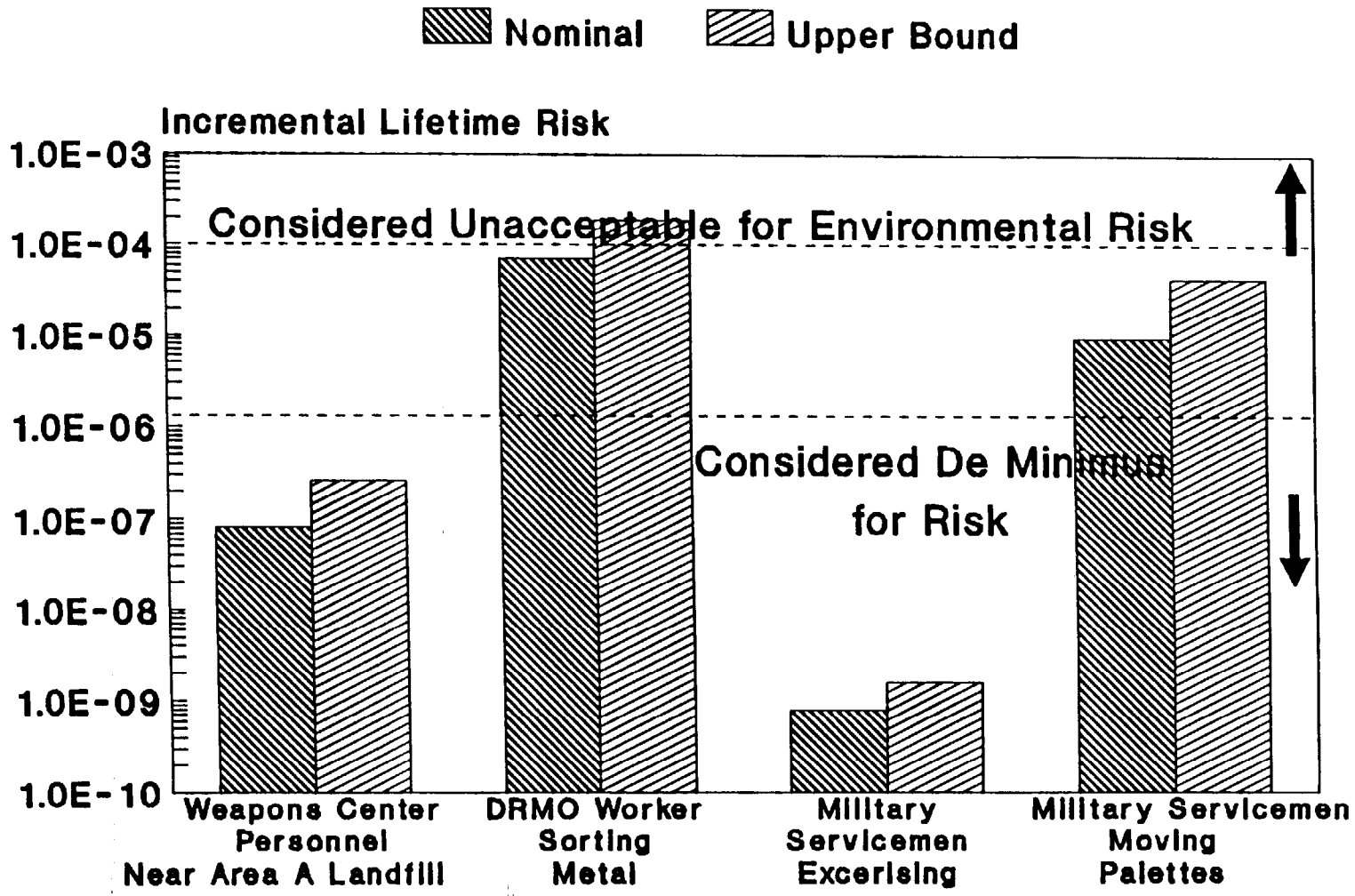


Figure 6-5 Lifetime Cancer Risks Onsite Receptors



because often in occupational settings, risks are viewed differently than for settings in which the exposures are not work-related or are involuntary. These particular risk levels (1.0E-4 and 1.0E-6) are similar to those cited in a recent article by Travis, et al. (1987), entitled Cancer Risk Management. Basically, these authors observed that at an individual risk level of approximately one in one million, no regulatory action is taken (a de-minimus level) while at a risk level of four in one thousand regulatory action was always taken. In between these risk levels, regulatory action appeared to be based on a combination of factors including the size of the exposed population and cost effectiveness considerations.

Depictions of Hazard Index Ratios are given in Figures 6-6 to 6-9. As can be seen, a horizontal line has been drawn at "1". As noted earlier, ratios in excess of "1" can be viewed as benchmarks with regard to the potential for chronic, generally sublethal, effects.

6.4.3.1 Area A Landfill

Utility Worker Repairing Storm Sewers in Area A Landfill

The hazard indices do not exceed the benchmark established by EPA (Figure 6-6). For the nominal case and upper bound case, the hazard indices for oral and dermal contact with soils are at least three orders of magnitude below the EPA benchmark of "1".

The carcinogenic risk associated with soil contaminant exposure was below the de minimus level of one in one million for the nominal case and slightly above this level for the upper bound case (Figure 6-2).

Based on the results of these analyses risks to these workers are judged to be low to negligible.

Weapons Center Personnel Exposed to Fugitive Dust from Area A Landfill

Systemic health risks and incremental risks of cancer are all below (within) levels considered acceptable (Figures 6-5 and 6-9). Based on the results risks to these workers associated with fugitive dusts are negligible.

Military Servicemen Moving Palettes with Area A Landfill

No systemic health risks were identified for these workers (Figure 6-9). Lifetime cancer risks were at and above one in one hundred thousand (1E-5) for nominal and upper bound exposures respectively (Figure 6-5). The estimated risk was due to the presence of PCBs in surface soils. The risks fall within EPA's range of 1E-6 to 1E-4. There is uncertainty in the risk estimates based on the size and nature of the exposure population as well as the exposure assumptions.

Military Servicemen Exposed to Fugitive Dust While Engaged in Recreational Activities Near Area A Landfill

Risks to this exposure group are negligible (Figure 6-5 and 6-9).

Figure 6-6. Hazard Indices (Health Risk) Utility or Construction Workers

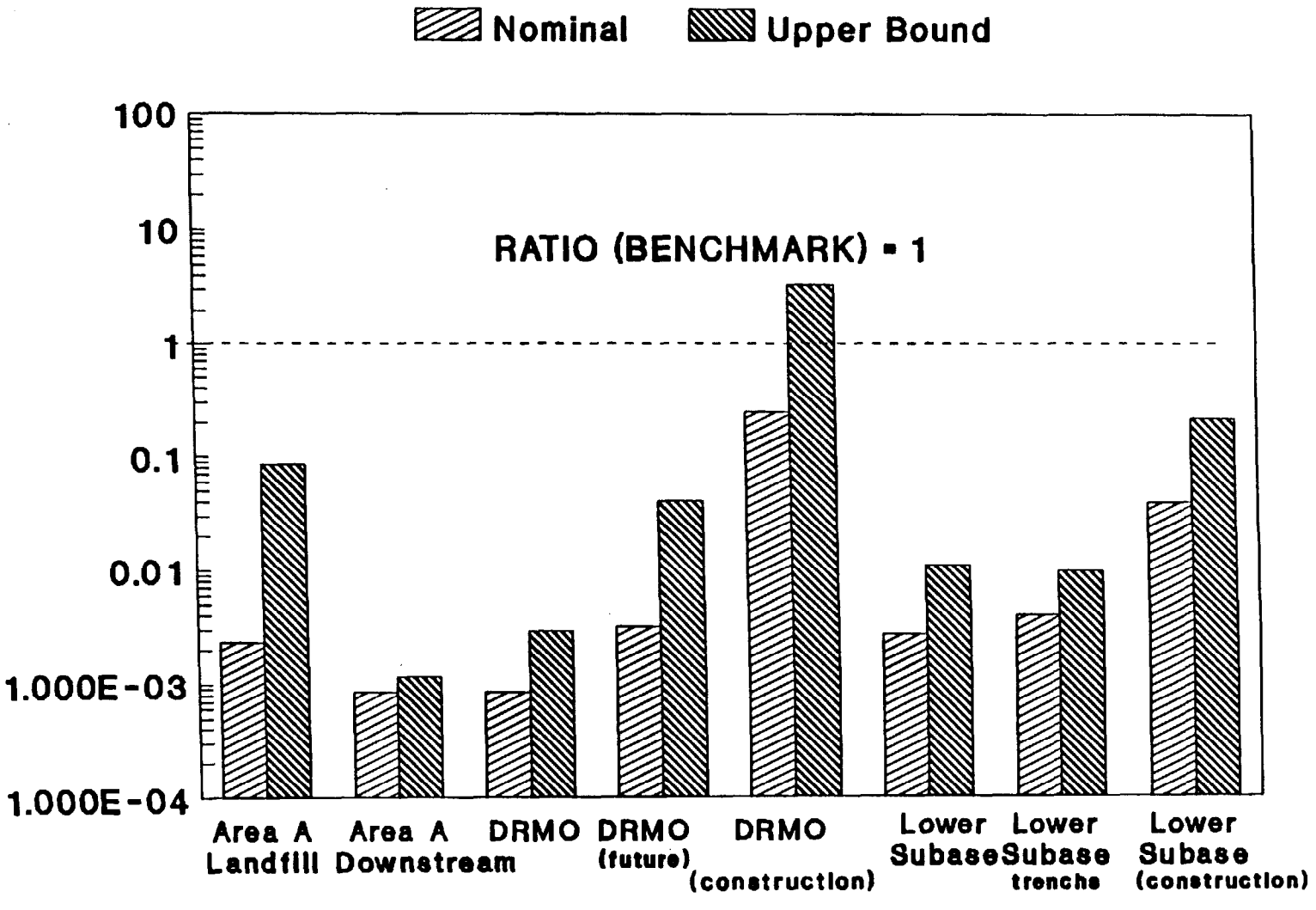


Figure 6-7 Hazard Indices (Health Risk) Subase Children

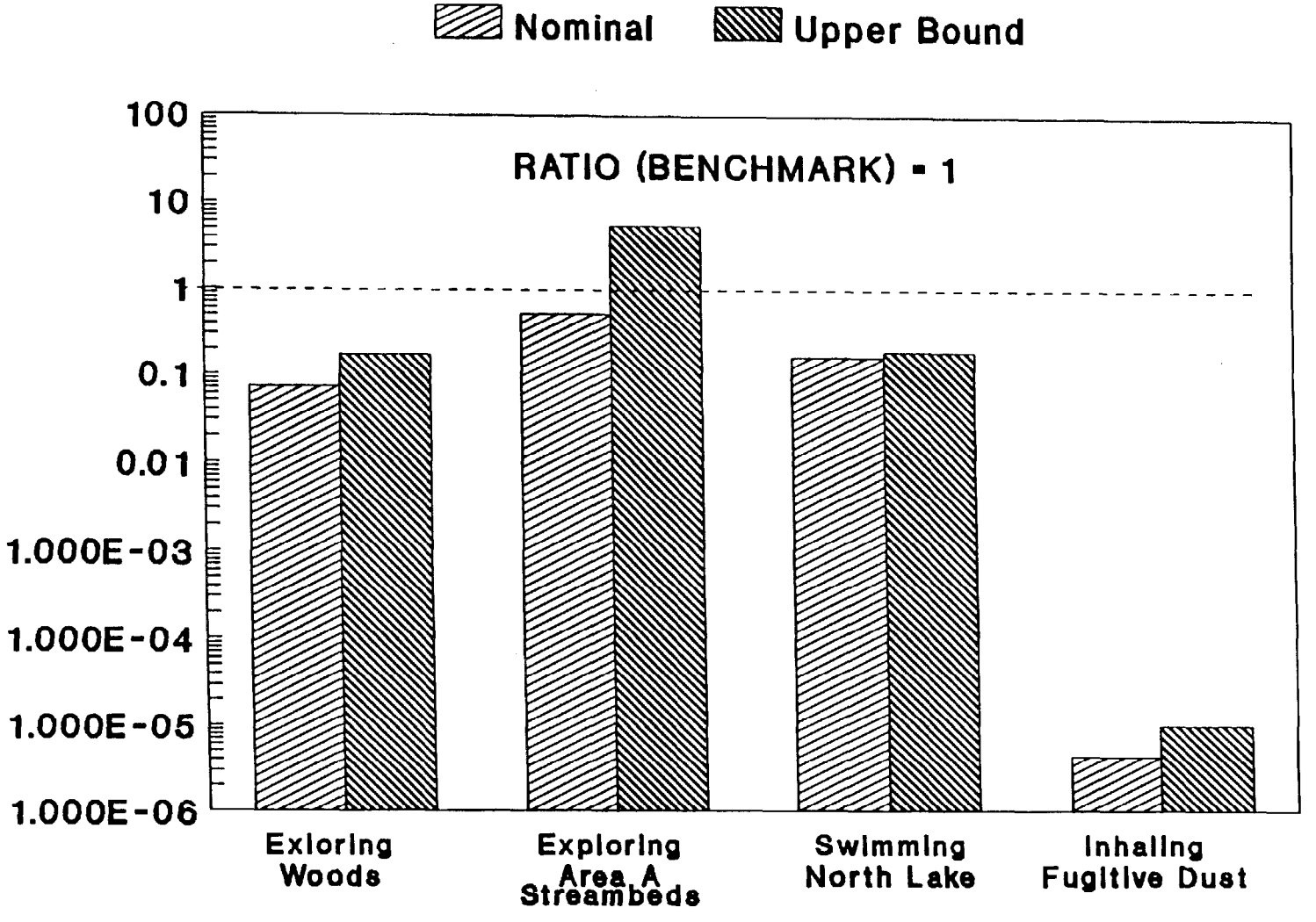


Figure 6-8 Hazard Indices (Health Risk) Offsite Receptors

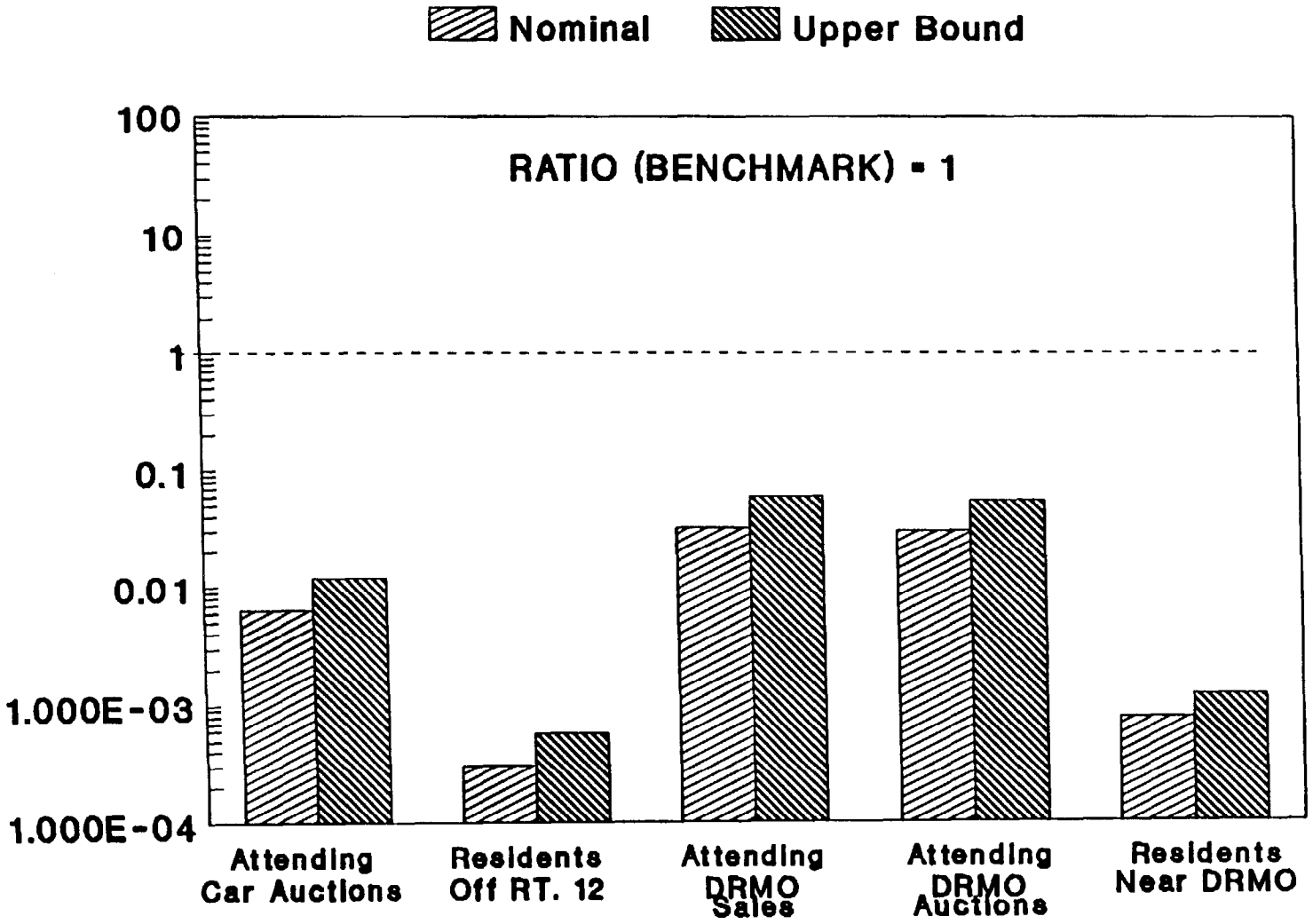
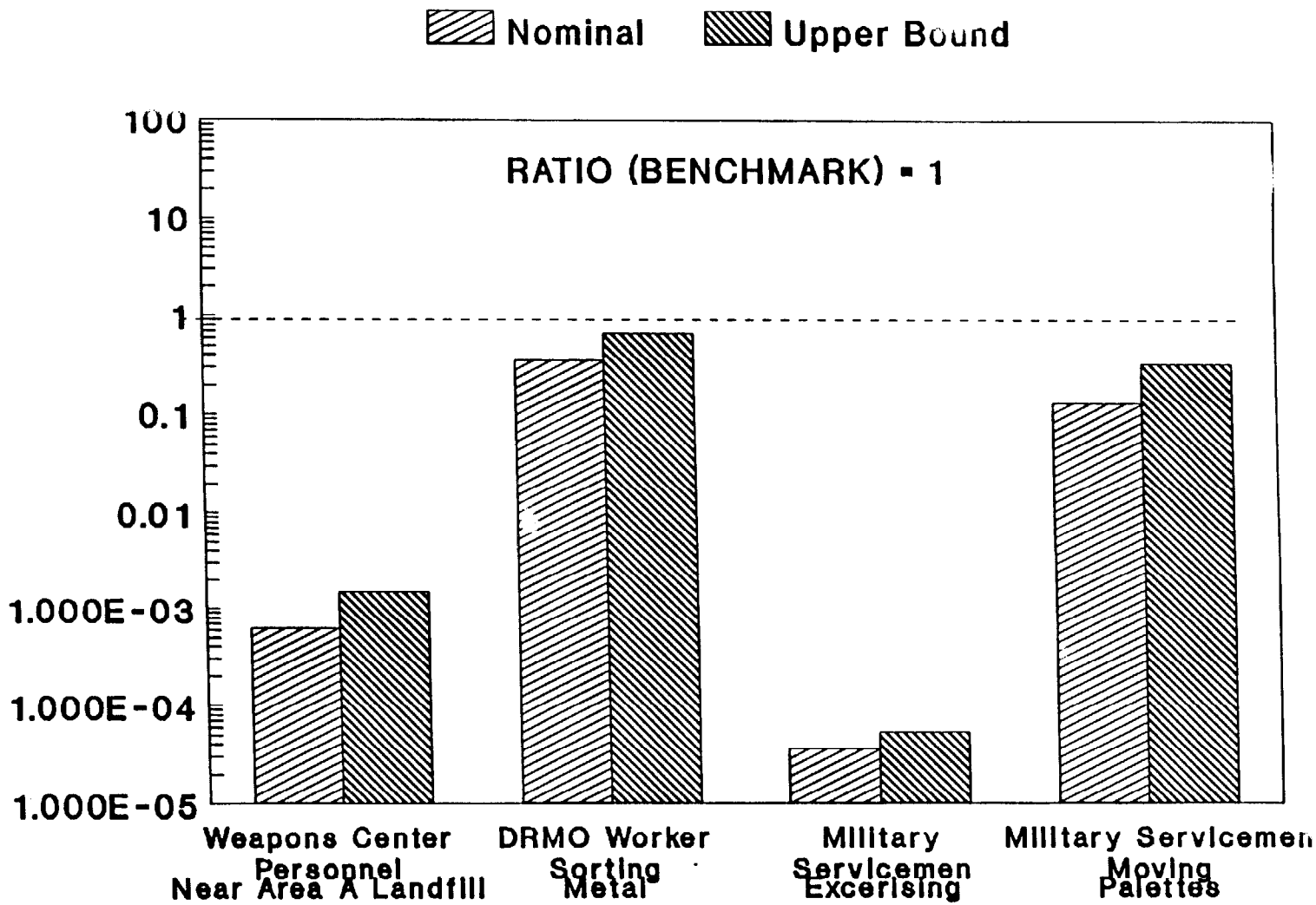


Figure 6-9 Hazard Indices (Health Risk) Onsite Receptors



Groton/Ledyard Residents Exposures to Fugitive Dust from Area A Landfill

Risks to offsite residents due to the transport of fugitive dusts are judged to be negligible based on comparisons with EPA's suggested benchmarks (Figures 6-4 and 6-8).

Citizens Attending Car Auctions in Deployed Parking

Risks to people participating in car auctions are estimated to be negligible (Figures 6-4 and 6-8).

6.4.3.2 Area A Downstream

Subase Children Exploring the Woods within Area A Wetland, Landfill, and Downstream Watercourses

Systemic (noncarcinogenic) health risks are estimated to be negligible for this exposure group (Figure 6-7). However, nominal lifetime cancer risk exceeded one in one million (1E-6) and the upper bound estimate exceeded one in one hundred thousand (1E-5) (Figure 6-3). The carcinogenic risk is due to the presence of PCB Arochlor 1260 through oral or dermal contact with soils.

Subase Children Exploring Streambeds and Area A Wetland

No systemic health risks were estimated for the nominal case but the upper bound case did exceed EPA's benchmark of "1" for a hazard index (Figure 6-7). Estimated carcinogenic risks are above the de minimus environmental carcinogenic risk limit of 1E-6 for both the nominal and upper bound cases (Figure 6-3). The upper bound case exceeds a risk level of one in one hundred thousand (1E-5). The compounds that contribute to the carcinogenic risk through ingestion and dermal contact with the sediments are the pesticides.

Subase Children Swimming in North Lake

Swimming in North Lake does not pose any potential health risks as a result of contact with the water or playing on the beach (Figure 6-3). Incremental cancer risk estimates are considered de minimus for environmental risk (Figure 6-7).

Utility Worker Repairing Utility lines in Area A Downstream

Systemic (noncarcinogenic) and carcinogenic risks are estimated to be negligible to these workers (Figures 6-2 and 6-6).

6.4.3.3 Defense Reutilization and Marketing Office

Citizens Attending Monthly Auctions at DRMO

Systemic (noncarcinogenic) risks associated with this activity are negligible (Figure 6-8). Lifetime cancer risks did exceed one in one million (1E-6) for the nominal and upper bound

cases (Figure 6-4). However, these estimates are considered to be overestimates because of a conservative assumption made concerning the daily incidental ingestion of soils (100 mg/day). It is very unlikely that individuals involved in these auctions would ingest this quantity of soil. It is more likely that the amount of incidental soil ingestion is an order of magnitude less. This would result in risk estimates below the de minimus level.

Citizens Attending Public Sales at DRMO

Noncarcinogenic risks associated with this activity are negligible (Figure 6-8). However, as with the monthly auctions, lifetime cancer risks exceeded the de minimus level of one in one million (Figure 6-4). Again, this was due in part to a conservative assumption regarding soil ingestion as discussed above.

Navy Workers Sorting Scrap Metal

Systemic (noncarcinogenic) risk(s) related to this activity are negligible (Figure 6-9). However, incremental lifetime risks of cancer approached and exceeded the one in ten thousand (1E-4) level for the nominal and upper bound cases (Figure 6-5). Compounds that contributed to the risk included PCBs, carcinogenic PAH, and the metal beryllium.

Utility Worker Exposed to Soils and Ground Water in DRMO Under Current Conditions

For this exposure scenario, the noncarcinogenic and carcinogenic risks were estimated to be negligible (Figures 6-2 and 6-6).

Utility Worker Exposed to Soils and Ground Water In DRMO Under Future Conditions

For these exposure scenarios, the noncarcinogenic and carcinogenic risks were estimated to be negligible (Figures 6-2 and 6-6).

Construction of A Hazardous Waste Storage Facility

There may be systemic health (noncarcinogenic) risks associated with this proposed construction activity (Figure 6-6) if health and safety measures are not followed. These are due to the presence of lead in soils. The maximum lead exposure point concentration ingestion of soil. The maximum exposure concentration is 8,100 mg/kg lead in soil from a well location, 6MW3 2-4 feet.

The nominal carcinogenic risk estimate is close to the de minimus level of one in one million (1.6E-6) and the upper bound estimate exceeds this level (Figure 6-2). The probability of carcinogenic risk is attributed to the presence of PCBs in soil.

Ledyard Residents Exposures to Fugitive Dust from DRMO

Systemic (noncarcinogenic) and cancer risks are estimated to be negligible (Figures 6-4 and 6-8).

Subase Children Exposed to Fugitive Dust from DRMO and Area A Landfill

Systemic (noncarcinogenic) and cancer risks are estimated to be negligible (Figures 6-5 and 6-7) via exposure to fugitive dusts.

6.4.3.4 Lower Subase

Utility Worker Exposed to Soils and Ground Water in Lower Subase Vaults

Systemic (noncarcinogenic) health and incremental cancer risks are judged to be negligible (Figures 6-2 and 6-6).

Utility Worker Exposed to Soils and Ground Water In Lower Subase

Systemic (noncarcinogenic) health and incremental cancer risks are judged to be negligible (Figures 6-2 and 6-6).

Future Construction of Buildings in Lower Subase

Systemic (noncarcinogenic) health and incremental cancer risks are judged to be negligible (Figures 6-2 and 6-6).

6.4.4 Uncertainties in Estimates

Because the toxicity values (Potency Factors, RfDs, AICs, and AISs) published by EPA are based on exposure dose and not on absorbed dose, it is not appropriate to estimate the efficiency of absorption via the gut and the lung, i.e., the potencies already incorporate information on those effects. However, there may be certain "matrix effects" associated with differences between media in which the compound is received. Such matrix effects can alter the bioavailability of the compound. There is little quantitative information concerning these matrix effects and they are generally ignored. This results in a conservative estimate of dose.

Uncertainty Analysis

Uncertainty analyses is an important element of risk characterization. Results of such an analysis provide insights into the confidence of the results. Uncertainty analysis typically includes:

- assessments of the sources of uncertainty, the soundness of assumptions and the extent to which they were made in a conservative manner, and other qualifying statements that may be appropriate; and

- sensitivity analyses of key assumptions or input parameters.

Uncertainty in Health Effects Estimates

There are uncertainties associated with both the estimates of risk from carcinogens and

non-carcinogens. The difficulty in extrapolating from data on high doses to animals to low doses in humans is well recognized and is discussed in detail in various toxicological texts.

The EPA is attempting to standardize its approach to determining RfDs. The RfD Work Group within EPA has developed a systematic approach to summarizing its evaluations, conclusions, and reservations regarding RfDs in a "cover sheet". The cover sheet includes a statement on the confidence the evaluators have in the stability of the RfD: high, medium, or low. High confidence indicates that the RfD is unlikely to change in the future because there is consistency among the toxic responses observed in different sexes, form, study designs, or in dose-response relationships, or the reasons for differences, if any, are well understood. Often, high confidence is given to RfDs that are based on human data for the exposure route of concern, because in such cases the problems of interform extrapolation are avoided. Low confidence indicates that the RfD may be especially vulnerable to change if additional chronic toxicity data are published on the compound, because the data supporting the estimation of the RfD are of limited quality and/or quantity.

The EPA or consultants following agency policy do not simply use the NOAEL, but develop from it a risk reference dose or "safe threshold" by dividing this NOAEL by a series of uncertainty factors, resulting in a much lower concentration for the purpose of defining a RfD. The RfD has been viewed as the amount of a compound to which a person can be exposed on a daily basis over an extended period of time (usually a lifetime) without suffering a deleterious effect.

The result of the application of uncertainty factors is that for many compounds the RfD is calculated to be 100 times to 10,000 times less than the NOAEL.

Because of the uncertainty factor (margin of safety) built into the RfD value, exceedence of the number has no immediate real meaning with regard to specific health effects, the frequency of effects, or the magnitude of effects. However, exceedence of the number should serve as a warning that the potential for unacceptable exposure does exist and precautions should be taken to limit exposure.

7.0 ECOLOGICAL RISK ASSESSMENT

7.1 Introduction

This section presents the findings of the ecological risk assessment performed for the Naval Submarine Base - New London (NSB-NLON) in Groton, Connecticut. NSB-NLON is on the east bank of the estuarine portion of the Thames River.

The ecological risk assessment evaluates the probable migration pathways of site contaminants to both aquatic and terrestrial receptors. Risks to ecological receptors are evaluated using observations of biological conditions at the site, measurements of contaminants in biota and environmental media, and predictive models of bioaccumulation. Measured or estimated exposure concentrations are compared with literature values of levels not known to produce toxic effects or with EPA Ambient Water Quality Criteria, where appropriate, to assess risks to site biota.

7.1.1 Approach and Organization

This assessment addresses Step I and Step II sites separately. However, the assessment approach for some of these sites is the same since they potentially affect the same environmental receptors, aquatic biota in the Thames River. These sites are also developed; therefore, this is the only exposure pathway for contaminants in these areas to reach environmental receptors. The Step I site evaluated in this manner is the Goss Cove Landfill. Step II sites addressed in a similar fashion are the Defense Reutilization and Marketing Office (DRMO) and the Lower Subase. Risks to both aquatic and terrestrial receptors are addressed for Area A sites.

The approach to risk assessment used in this section follows EPA guidelines (EPA,1986). The ecological risk assessment section of the report is divided into these main headings:

- Hazard Identification
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

The Hazard Identification (Section 7.2) evaluates the data to be used in the risk assessment and selects compounds of interest. Since this work was discussed in the Human Health Risk Assessment (Sections 6.1.1 and 6.1.3), this section of the report only addresses these issues where they pertain specifically to ecological risks.

The Exposure Assessment characterizes environmental receptors to site contamination, identifies exposure pathways, and quantifies those exposures. The sites were visited to characterize the environmental receptors (Section 7.3.1). Section 7.3.2 identifies exposure pathways in Step I and Step II sites. The exposure concentrations are quantified in Section 7.3.3. For some exposures, direct measurements of contaminants in environmental media were used (e.g. metals concentrations in soils for plant exposures or surface water concentrations in ponds for fish exposures). Sample locations for Area A are shown on Plate 6-1. Other exposures were quantified via simple analytical models. Examples of these quantification

methods include estimation of soil moisture concentrations from soil concentrations for terrestrial invertebrate exposures and use of a simple analytical bioaccumulation model to estimate exposures to birds and mammals due to ingestion of terrestrial invertebrates. A discussion of the uncertainty associated with these estimates is included (Section 7.3.4).

Exposure concentration criteria are discussed in the Toxicity Assessment (Section 7.4). Where appropriate, EPA Ambient Water Quality Criteria (EPA, 1986) were used to assess risks. For some organisms, such as soil invertebrates and small birds and mammals, we developed criteria based on toxicity information available in the literature.

The Risk Characterization (Section 7.5) compares measured or estimated exposure concentrations to toxicity-based criteria and assigns a relative magnitude of risk to individual organisms of certain receptor species (e.g., soil invertebrates, small birds and mammals). These results are discussed as to their ecological significance based on scientific judgement and observations at the site.

7.1.2 Overview of Environmental Receptors

Environmental receptors of contaminants from the Groton site consist of nearby ecosystems and their resident and visiting biota. This section briefly describes the environmental receptors of contaminants from the Step I and Step II sites. Section 7.3.1 provides an in-depth characterization of ecological receptors, particularly those in the Step II sites.

Most of the Step I sites consist primarily of developed property (Torpedo Shop, Spent Acid Storage and Disposal Area, and Former Gasoline Station). As such, they do not comprise a natural environment, and it is not necessary to assess ecological risks for these sites. Compounds of concern were detected in environmental media at the CBU Drum Storage Area and OBDANE sites at very low concentrations, and therefore these sites were excluded from further assessment. The Rubble Fill at Bunker A-86 site was only qualitatively evaluated from a human health risk standpoint.

The Step I site that may pose a potential ecological risk is the Goss Cove Landfill. It is on the shore of the Thames River estuary, and ground water from this site discharges to the Thames River. The primary environmental receptors in this portion of the Thames River are benthic organisms and fish. This risk is discussed in Section 7.5.1.

Two types of Step II sites were treated separately in this assessment. The developed sites that may pose an ecological risk due to the discharge of contaminated ground water to the Thames River, the Defense Reutilization and Marketing Office (DRMO) and the Lower Subase, were treated similarly to the Goss Cove Landfill. Environmental receptors at these sites consist of fish and benthic organisms near the point of discharge in the Thames River.

Environmental receptors in Area A consist of biota in the Area A Wetland, Over Bank Disposal Area, and Downstream Watercourse area. The biota in these areas are plants, invertebrates, fish, amphibians, birds, and mammals that reside in this area, migrating birds that visit the area seasonally, and mammals and birds that visit the area occasionally. These receptors may be exposed to contaminants in surficial soils, contaminants in ground water where it may

seasonally discharge to the ground surface, and contaminants in the surface water and sediments of ponds and streams. Higher trophic level organisms in the food web may be exposed to contaminants via bioaccumulation in lower level organisms such as soil invertebrates in the wetland and benthic invertebrates in the ponds and streams.

7.2 Hazard Identification

7.2.1 Evaluation of Data/Selection of Compounds of Interest

The data evaluation and selection of compounds of interest for the ecological risk assessment were the same as for the human health risk assessment. Sections 6.1.1 and 6.1.3 discuss these processes. Table 6-2 in Section 6.1.3 presents the compounds of interest. The compounds of interest were selected based on their detection in all media. However, some of the organic compounds of interest posed no ecological risk because they were not detected in media to which environmental receptors may be exposed. The only organic compounds assessed for the Step I site, Goss Cove Landfill, were those detected in ground water at this location (refer to Table 4-14). Compounds not detected in soil, sediment, surface water or ground water at Step II sites include the volatile organic compounds chloromethane, 1,2-dichloroethane, tetrachloroethane, 1,1,2-trichloroethane, and 4-methyl-2-pentanone; the semi-volatile organic compounds2-methyl-naphthalene,dibenz(ah)anthracene,di-n-butylphthalate,2,4-dimethylphenol, 4-methylphenol, phenol, and N-nitrosodiphenylamine; the pesticides beta-BHC, endrin, endrin ketone, and methoxychlor, and the PCB Arochlor 1254.

As in the human health risk assessment, if a compound was not detected in an exposure medium, the exposure concentration for a non-detectable level was assumed to be zero. If the compound was detected in at least one sample in that medium, the non-detectable concentration was estimated as one half the average sample quantitation limit (Refer to Section 6.1.1 of the Human Health Risk Assessment).

7.2.2 Contaminated Media

Compounds of concern were detected in soils, sediments, surface water, and ground water. The ecological risk assessment addresses wetland soils/sediments separately from stream, pond, and river sediments. This distinction is based on physical and biological characteristics. Soils/sediments in the wetlands may be saturated periodically, but for most of the year they are not underwater and retain less than 100% soil moisture. They are also likely to have a higher organic carbon content than pond or stream sediments. Wetlands soils/sediments support a different invertebrate community than do pond or stream sediments. For this reason and to avoid confusion with pond and stream sediments, this section of the report will refer to soil or sediment samples from Area A wetland, OBDA, and downstream areas that are not pond or stream sediment samples as "soils". This convention is different from that followed in other sections of the report.

7.3 Exposure Assessment

7.3.1 Characterization of Environmental Receptors

7.3.1.1 Goss Cove Landfill

Ground water from the Goss Cove Landfill discharges to the Thames River. This section characterizes the Thames River and discusses its resident biota.

The Shetucket and Yantic Rivers meet to form the Thames River approximately 12 miles north of the NSB-NLON. The portion of the river adjacent to NSB-NLON is estuarine. It is classified by the Connecticut Department of Environmental Protection (CTDEP) as class SC with the goal of improving future water quality to Class SB, suitable for swimming and harvesting of shellfish and desirable to promote the restoration of an anadromous fishery. The Thames River currently supports sport fishing. It also provides wildlife habitat.

The river discharges approximately 2600 cfs of freshwater to Long Island Sound (Soderberg and Bruno, 1971) and the flushing time for freshwater is approximately one half to two days (Welsh, 1984). Stratification in the northern two thirds of the river can be great depending on freshwater inflow. At times, the bottom saline waters become nearly depleted of dissolved oxygen. However, the portion of the river adjacent to NSB-NLON is less likely to be stratified due to the greater input of water from Long Island Sound in this area.

Studies of finfish in the Thames River have identified Winter Flounder, Tomcod, and Windowpane Flounder as the most abundant fish in the deeper channels, while the Mumichog and Striped Killifish are abundant near the shore (Tolderlund, 1975; Marsh, 1974; Welsh and Stewart, 1984). The Thames River is also a feeding area for long-range coastal migrating fish such as Menhaden, Bluefish, Striped Bass, and Mackerel. Seasonal visitors from Long Island Sound include Tautog, Weakfish, Porgy, and Whiting. There is also a limited River Herring run to a freshwater nursery area upstream at Norwich, Connecticut.

Sampling of benthic species in the river channel adjacent to NSB-NLON in March 1990 (Maguire Group, Inc., 1990) identified several polychaete worms and one bivalve species, the Coot Clam (Mulinia lateralis), an opportunistic species. The referenced study did not include near-shore samples or observations in the area of NSB-NLON.

The only benthic species of economic importance identified in the Thames River are the Oyster and the Hard-Shell Clam. Much of the river is closed to shellfishing due to high coliform levels. However, there is an oyster bed west of the submarine base and several Hard-Shell Clam beds further south in Waterford, Connecticut.

7.3.1.2 DRMO and Lower Subase

Ground water from the DRMO and Lower Subase also discharges to the Thames River. The same potential receptors will be addressed for these sites as for the Goss Cove Landfill.

7.3.1.3 Area A

The remainder of this section discusses environmental receptors in the Area A Wetlands, Downstream Watercourses, and the Over Bank Disposal Area. Environmental receptors in this area were characterized based on several site visits.

The Area A Wetland comprises approximately 30 acres east of the Weapons Center, south and west of the Perimeter Security Road, and north of Area A Landfill (refer to Figure 1-12, Site Plan Area A). The vegetation in most of the wetland is herbaceous and is dominated by the marsh reed Phragmites. Phragmites thrive in disturbed soil and provide poor habitat for birds and small mammals. A small area (approximately 300 feet by 350 feet) near the southern portion of the wetland is upland deciduous forest. Deciduous trees in this area include Black Cherry, Black and Gray Birch, Red Maple, and Staghorn Sumac. Note that Staghorn Sumac grows well in disturbed soils. Shrubs identified in this area are Multiflora Rose, American Bittersweet, and Blackberry. A more complete list of vegetation species observed in Area A is in Appendix F-1.

A small pond is in the eastern portion of the wetland adjacent to the landfill. The pond is shallow (one to two feet deep) and choked with rooted aquatic vegetation (primarily Ceratophyllum). Numerous water beetles and insect larvae inhabit the pond. The bottom muck of the pond is black and one to two feet deep.

A dike separates the wetland area from the downstream watercourses. The downstream watercourses are described in Section 1.2.5.8. A stream exits the dike on the west side of the Area A wetland and flows into a small pond approximately 200 feet downstream. Flow from the small pond enters a stream that flows north and west toward Triton Avenue. This stream is culverted under Triton Avenue and Shark Boulevard and eventually discharges to the Thames River via the DRMO outfall. During wet weather or periods of high water levels, water from the pond discharges on the south side and enters a stream that flows through the Over Bank Disposal Area. This stream bypasses North Lake and flows through a series of culverts to the golf course. It eventually discharges to the Thames River. A second pond, to the south of the previously mentioned pond, is formed by ground water inflow and flows to the west around North Lake via culverts.

The Downstream Watercourse area west of the dike is an upland deciduous forest. Tree species observed in this area include Red, Black, and White Oak, Black and Gray Birch, Red Maple, Beech, and Witch Hazel. The shrubs observed were Mountain Laurel, Sweet Pepperbush, Bayberry, and American Bittersweet. Appendix F-1 contains a more complete species list of vegetation observed in Area A.

In addition to vegetation, environmental receptors in Area A include resident and visiting birds, reptiles, amphibians, and mammals. A list of species observed in Area A is in Appendix F-1.

The remainder of this section briefly discusses habitat and food requirements of those species that are likely to be predominant on the site. In certain cases, information on species not observed on the site but presumed to be present is included. The food and habitat

requirements of species that occur at the ends of food chains are emphasized as they may be the most vulnerable to the uptake of contaminants.

Invertebrates and plants serve as the base of the aquatic and terrestrial food web. Direct observations were not made of benthic invertebrates in the ponds and streams of Area A. Benthic invertebrates may be consumed by several of the resident species including fish and frogs. Fish may be present in the ponds, although none were observed there. Mallard Ducks feed on submersed vegetation in the ponds.

The base of the food web for the terrestrial vertebrates will consist primarily of both detrital organic matter occurring within leaf litter and surficial soils and plant matter (leaves, bark, fruits, berries, and nuts). Many invertebrate and vertebrate species feed directly on these materials.

Soil invertebrates and insects, a primary source of food to many vertebrate species on the site, serve as a critical component of the terrestrial food web. Earthworms are among the more important invertebrates that serve as food items.

Amphibians

Frogs were observed to be abundant in the pond in the wetland area and in the streams of the downstream watercourse area. Species observed include Green Frog, Spring Peeper, and Leopard Frog. Frogs may be exposed to site related contaminants via several pathways. Their eggs are deposited in surface water, their larvae mature in surface water, and adults typically reside throughout their lifetime in the same pond in which they were reared. Their diet includes insects.

Birds

Diets of several of the bird species observed at the site are summarized below. The species described here represent a cross section of food habits and habitat requirements of birds residing at or visiting Area A.

Mallard Duck: This duck's adaptability has made it one of the most common wild ducks in the world. It is capable of breeding and maintaining its populations under a wide range of conditions. It feeds readily on land and requires very little water. The mallard eats many kinds of succulent plants, seeds, acorns, insects (particularly grasshoppers), many small aquatic animals, and probably all the grains grown within its range. It is resident throughout the year.

Sparrows: Several sparrow species have been observed on the site. The House Sparrow is a permanent resident that feeds primarily on plant matter ranging from fruit and grain to garbage; it can be quite destructive to plants. When vegetable matter is not available, it will eat insects. The Swamp Sparrow will inhabit muddy areas such as bogs or swamps and it is seldom seen. They are seasonal residents generally between March and November. The food of the Swamp Sparrow consists of insects and the seeds of weeds; because of its proximity to aquatic habitats it often feeds on aquatic insects. The Field Sparrow is a seasonal resident in the northeast generally between April and November. This species is usually found in old fields and

bushy pasture areas. This species feeds on both plant and animal matter. It feeds largely on seeds of grasses and to less extent on those of garden weeds. Animal matter, mostly insects, has been observed to comprise about 40 percent of its diet.

Northern Mockingbird: This species is a permanent resident. The mockingbird feeds largely on insects. It will also feed on the fruit of a number of wild plant species.

Crow: The food of the crow consists of almost anything edible alive or dead including birds eggs, young birds, mammals, reptiles, fishes, insects, crustaceans, and worms. Dead animals of any size provide a source of food. The crow will also eat plant matter including seeds, nuts, acorns, grains, and fruits. The crow is an extremely adaptable species and a permanent resident.

Red-tailed Hawk: This species can be either a permanent resident or may migrate into or through the area. The food of the hawk consists largely of mice. It will also take rabbits, gophers, and squirrels. It will prey on snakes when they are present in abundance, but it rarely consumes birds.

Gray Catbird: Catbirds are migratory species that breed at the edge of the marsh. Gray catbirds migrate to warmer climates starting in the early Fall after they have been fledged from the nest. The diet of newly hatched young and fledglings consists of worms, pillbugs, caterpillars, larvae, and beetles, i.e., terrestrial invertebrates inhabiting the ground layer. The fledglings reside in their territory for approximately 60 days before they migrate to warmer climates in early September.

Mammals

This section discusses the feeding habits of several mammal species either observed in Area A or expected to occur there. These species are discussed here because their feeding habits are representative of small mammals in Area A.

Eastern Gray Squirrel: This species observed in Area A is one of the more common small mammals in the northeast. Squirrels typically exhibit population densities of one to 16 per acre. The squirrel feeds primarily on plant matter and their diet consists of acorns, fungi, seeds, and berries. On occasion, it will consume small birds or carrion. Acorns are the major component of its diet during the winter. The species makes its home in trees and may live up to 15 years.

Eastern Cottontail: This species observed in Area A lives in fields and thickets and is well adapted for life in maturing woodlands. The diet consists almost entirely of plant matter including leafy material in the summer and bark and twigs in the winter. It does not make burrows of its own but may use those made by other species. It has a life span of about eight years.

Woodchuck: This species observed in Area A is a common animal on the edges of fields. It makes its home in the ground where it digs extensive burrows. Its territory is generally less than 330 feet in length. Woodchucks have a varied diet comprised primarily of succulent

plants. However, it does eat insects and occasionally small rodents such as mice or voles. It lives up to nine years.

Muskrat: The muskrat's habitat is marshes and wooded swamps. Muskrats were observed in the marsh portion of Area A east of the dike. They build their nests in mounds of non-woody plant stems. The muskrat's diet consists mainly of aquatic vegetation, especially wild rice, cattails, and arrow heads although they may supplement their diet with aquatic invertebrates.

Eastern Chipmunk: Chipmunks are classified as ground squirrels, living in subterranean burrows. They are commonly found in and near stone walls in the northeast. They are solitary animals and strongly territorial; their territories seldom exceed two acres. They may exhibit periods of inactivity during the hottest times of the summer and during winter when they remain in their burrows. They have a varied diet consisting of acorns, seeds, nuts, fruits, eggs, meat, and insects. A recent study showed that insects may comprise up to 20% of their diet during the summer. They have also been reported to eat mice, small birds, eggs, and small snakes. They may live for two to four years.

White-Footed Mouse: This mouse species observed in Area A makes its home in ground burrows, abandoned birds nests, or hollows in trees or logs. The species has well defined small territories of approximately 30 to 100 feet in radius. It is a nocturnal feeder with an omnivorous diet. It feeds primarily on dried seeds and berries but may also eat insects and the carrion of small mammals and birds. It has a lifespan of about five years.

Star-Nosed Mole: This species is a solitary animal that makes its home in damp or boggy soil. It feeds above ground as well as below on invertebrates associated with soils and leaf litter including earthworms, insects, snails, and slugs. It has also been observed to occasionally consume small vertebrates, as well as decaying plant matter. It is a good swimmer and diver and will eat aquatic insects and small fish. It is active throughout the year and has a lifespan of about two to three years.

Short-tailed shrew: This species is one of the most voracious predators of small invertebrates and other vertebrates. It nests underground; its runways usually parallel the surface and are located in the top ten centimeter of soil. The home range averages about five acres. Depending on habitat quality, density varies between one and 15 shrews per acre. Earthworms are the major diet item but millipedes, insects, and occasionally mice and voles are also eaten. Most shrews eat the equivalent of their body weight in food per day (8 grams). Breeding season lasts from February to September and gestation requires 21 days. Its lifespan is approximately one year. Populations are highly variable and occasionally crash.

Raccoon: This species observed in Area A is common in rural areas and can also be found in developed regions. In most areas where raccoons are present, their density is approximately one per ten acres, although higher densities have been reported for some areas (several per acre). The species makes its home in hollow trees, logs, rock crevices, and ground burrows. The raccoon will eat practically anything from small birds and mammals to fruit, nuts, garden vegetables, and garbage. The species also feeds on various aquatic invertebrates and vertebrates such as frogs. It lives up to 14 years.

Otter: An otter has been observed in Area A in the downstream pond nearest the dike. The habitat of the river otter is rivers, ponds, and lakes in wooded areas. They dig their dens in the banks. They feed mainly on fish, but will also eat terrestrial invertebrates and small mammals such as mice.

7.3.2 Identification of Exposure Pathways

7.3.2.1 Goss Cove Landfill

Discharge of ground water from this site to the Thames River may effect river water and sediment quality. Benthic organisms in the sediments of the Thames River may ingest contaminated sediments. They are in direct contact with potentially contaminated interstitial pore water and may also ingest it.

Potential exposure pathways for fish in the Thames River include direct contact with potentially contaminated surface water and ingestion of potentially contaminated suspended sediments and invertebrates. Non-mobile benthic organisms in the area of ground water discharge may potentially experience the greatest exposure concentrations prior to complete mixing of contaminants in the river.

7.3.2.2 DRMO and Lower Subase

Discharge of ground water from this site to the Thames River may effect river water and sediment quality. Organisms in the river may be exposed to contaminants via the pathways described above for the Goss Cove Landfill.

7.3.2.3 Area A Wetlands, Downstream Areas, and Over Bank Disposal Area

The primary ecological exposures to contaminants in Area A occur at lower trophic levels. These include exposures of plants and terrestrial soil invertebrates to contaminants in soil and shallow ground water in Area A wetland, downstream areas, and the Over Bank Disposal Area and exposures of aquatic plants and benthic invertebrates to contaminants in stream sediments in the downstream area. Exposures at higher trophic levels occur via ingestion of invertebrates by small mammals and birds and direct exposure of amphibians and other aquatic species (fish) to surface water and sediments. Incidental ingestion of soil and ingestion of surface water are other potential routes of exposure.

Terrestrial plants are exposed at the root level to contaminants in soil and soil moisture. Longer rooted plants and plants in areas with saturated soils, such as wetlands, may be exposed to contaminants in shallow ground water. Exposure of aquatic vegetation to site contaminants may occur through two pathways. These are exposure to contaminants in interstitial pore water in the sediments and to contaminants in surface water.

Frogs represent a maximally exposed upper tier of the food chain in this area. Their eggs are deposited in surface water, their larvae mature in surface water, and adults typically reside throughout their lifetime in the same pond in which they were reared. Frogs may absorb some compounds through their skin. Their diet includes insects. Amphibians may be exposed

to contaminants in interstitial water in sediment during the part of the year that they are dormant and to surface water and possibly contaminated food during the rest of the year.

Both the Area A wetland and downstream areas are characterized by a shallow water table. Soil invertebrates in these areas may be exposed to contaminants that have dissolved from soils into soil moisture. Some invertebrates (worms) also ingest soil. Soil invertebrates will also be exposed to some extent to contaminants in ground water where the water table periodically intercepts the ground surface.

Benthic invertebrates in ponds and streams in Area A will be exposed to site related contaminants in sediments and interstitial sediment pore water.

Higher trophic level organisms, specifically, mammals and birds visiting or living at the site, will be exposed to compounds via ingestion of contaminated food. Those carnivores whose diets are comprised largely of soil invertebrates will be at greatest risk. Herbivores are less at risk, due to the substantially lower concentrations of compounds found in their diets. Berries and leaves typically contain orders of magnitude less of a given contaminant than soil invertebrates from the same location (Menzie et al., 1991). Along with the ingestion of soil invertebrates, other pathways of exposure for carnivores are soil ingestion (associated with the intake of soil invertebrates), ingestion and contact with surface water, and dermal contact with soils (burrowing). These exposures are considered secondary to ingestion of soil invertebrates and are difficult to quantify.

Potential exposures to fish that may be present in the ponds in Area A downstream will be via direct contact with pond water and via ingestion of invertebrates that have accumulated the contaminants. Fish may be present in the ponds although none were observed there. Fish and aquatic organisms in the Thames River may be exposed to dissolved contaminants or those adsorbed onto suspended sediments transported from Area A in the downstream watercourses.

7.3.3 Quantification of Exposure

7.3.3.1 Goss Cove Landfill

To assess exposures of aquatic invertebrates and fish in the Thames River to contaminants discharged in ground water from the Goss Cove Landfill, we estimated exposure concentrations based on dilution in the river at the point of discharge. We assumed that ground water in the overburden aquifer discharges to the Thames River. Most of the discharge is likely to occur along the banks of the river. A small mixing zone along the banks of the river will experience higher contaminant concentrations prior to complete mixing in the river. Since it is likely that the magnitude of this discharge is quite small compared to flow in the river due to freshwater input from upstream and tidal flushing, dilution will occur quickly. Dilution for the sites discharging ground water to the Thames River was estimated using the USGS Thames River average flow of 1300 cubic feet per second, a mixing zone 10 feet wide (compared to the width of the river of 2000 feet), and the ground water inflow to the site as reported in Section 3.0. At the Goss Cove Landfill, dilution is estimated to be on the order of 4/100. Note that this estimate is conservative in that it does not account for dilution due to tidal flushing. Therefore, the estimated average and worse case exposure concentrations will be approximately 4/100 of

the average and maximum ground water concentrations, respectively, of contaminants at the Goss Cove Landfill. These estimated concentrations are compared with EPA Ambient Water Quality Criteria (AWQC; EPA,1986).

7.3.3.2 DRMO and Lower Subase

Ecological exposures to contaminants in ground water at these sites are estimated in the same manner as for Goss Cove Landfill. For DRMO, dilution is estimated to be on the order of 4/100, while it is estimated to be approximately 14/100 for the Lower Subase.

7.3.3.3 Area A - Terrestrial Exposures

Plants: Since soil concentrations that produce toxic responses in plants are available in the literature for some contaminants, we used measured surficial soil or sediment concentrations at each sample location to assess risks to plants. This evaluation was conducted primarily for metals since organic contaminants are much less likely to be taken up by plants or to bioaccumulate in them (Menzie et al., 1991).

Soil Invertebrates: The main exposure pathway of soil invertebrates to site contaminants is via interstitial water in soils. We estimate this exposure using two approaches. Both approaches conservatively assume that the soil invertebrate is completely and constantly exposed to pore water. The first approach assumes constant exposure of soil invertebrates to ground water discharging to the ground surface in wetland areas and uses the ground water concentration as the exposure concentration. The second approach uses the Equilibrium Partitioning (EP) Method to estimate soil moisture concentrations of organic contaminants from soil concentrations. Both methods compare exposure concentrations to Water Quality Criteria established by the EPA and No Observed Adverse Effect Levels (NOAELs) from literature to assess potential risk to environmental receptors.

Soil invertebrates in contaminated areas may encounter elevated levels of compounds, while those in non-contaminated areas experience little or no exposure. We therefore calculate soil invertebrate risk on a localized basis (i.e., station by station). We use each station individually to assess risk to soil invertebrates for both approaches.

To assess risks to soil invertebrates due to direct exposure to ground water, we compared ground water concentrations with Water Quality Criteria for shallow wells where it appeared possible for ground water to intercept the ground surface for at least part of the year. For this assessment, we chose shallow overburden wells in the Area A Wetland (2WMW3S, 2WMW5S, and 2WMW6S), Area A downstream (2DMW11S and 2DMW16S), and Over Bank Disposal Area (3MW12S) that have well screens no more than 15 feet below the ground surface. Of these, wells 2WMW5S and 3MW12S best represent exposure concentrations because they are closest to areas where ground water discharges to the ground surface.

To assess risks to soil invertebrates due to exposure to interstitial pore water and soil moisture by the EP Method, we considered only surface and near-surface soil samples from within the Area A Wetland, downstream area, and OBDA as representative of environmental exposure. We restricted our assessment to soil samples collected within four feet of the ground

surface in these areas.

The following relationship was used to calculate a chronic sediment quality criterion from chronic Ambient Water Quality Criteria or from NOAELs (Markwell et al., 1989):

$$C_s = x\ K_{ow}m\ f_{oc}\ C_{WI}$$

where:

C_s	=	equilibrium concentration of chemical in soil or the chronic sediment quality criterion (ppb)
x	=	proportionality constant
K_{ow}	=	octanol/water partition coefficient
m	=	nonlinearity constant
f_{oc}	=	organic carbon fraction
C_{WI}	=	equilibrium concentration of chemical in soil pore water or Ambient Water Quality Criterion or NOAEL (ppb)

In this case, the relationship $K_{oc} = x\ K_{ow}\ m$ was substituted into the equation. The toxicity quotient was then calculated as the sediment criterion divided by the measured soil concentration.

Soil concentrations and a simple analytical model were used to predict the body burdens of PAHs and DDT and its metabolites DDD and DDE in soil invertebrates. (DDT and its metabolites are also called DDT residues or DDTR.) DDTR and PAHs were chosen for this assessment because they were detected at elevated concentrations in soils and because of their potential to bioaccumulate. The estimated body burdens are used to represent the dietary intake of contaminants by mammals and birds that feed on soil invertebrates. Because birds and other mammals are assumed to forage throughout the site, and even though the soil concentrations are not normally distributed, we use the arithmetic mean of soil concentrations to estimate a mean soil invertebrate concentrations to assess bird and mammalian exposure. If the wetland soil/sediment sampling was not random (i.e., if samples were collected based upon suspected areas of contamination), then the arithmetic mean would be a conservative estimate of exposure point concentration.

Appendix F-2 contains statistical summaries of the soil concentrations for Area A. The data are presented by area and include the number of samples, number of times each compound was detected, maximum concentration, and arithmetic mean.

From this soil data, mean soil invertebrate body burdens of DDTR and PAHs were calculated based upon a bioaccumulation model proposed by Markwell et al. (1989) for oligochaete worms. The model estimates residues by evaluating the distribution of contaminants among three compartments: soil, soil moisture, and invertebrate tissue. The soil moisture concentration C_{WI} is calculated in accordance with the previous equation using the values of Markwell et al. for the empirical constants:

$$x = 0.66$$
$$m = 1.029$$

They also state the following relationship between soil organisms and soil pore water:

$$C_B = C_{WI} Y_L K_{ow} p$$

where:

C_B = persistent organic chemical concentration of organism
C_{WI} = equilibrium concentration of chemical in pore water
Y_L = lipid content of organism
K_{ow} = octanol/water partition coefficient
p = nonlinearity constant

Markwell et al. suggest that p approaches unity in most cases. Thus, for this application, p was assigned a value of one.

Substituting for C_{WI}, K_{ow}, x, and m in this expression results in the relationship:

$$C_B = (C_s Y_L / f_{oc}) (K_{oc}^{-0.028}/0.67)$$

The resulting estimated bioaccumulation factors are dependent primarily on the organic carbon content of the soil and lipid content of the soil organism. An organic carbon content of 5% was assumed for site soils and sediments. A lipid content of two percent was assumed for soil invertebrates based on the work of Stafford et al. (1988) on the earthworm Lumbricus terrestris. The resulting estimates of soil invertebrate body burdens of DDTR and PAHs are used to calculate contaminant dose and body burdens in higher trophic levels.

Amphibians: On April 14, 1990, aquatic biota sampling was performed in Area A wetland and downstream watercourse areas. The objective was to collect fish samples from within the ponds in the downstream area. No fish were observed on that date, but numerous frogs were observed. Therefore, frogs were collected instead. The frogs were caught with a net or a hook and line.

Four frogs were collected from the pond in the wetland area and two were collected from streams in the downstream area below the dike. Frog collection locations are on Plate 6-1. The frogs were analyzed for pesticides, PCBs, metals, and body lipids. A control frog was collected from a pond presumed to be uncontaminated at the Manomet Bird Observatory in Massachusetts. The analytical results are in Table 7-1. Note that pesticides and PCBs were not detected in frog tissues above the sample quantitation limit.

Birds and Mammals: The dietary exposure point concentrations for birds and mammals that feed on soil invertebrates, estimated as described above, are used to estimate the daily dose of compounds to them. The estimates are used to predict possible effects and risks.

A simple bioaccumulation model was used to predict the body burdens of DDTR and PAHs in mammals and birds using bioconcentration factors (BCFs). We restricted this analysis to DDTR and PAHs because they were the predominant contaminants on site; DDTR is known to be potentially accumulated and transferred in terrestrial food webs. Estimates are compared

TABLE 7–1
AREA A WETLANDS
SUMMARY OF TISSUE ANALYTICAL DATA (FROG)

PARAMETER	SAMPLE ID:	POND 1A	POND 1A	POND 1B	POND 1B	POND 1C	POND 1C	POND 1D	POND 1D
	MATRIX:	Frog Tissue	Frog Liver	Frog Tissue	Frog Liver	Frog Tissue	Frog Liver	Frog Tissue	Frog Liver
Percent Body Lipids (mg/gm)		4	24.4	1	18.5	1	ND	7	112
TAL INORGANICS (ppm)									
Aluminum		470	NA	16 J	NA	26 J	NA	7.5 J	NA
Antimony		ND	NA	ND	NA	ND	NA	ND	NA
Arsenic		ND	NA	ND	NA	ND	NA	ND	NA
Barium		ND	NA	ND	NA	ND	NA	ND	NA
Beryllium		ND	NA	ND	NA	ND	NA	ND	NA
Cadmium		ND	NA	ND	NA	ND	NA	ND	NA
Calcium		3000	NA	170 J	NA	270 J	NA	240 J	NA
Chromium		1.2	NA	ND	NA	ND	NA	ND	NA
Cobalt		ND	NA	ND	NA	ND	NA	ND	NA
Copper		2.1	NA	ND	NA	ND	NA	1	NA
Iron		44 J	NA	15 J	NA	15 J	NA	22 J	NA
Lead		ND	NA	0.66	NA	ND	NA	0.78	NA
Magnesium		270	NA	120	NA	220	NA	220	NA
Manganese		3.5 J	NA	2 J	NA	3.8 J	NA	0.58 J	NA
Mercury		ND	NA	ND	NA	ND	NA	ND	NA
Nickel		ND	NA	ND	NA	ND	NA	ND	NA
Potassium		3000 J	NA	3000 J	NA	3300 J	NA	3100 J	NA
Selenium		0.65	NA	0.58	NA	0.4	NA	0.88	NA
Silver		1.8 R	NA	ND R	NA	ND R	NA	ND R	NA
Sodium		1000 J	NA	850 J	NA	680 J	NA	930 J	NA
Thallium		ND	NA	ND	NA	ND	NA	ND	NA
Vanadium		ND	NA	ND	NA	ND	NA	ND	NA
Zinc		11 J	NA	7.2 J	NA	6.4 J	NA	7.8 J	NA
Boron		500 J	NA	510 J	NA	470 J	NA	420 J	NA
Cyanide		ND	NA	17	NA	5.8	NA	4.1	NA
TCL PESTCIDES/PCBs (ppm)									
Pesticides/PCBs		ND	ND	ND	ND	ND	ND	ND	ND

TABLE 7–1 (continued)
AREA A WETLANDS
SUMMARY OF TISSUE ANALYTICAL DATA (FROG)

PARAMETER	SAMPLE ID: MATRIX:	LOWER STREAM 1 Frog Tissue	LOWER STREAM 2 Frog Tissue	LOWER STREAM 2 Frog Liver	MBO 18 Control Frog Tissue	MBO 18 Control Frog Liver
Percent Body Lipids (mg/gm)		5	ND	93.3	ND	7.5
TAL INORGANICS (ppm)						
Aluminum		140 J	35 J	NA	13	NA
Antimony		ND	28 J	NA	ND	NA
Arsenic		ND	ND	NA	ND	NA
Barium		4.7	ND	NA	ND	NA
Beryllium		ND	ND	NA	ND	NA
Cadmium		0.55	ND	NA	ND	NA
Calcium		10600	6400	NA	240 J	NA
Chromium		ND	ND	NA	ND	NA
Cobalt		ND	ND	NA	ND	NA
Copper		14	ND	NA	1.1	NA
Iron		360 J	23 J	NA	13 J	NA
Lead		2.7	ND	NA	ND	NA
Magnesium		600	290	NA	240	NA
Manganese		18 J	2.2 J	NA	0.68 J	NA
Mercury		ND	ND	NA	ND	NA
Nickel		ND	ND	NA	ND	NA
Potassium		2700 J	2900 J	NA	3000 J	NA
Selenium		0.84	0.45	NA	0.65	NA
Silver		ND R	ND R	NA	ND R	NA
Sodium		1200 J	1300 J	NA	860 J	NA
Thallium		ND	ND	NA	ND	NA
Vanadium		ND	ND	NA	ND	NA
Zinc		67 J	11 J	NA	7.4 J	NA
Boron		440 J	480 J	NA	450 J	NA
Cyanide		ND	5.4	NA	56	NA
TCL PESTCIDES/PCBs (ppm)						
Pesticides/PCBs		ND	ND	ND	ND	ND

NOTES:

1) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.2 for further explanation.

2) ppb indicates a concentration of parts per billion; ppm is parts per million.

3) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

to concentrations in field collected birds from the site. The model uses estimates of concentrations of compounds in diet and an estimate of the relative consumption of a particular diet. The resulting equation is:

$$C_b = (BCF)\ (C_f)\ (D_{frac})$$

where:

C_b = whole body (wet weight) concentration in animal
BCF = bioconcentration factor (dry weight food to whole animal, wet weight)
C_f = Concentration of contaminant (dry weight)
D_{frac} = fraction of animal's diet consisting of the contaminated food

Bioconcentration factors for birds and mammals for DDTR and PAHs were obtained from reported literature values and are presented in Table 7-2.

TABLE 7-2
DDTR BIOCONCENTRATION FACTORS FOR BIRDS AND MAMMALS

Animal	BCF	Source
Short-tailed Shrew	0.2	Forsythe and Peterle (1984)
Vole	0.3	Forsythe and Peterle (1984)
White-throated Sparrow	2.2	Mahoney (1974)

BCF reported as food (dry weight) to whole body (wet weight).

Field data were obtained on body burdens of pesticides, PCBs, and metals for some higher trophic level organisms in the terrestrial food web. This entailed collecting song birds from the wetland and downstream areas and analyzing body burdens (Plate 6-1).

Fledgling catbirds were collected for this purpose because they had not yet migrated outside the study area. Catbirds breed at the edge of the marsh. Gray catbirds migrate to warmer climates starting in the early Fall after they have been fledged from the nest. Therefore, if mature birds were sampled and the chemical analysis of their tissue detected pesticides or other contaminants, it would be more difficult to determine whether exposures occurred within the study site or at other migratory designations.

Once catbird eggs hatch, the young are fed for 12-14 days in the nest, then young birds fledge the nest and feed within their territorial boundary (approximately 2.5 acres) for one to two months. Catbirds lay three to five eggs and the eggs hatch between late June and July. The diet of newly hatched young and fledglings consists of worms, pillbugs, caterpillars, larvae, and beetles, i.e., terrestrial invertebrates inhabiting the ground layer. Their exposures to pesticides would occur through diet and contact with contaminated water, soil or vegetation. The fledglings reside in their territory for approximately 60 days before they migrate to warmer climates in early September. The collection of fledgling catbirds occurred at the Groton site in late August. Therefore, pesticides detected in their tissues can be associated with exposures occurring within their territory of 2.5 acres.

We did not observe catbird eggs in the study area because at the time of sampling in August, the catbird's egglaying season had already passed. Note that song bird eggs do not usually exhibit shell thinning usually associated with DDT exposure. Predatory birds are noted for this reproductive abnormality associated with pesticide exposure.

Fourteen gray catbird fledglings were trapped in the Wetland A and downstream areas with nets and sacrificed by a physically nondestructive and nonchemical method. Three birds were collected from an offsite reference area in Plymouth, Massachusetts to represent offsite birds from an uncontaminated area. The reference area is used by the Manomet Bird Observatory for the study of bird populations. The bird specimens were stored in borosilicate glass containers. The specimens were debeaked, declawed, and their guts were removed before chemical analysis for pesticides/PCBs, metals and body lipids. The analytical results of bird specimens are in Table 7-3. Note that pesticides and PCBs were not detected in bird tissues above sample quantitation limits ranging from 0.75 to 1 mg/kg.

7.3.3.4 Area A - Aquatic Exposures

Fish and aquatic invertebrates may be exposed to contaminants in surface water in the ponds in the downstream areas, although no fish were observed there. We evaluated these exposures via comparison to Ambient Water Quality Criteria and effect levels reported in the literature. Benthic invertebrates will be exposed to contaminants via the interstitial pore water in sediments in the ponds and streams. We estimated exposure concentrations for these organisms by using the equilibrium partitioning method.

7.3.4 Uncertainty in Exposure Estimates

Uncertainty in the exposure estimates arises from the assumptions underlying the estimates. Although we have made conservative assumptions where possible and used documented approaches in estimating exposure concentrations, there is uncertainty in the nature of the process.

Exposure concentration estimates presented here for the Thames River are based on general assumptions and not on measurements of flow rates or mixing areas within the river. Therefore, the degree of uncertainty in these estimates is great, and they should be viewed as a qualitative evaluation only.

The second source of uncertainty relates to the collection stations for frogs. Frogs were collected from the pond in Area A Wetland and from streams in the Downstream Watercourse Area. No chemical analyses were performed on sediments from the pond in the wetland. We are, therefore, unable to compare exposure concentrations with body burdens for frogs collected from this pond. Frogs were not collected from the small ponds in the eastern part of the Downstream Watercourse Area; chemical analyses of sediments indicated elevated levels of DDTR in these ponds, the highest levels detected in Area A. We are unable to compare frog body burdens from this area with exposure concentrations. At the time the frogs were collected, the contaminant distribution in sediments was not well characterized. Therefore, results of frog tissue analysis, while representative of the areas sampled, may not represent the DDTR levels of amphibians in the more highly contaminated regions of Area A.

TABLE 7-3
AREA A WETLANDS
SUMMARY OF TISSUE ANALYTICAL DATA (BIRD)

PARAMETER	SAMPLE ID: / MATRIX:	MBO 1 Bird Tissue	MBO 2 Bird Tissue	MBO 3 Bird Tissue	MBO 4 Bird Tissue	MBO 5 Bird Tissue	MBO 6 Bird Tissue	MBO 7 Bird Tissue	MBO 8 Bird Tissue	MBO 9 Bird Tissue
Percent Body Lipids (mg/gm)		17	15	13	16	14	13	15	16	15
TAL INORGANICS (ppm)										
Aluminum		34	6.9	8.7	9.8	11	7.7	44	ND	ND
Antimony		ND	ND	6.2	ND	ND	ND	21	ND	ND
Arsenic		ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium		ND	4	ND	ND	ND	ND	ND	ND	ND
Beryllium		ND	ND	ND	ND	ND	ND	0.4	ND	ND
Cadmium		ND	ND	ND	ND	ND	ND	2.2	ND	ND
Calcium		1680	13400	9100	8000	6100	2900	2600	6000	4400
Chromium		ND	1.4	ND	ND	ND	ND	5.9	ND	ND
Cobalt		ND	ND	ND	ND	ND	ND	4.5	ND	ND
Copper		7.9	4.8	7.3	7.6	11	6.2	11	3.1	4.3
Iron		170 J	65 J	90 J	66 J	78 J	430 J	130 J	76 J	150 J
Lead		ND	2.3	1	1.1	1.9	1	ND	0.98	ND
Magnesium		210	430	330	340	320	270	310	320	280
Manganese		1.3	1.5	1.8	1.5	2.4	1.7	2.5	0.9	1.6
Mercury		ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J
Nickel		1.5	ND	ND	ND	ND	1.6	8	ND	ND
Potassium		2900	3100	3200	3100	3200	3400	4100	3100	3300
Selenium		1.1	1	0.94	0.77	0.8	0.67	0.52	0.39	0.46
Silver		ND R	ND R	ND R	ND R	ND R	ND R	8.4 R	ND R	ND R
Sodium		1300	1300	1200	1200	1200	1200	1400	1100	1100
Thallium		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R
Vanadium		ND	ND	ND	ND	ND	ND	6.3	ND	ND
Zinc		17 J	30 J	24 J	24 J	22 J	22 J	16 J	21 J	20 J
Boron		630 J	700 J	740 J	760 J	730 J	700 J	820 J	700 J	720 J
Cyanide		ND	ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTCIDES/PCBs (ppm)										
Pesticides/PCBs		ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 7–3 (continued)
AREA A WETLANDS
SUMMARY OF TISSUE ANALYTICAL DATA (BIRD)

PARAMETER	SAMPLE ID: / MATRIX:	MBO 10 Bird Tissue	MBO 11 Bird Tissue	MBO 12 Bird Tissue	MBO 13 Bird Tissue	MBO 14 Bird Tissue	MBO 15 Control Bird Tissue	MBO 16 Control Bird Tissue	MBO 17 Control Bird Tissue
Percent Body Lipids (mg/gm)		17	18	16	12.7	17.5	18	18	17
TAL INORGANICS (ppm)									
Aluminum		6.5	8.7	11	41	ND	11	6.5	ND
Antimony		ND	ND	ND	23	ND	5.8	ND	ND
Arsenic		ND	ND	ND	ND	ND	ND	ND	ND
Barium		ND	ND	ND	4	ND	3.1	ND	ND
Beryllium		ND	ND	ND	0.35	ND	ND	ND	ND
Cadmium		ND	ND	ND	2	ND	ND	ND	ND
Calcium		1920	7100	7000	5800	8400	13600	4900	3900
Chromium		1	ND	ND	4.9	ND	ND	ND	ND
Cobalt		ND	ND	ND	3.8	ND	ND	ND	ND
Copper		4.2	3.7	4.7	9.2	ND	3.2	5.5	4.8
Iron		83 J	120 J	110 J	170 J	67 J	91 J	95 J	130 J
Lead		ND	0.47	1.6	0.5	0.53	0.77	0.42	0.41
Magnesium		230	350	320	370	310	430	260	280
Manganese		2.2	1.5	1.1	2.6	2.5	2.2	1.5	1.1
Mercury		ND J	ND J	ND J	ND J	ND J	ND J	ND J	ND J
Nickel		ND	ND	ND	7	ND	ND	ND	ND
Potassium		3300	3300	3000	4200	2700	3000	3000	3100
Selenium		0.37	1	ND	ND	0.35	0.38	0.19	0.27
Silver		1.4 R	ND	ND	7.5	ND	ND	ND	ND
Sodium		1100	1200	1200	1500	1100	1200	1100	1100
Thallium		ND R	ND R	ND R	ND R	ND R	ND R	ND R	ND R
Vanadium		ND	ND	ND	5.7	ND	ND	ND	ND
Zinc		14 J	21 J	19 J	21 J	22 J	26 J	17 J	17 J
Boron		710 J	670 J	670 J	750 J	700 J	670 J	590 J	710 J
Cyanide		ND	ND	ND	ND	ND	ND	ND	ND
TCL PESTCIDES/PCBs (ppm)									
Pesticides/PCBs		ND	ND	ND	ND	ND	ND	ND	ND

NOTES:

1) Assigned letters adjacent to numerical values are data qualifiers. Refer to Section 2.2 for further explanation.

2) ppb indicates a concentration of parts per billion; ppm is parts per million.

3) ND means not detected, less than detection limit. Refer to Section 2.2 for further explanation. NA indicates not analyzed.

There is some uncertainty associated with the pesticide analytical results. The detection limits were relatively high in both frog and bird samples (range of 0.75 to 1 mg of contaminant per kg of tissue) compared to the laboratory method blanks within the sample batches. The detection limit in the reagent blank was 0.3 mg/kg. The reagent blank results indicate how well an instrument is performing on that day. The matrix spike recovery was within the normal acceptable range. Matrix spike analysis reveals if a known quantity of pesticide can be detected within the actual sample medium. Based on the matrix spike and blank results, it is possible that the high detection limits may be due to matrix interferences within each sample. The laboratory was asked to re-examine the chromatographs. This review indicated a low signal in tissue samples that DDE was present in trace amounts below the sample quantitation limits (0.75 to 1 mg/kg).

7.4 Toxicity Assessment

7.4.1 Plants

Although plants can take up organic contaminants from soil moisture and ground water via their roots, in general, uptake is quite low compared to soil concentrations. Some native plants growing in soils with high levels of DDTR contamination accumulate DDTR at very low levels (on the order of 0.02 mg/kg) while other native plants do not accumulate DDTR to detectable levels (Menzie et al., 1991). Based on this information, we concluded that risks to plants from organic contaminants at the site are low, and we did not address them further.

The literature provides concentrations of metals that produce toxic responses in plants. Rinne (1986) provides the equivalent of No Observable Adverse Effects Levels (NOAELs) for plants and higher trophic level organisms that may be exposed to accumulated levels of contaminants in plants.

7.4.2 Soil and Benthic Invertebrates

Several analyses presented in this report involve predicting the potential risks associated with exposure of soil and benthic invertebrates to contaminants that have dissolved into either ground water, soil moisture, or sediment pore water. In evaluating these risks, information is needed on the concentrations of contaminants in water that may pose risks to invertebrates that are either immersed in or are in communication with contaminated water.

Information on toxicity of compounds of interest to terrestrial invertebrates in contact with ground water was unavailable; in lieu of these data, aquatic invertebrate toxicity values were used to predict effects which may pose similar risks to terrestrial invertebrates in contact with water. Toxicities of compounds to terrestrial invertebrates may differ from those to fresh water invertebrates. However, the assumption that the terrestrial invertebrate is exposed to as much water as a freshwater invertebrate is highly conservative.

Ambient Water Quality Criteria and acute and chronic No Observed Adverse Effect Levels (NOAELs) were used to develop criteria such that aqueous concentrations below these values would not pose a risk to invertebrates. Many of the NOAELs are based upon effects of compounds on Daphnia magna and Daphnia pulex (water fleas). Information on NOAEL values

used in this assessment was obtained or derived from a variety of sources and methodologies, detailed below:

Source	Data Used to Derive Toxicity Criteria
EPA Water Quality Criteria (1986)	WQC or LOAEL
EPA Interim Sediment Quality Criteria (1988)	Interim PAH WQC
Acquire Database (1990)	Lowest NOAEL or LC_{50}
Literature Review	Lowest NOAEL or LC_{50}

The following methodology was used to derive toxicity criteria:

If an EPA ambient water quality criterion (WQC) for a compound of interest was available, that WQC was used. If no WQC was available for the compound, but EPA did provide an acute or chronic lowest observed effects level (LOAEL), the LOAEL was multiplied by 0.1 (an uncertainty factor of 10) to arrive at an acute or chronic NOAEL value. This approach is similar to the derivation of toxicological values for hazard assessment to humans. A factor of 10 (rather than 100 or 1000) is used since we are evaluating risks to local populations rather than any specific sensitive individual animal.

For polynuclear aromatic hydrocarbons (PAHs), EPA has developed interim water quality criteria for fluoranthene, pyrene, benzo(a)pyrene, and benzo(a)anthracene. Since no other information on toxicity of PAHs to aquatic organisms was available, PAHs whose structures are similar to any of those PAHs for which WQC have been developed were assigned an equivalent WQC. For example, EPA assigned a chronic WQC of 1.2 ug/l for benzo(a)pyrene; therefore, in our assessment indeno(1,2,3-cd)pyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene were also assigned a chronic WQC of 1.2 ug/l, since these compounds have a similar chemical structure and may induce similar toxic effects.

For some of the compounds, toxicity information was available through EPA's Acquire database. The lowest NOAEL or LOAEL reported for the compound was used; if a LOAEL value was obtained, it was adjusted (by a factor of 0.1) as mentioned previously.

Recent literature was also reviewed for toxicity data. If the only toxicity data available were LC_{50} values, we selected the lowest LC_{50} value for aquatic invertebrates, usually Daphnia magna or Daphnia pulex (water flea) and multiplied the value by 0.3 to obtain an acute criterion and by 0.05 to obtain a chronic criterion. These values are based upon general information concerning the relationship between LC_{50}s and acute and chronic acceptable concentrations. The method is similar to those applied in water quality evaluations for toxic National Pollutant Discharge Elimination System discharges.

A summary of the acute and chronic toxicity criteria used in this study to assess risks to invertebrates is provided in Table 7-4. Note that many of the screening criteria used in Section 4.0 are based on human health risk associated with fish consumption. The toxicity values used here are more applicable and appropriate for an ecological assessment.

Note that toxicity data were not available for several compounds detected in environmental media accessible to ecological receptors. These compounds include carbon disulfide, 2-methylphenol, 4-chloroaniline, dibenzofuran, and 2-nitroaniline. Carbon disulfide was detected in wetland and downstream area soils, and in sediments and surface water in the downstream area at low concentrations (a few ug/l or ug/kg). Since carbon disulfide can be naturally occurring and it was detected in environmental media in Area A at low levels, we assumed that it posed no risk to ecological receptors. The other four compounds for which no toxicity data were available, 2-methylphenol, 4-chloroaniline, 2-nitroaniline, and dibenzofuran, were only detected in one or two surficial soil or sediment samples at relatively low concentrations. (The detected concentration of 2-nitroaniline in a pond sediment sample was 3.1 mg/kg. Concentrations of the other compounds were less than 1 mg/kg.) Based on the isolated presence of these compounds and their detection at relatively low concentrations, we did not address their associated risk further and assumed that they do not pose a risk to environmental receptors in Area A.

7.4.3 Fish and Aquatic Organisms

Exposure concentrations were compared to EPA Ambient Water Quality Criteria to assess toxicity of ground water discharging from Goss Cove Landfill, DRMO, and the Lower Subase to the Thames River and to assess toxicity of surface water in Area A. If an AWQC was not available but a LOAEL was given, a NOAEL was estimated as 10 per cent of the LOAEL. These comparisons are on Tables 7-5 (Goss Cove Landfill), 7-6 (DRMO), 7-7 (Lower Subase), and 7-8 (surface water in Area A).

7.4.4 Birds and Mammals

Information was developed on the threshold NOAEL values for exposure to DDTR and PAHs in the food of birds and mammals. This assessment is restricted to these compounds based on their toxicity, detection on site, and the potential for DDTR to biomagnify in the food chain. The toxicity information was acquired through computerized literature searches and through reviews of studies summarized or presented in EPA's Integrated Risk Information System, EPA's Health Effects Assessment Summary Tables (HEAST), Agency for Toxic Substances and Disease Registry Profiles, and United States Fish and Wildlife Service reviews of contaminants.

An effort was made to identify information for three general classes of biological effects: lethality, reproductive/developmental endpoints, and other chronic effects (e.g., enlargement of liver or blood effects). There is a large number of data gaps in the available information. However, some information was available on most of the predominant compounds.

TABLE 7-4 TOXICITY CRITERIA FOR SOIL AND BENTHIC INVERTEBRATES			
Parameter	**Acute Criterion (ug/l)**	**Chronic Criterion (ug/l)**	**Reference**
VOLATILE ORGANIC COMPOUNDS			
Nonchlorinated Aromatics			
Benzene	3000	500	b
Ethylbenzene	22500	3750	b
Toluene	3810	635	b
Xylene (total)	4050	675	b
Chlorinated Compounds			
Chloromethane			
1,1-Dichloroethane	3480	580	b
1,2-Dichloroethane	11800	2000	a*
1,1-Dichloroethene	3480	580	b
1,2-Dichloroethene (total)	3480	580	b
Methylene Chloride	68000	11000	b
Tetrachloroethane	9320	2400	
Tetrachloroethene	528	84	a*
Trichloroethene	4500	2190	a*
1,1,1-Trichloroethane	5400	900	b
1,1,2-Trichloroethane	5400	900	b
Vinyl Chloride			
Other VOCs			
Acetone	30000	5000	b
2-Butanone	30000	5000	b
4-Methyl-2-Pentanone			
Carbon Disulfide			
SEMI-VOLATILE COMPOUNDS			
Noncarcinogenic PAHs			
Acenaphthene	1300	86	c
Acenaphthylene	250	13	c**
Anthracene	250	13	c**
Fluoranthene	250	13	c
Fluorene	250	13	c**
2-Methylnaphthalene			
Naphthalene	230	62	a*

TABLE 7-4 (continued) TOXICITY CRITERIA FOR SOIL AND BENTHIC INVERTEBRATES			
Parameter	**Acute Criterion (ug/l)**	**Chronic Criterion (ug/l)**	**Reference**
Phenanthrene	600	35	c
Pyrene	250	13	c
Carcinogenic PAHs			
Benzo(a)anthracene	61	3	c
Benzo(a)pyrene	25	1.2	c
Benzo(b)fluoranthene	600	35	c**
Benzo(g,h,i)perylene	25	1.2	c**
Benzo(k)fluoranthene	600	35	c**
Chrysene	250	13	c**
Dibenz(a,h)anthracene	25	1.2	c**
Indeno(1,2,3-cd)pyrene	25	1.2	c**
Other Semi-Volatile Compounds			
Bis(2-ethylhexyl)phthalate	94	0.3	a*
Di-n-Butylphthalate	630	105	d***
2,4-Dimethylphenol	212		a*
4,6-Dinitro-2-methylphenol			
2-Methylphenol			
4-Methylphenol			
Phenol	1020	256	a*
Benzoic Acid	38700	6450	b***
4-Chloroaniline			
Dibenzofuran			
2-Nitroaniline			
N-Nitrosodiphenylamine (1)			
PESTICIDES			
4,4'-DDE	105		a*
4,4'-DDD			
4,4'DDT	1.1	0.001	a
Beta-BHC	100		e*
Endrin	0.18	0.0023	a
Enrin Ketone			
Methoxychlor		0.03	a

TABLE 7-4 (continued) TOXICITY CRITERIA FOR SOIL AND BENTHIC INVERTEBRATES			
Parameter	**Acute Criterion (ug/l)**	**Chronic Criterion (ug/l)**	**Reference**
PCBs			
Aroclor 1260	2	0.014	a
Aroclor 1254	2	0.014	a
INORGANICS			
Metals			
Aluminum			
Antimony	900	160	a*
Arsenic	85	4.8	a*
Beryllium	13	0.53	a*
Boron			
Cadmium	3.9	1.1	a
Copper	18	12	a
Iron		1000	a
Lead	82	3.2	a
Manganese			
Mercury	2.4	0.012	a
Nickel	1400	160	a
Selenium	260	35	a
Zinc	120	110	a

a - USEPA(a) (1987)
b - Acquire database
c - USEPA (b) (1988)
d - US ACOE (May 1984)
e - IRIS database
* AWQC calculated as 10% of LOAEL provided in listed source
** AWQC estimated from listed source
*** AWQC acute and chronic calculated as 0.3 and 0.05 of LC50, respectively

TABLE 7-5 RISKS TO BIOTA IN THE THAMES RIVER GOSS COVE LANDFILL				
Parameter	Ambient Water Quality Criteria (ug/l)		Maximum Concentration (ug/l)	Average Concentration (ug/l)
	Acute	Chronic		
VOLATILE ORGANIC COMPOUNDS				
Nonchlorinated Aromatics				
Benzene	530		2	2
Ethylbenzene	3200		120	61
Toluene	1750		450	118
Xylene (total)			610	254
Chlorinated Compounds				
1,2-Dichloroethene (total)	4500	2190	12	5.5
Vinyl Chloride			5	5
Other VOCs				
Acetone			700	179
4-Methyl-2-pentanone			200	54
SEMI-VOLATILE COMPOUNDS				
Noncarcinogenic PAHs				
Acenaphthene	170	52	11	7
Fluoranthene	398		4	4.8
Fluorene			8	6.2
2-Methylnaphthalene			12	8.2
Naphthalene	2300	62	62	30
Phenanthrene			14	7.8
Other Semi-Volatile Compounds				
2,4-Dimethylphenol	212		310	129
2-Methylphenol			140	45
4-Methylphenol			500	214
Phenol	1020	256	26	12
Benzoic Acid			3	20
Dibenzofuran			4	4.5
Metals				
Aluminum			36.6	84
Arsenic	85	4.8	7	5.2
Boron			50000	13450
Cadmium	3.9	1.1	2.4	2.3
Copper	18	12	7.8	7.6
Iron		1000	5700	2360
Lead	82	3.2	2.4	2.5
Manganese			226	165
Selenium	260	35	7	3.6
Zinc	120	110	17.6	10.5

1. Maximum and average is for shallow wells in Goss Cove Landfill. Shading indicates value over AWQC.
2. Only compounds detected in at least one shallow ground water sample from Goss Gove Landfill are listed here.
3. Ambient Water Quality Criteria for the protection of freshwater organisms are from EPA, 1986.
4. Criteria for volatiles and semi-volatiles are LOAELs (EPA, 1986) multiplied by an uncertainty factor of 0.1.

TABLE 7-6 RISK TO BIOTA IN THE THAMES RIVER DRMO SITE				
Parameter	**Ambient Water Quality Criteria (ug/l)**		**Maximum Concentration (ug/l)**	**Average Concentration (ug/l)**
	Acute	**Chronic**		
Volatile Organic Compounds				
1,1-Dichloroethane	3480	580	2	2.4
1,2-Dichloroethene (total)	3480	580	2	2
Trichloroethene	4500	2190	8	3.6
Metals				
Arsenic	85	4.8	18.6	7.84
Boron			8800	5900
Cadmium	3.9	1.1	4	2.72
Copper	18	12	355	79.36
Iron		1000	4880	1266.6
Lead	82	3.2	3.4	2.68
Manganese			1000	391.5
Nickel	1400	160	23.2	18.98
Selenium	260	35	23.5	12.38
Zinc	120	110	356	81.06

1. Maximum and average is for shallow wells in DRMO.
2. Only compounds detected in at least one shallow ground water sample from DRMO are listed here.
3. Ambient Water Quality Criteria for the protection of freshwater organisms are from EPA, 1986.
4. Criteria for volatiles are LOAELs (EPA, 1986) multiplied by an uncertainty factor of 0.1.
5. Shading indicates value over AWQC.

TABLE 7-7
RISKS TO BIOTA IN THE THAMES RIVER
LOWER BASE

Parameter	Ambient Waste Quality Criteria (ug/l)		Maximum Concentration (ug/l)	Average Concentration (ug/l)
	Acute	Chronic		
VOLATILE ORGANIC COMPOUNDS				
Nonchlorinated Compounds				
Benzene	530		5	2.60
Ethylbenzene	3200		8	0.42
Toluene	1750		36	3.90
Xylene (total)			18	3.15
Styrene			2	0.08
Chlorinated Compounds				
1,1-Dichloroethane			15	2.98
1,1-Dichloroethene	1160		57	4.83
1,1,1-Trichloroethane			1	2.44
Vinyl Chloride			12	5.29
Other VOCs				
Carbon Disulfide			2	2.48
METALS				
Aluminum			10600	559.30
Arsenic	85	4.8	8.5	5.07
Boron			42000	7753.75
Cadmium	3.9	1.1	25.5	3.82
Copper	18	12	15.6	11.34
Iron		1000	11600	2461.50
Lead	82	3.2	22.2	4.16
Manganese			1090	246.37
Nickel	1400	160	27.2	19.73
Selenium	260	35	22	9.36
Zinc	120	110	63.4	20.68

1. Maximum and average is for shallow wells at Lower Base.
2. Only compounds detected in at least one shallow ground water sample from Lower Base are listed here.
3. Ambient Water Quality Criteria are from EPA, 1986.
4. Criteria for volatiles are LOAELs (EPA, 1986) multiplied by an uncertainty factor of 0.1.
5. Shading indicates values over AWQC.

TABLE 7-8
RISKS TO AQUATIC ORGANISMS - AREA A

	Ambient Water Quality Criteria		Downstream Watercourses									
	Acute	Chronic	2DSW1 Pond	2DSW2 Pond	2DSW4 Pond	2DSW3 Stream	2DSW5 Stream	2DSW7 Stream	2DSW8 Stream	2DSW9 Stream	2DSW10 N. Lake	DSW1 Stream
VOLATILE ORGANIC COMPOUNDS												
Nonchlorinated Aromatics												
Ethylbenzene	3200		ND	ND	ND	ND	ND	1	3	ND	ND	ND
Xylene (total)			ND	ND	ND	ND	ND	ND	6	ND	ND	ND
Styrene			ND	ND	ND	ND	ND	ND	2	ND	ND	ND
Chlorinated Compounds												
Tetrachloroethene	528	84	ND	ND	ND	ND	ND	ND	3	ND	ND	ND
Other VOCs												
Carbon Disulfide			ND	ND	ND	ND	3	ND	ND	ND	ND	ND
PESTICIDES												
4,4' DDD			ND	ND	1.9	ND	ND	ND	ND	ND	ND	ND
METALS												
Aluminum			99	104	159	87	35.3	71.2	95.6	116	148	71.4
Boron			2200	1600	1600	1600	3300	1800	1700	2000	1200	3300
Cadmium	3.9	1.1	ND	ND	2.1	ND	ND	ND	ND	ND	ND	ND
Copper	18	12	8.4	12.6	9.4	9	9.6	11.7	10.5	11.4	10	11.4
Iron		1000	3040	3250	5670	3490	3170	2890	2660	2980	711	2340
Lead	82	3.2	ND	5.6	ND	3.6	2.2	5.2	4.7	7	5.2	2.8
Manganese			172	175	639	179	1510	174	166	172	136	1030
Mercury	2.4	0.012	ND	ND	ND	ND	ND	ND	ND	1.5	ND	ND
Nickel	1400	160	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium	260	35	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	120	110	13.2	19.4	12	18	16	22.4	18.4	19.5	17.1	18

TABLE 7-8 (continued)
RISKS TO AQUATIC ORGANISMS - AREA A

	Ambient Water Quality Critera Acute	Chronic	7SW1 Stream	2DSW12 Thames	DSW1 Thames	Wetland 2WSW1 Upstream	Wetland 2WSW2 Downstream
VOLATILE ORGANIC COMPOUNDS							
Nonchlorinated Aromatics							
Ethylbenzene	3200		ND	ND	ND	ND	ND
Xylene (total)			ND	4	2	ND	ND
Styrene			ND	ND	ND	ND	ND
Chlorinated Compounds							
Tetrachloroethene	528	84	ND	ND	ND	ND	ND
Other VOCs							
Carbon Disulfide			ND	2	ND	ND	ND
PESTICIDES							
4,4' DDD			ND	ND	ND	ND	ND
METALS							
Aluminum			356	164	69.2	137	153
Boron			2000	9100	16000	1700	2100
Cadmium	3.9	1.1	ND	ND	ND	13.7	126
Copper	18	12	16.2	9.5	9.2	13	13.2
Iron		1000	558	1880	854	293	4010
Lead	82	3.2	4.4	ND	ND	7.8	2
Manganese			32.1	115	589	52	136
Mercury	2.4	0.012	ND	ND	ND	ND	ND
Nickel	1400	160	ND	ND	ND	ND	7.3
Selenium	260	35	1.2	ND	1.4	ND	ND
Zinc	120	110	54.1	16.9	13.9	22.8	19.6

Notes: 1)Results in ug/l. Shading indicates values over AWQC.

2)Only compounds detected in at least one surface water sample from Are are listed here.

3) Ambient Water Quality Criteria for the protection of freshwater organis are from EPA, 1986.

4)Criteria for volatiles are LOAELs (EPA, 1986) multiplied by an uncerta factor of 0.1.

The general procedures used to develop the NOAELs used in this analysis are:

1. Where RfD-type values presented in the EPA's HEAST Tables are used, they were multiplied by a factor of 10 in recognition of the fact that risks to ecological receptors are evaluated not on an a "sensitive" individual basis but on a local population basis.

2. If data were available for LOAEL levels in an animal species, these were divided by a factor of 100 to take into account that it is a LOAEL and to adjust for uncertainties associated with other inter-species extrapolations.

3. If data for NOAEL levels were available, these values were adjusted by dividing by a factor of 10 to account for inter-species extrapolations.

4. In some cases where a variety of data were available, a best estimate of NOAEL values were made.

These methods are similar to those used in human health risk assessment. Summaries of NOAEL values used in this assessment for birds and mammals are in Table 7-9.

TABLE 7-9
DOSE RESPONSE VALUES FOR BIRDS AND MAMMALS

Parameter	Doses to Birds (mg/kg/day)			Dose to Mammals (mg/kg/day)		
	Potential Lethal Effects	Potential Reproductive/ Developmental Effects	Potential Other Chronic Effects	Potential Lethal Effects	Potential Reproductive/ Developmental Effects	Potential Other Chronic Effects
DDTR	8	0.08		0.29	0.1	2.3
PAHs	400					0.79

1. DDTR value in birds is estimated as the lowest LD50 value available in the literature multiplied by 0.01; this LD50 value was for pheasant assuming they ate 5% of their body weight per day (Lamb et al.).
2. DDTR reproductive value for birds estimated as lowest available reported effects value of 4 mg/kg for finches; an ingestion rate of 20% of body weight per day was assumed (Garten and Trabalka, 1983).
3. DDTR lethal effects value for mammals is the reported mortality level for rats from long term studies multiplied by 0.1 (ATSDR, 1988).
4. DDTR development effects value for mammals is the NOAEL for rats multiplied by 0.1 (ATSDR, 1988.
5. DDTR chronic effects levels in mammals is lowest NOAEL value multiplied by 0.1 (ATSDR, 1988).
6. PAH lethal effects level for birds is NOAEL multiplied by 0.1 (Eisler, 1987).
7. PAH chronic effects value for mammals is the average RfD for 6 PAH compounds multiplied by 10 (EPA, 1991).

7.4.5 Uncertainties Related to Toxicity Information

The uncertainty in the development of toxicity criteria for soil invertebrates stems from the use of aquatic invertebrate toxicity data and from estimating NOAELs from LC_{50} data. Toxicities of compounds to soil invertebrates may differ from toxicities to fresh water aquatic

invertebrates. However, soil invertebrates are generally only exposed to contaminants in soil moisture and this exposure is much less that of aquatic invertebrates immersed in water. Therefore, we feel that the use of toxicity data from aquatic invertebrates results in the development of conservative criteria. We accounted for uncertainty in the developing toxicity criteria through the use of uncertainty factors (Refer to Section 7.4.2).

We also relied on the use of uncertainty factors in developing NOAEL for birds and mammals (Section 7.4.4). The main source of uncertainty in this part of the assessment is related to the interspecies use of toxicity data.

7.5 Risk Characterization

The risk characterization relies upon the Toxicity Quotient Approach as well as on direct observations of conditions in the field. These approaches provide an overall "weight of evidence" approach for the assessment. The Toxicity Quotient approach involves comparing an exposure concentration to a NOAEL. Values that exceed "1" (exposure/effects level) are considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. Because the NOAEL values typically have uncertainty factors of 10 built into them, it is useful to evaluate the significance of the Toxicity Quotients as follows:

Toxicity Quotient Exceeds "1": some small potential for environmental effects;

Toxicity Quotient Exceeds "10": good potential that greater exposures could result in effects based on experimental evidence;

Toxicity Quotient Exceeds "100": effects may be expected based on the fact that this represents an exposure level at which effects have been observed in other species.

In some cases, this section directly compares exposure point concentrations to known toxicity data or developed criteria.

The toxicity quotient approach as used here assumes that risks within a class of compounds (e.g., for VOCs) are additive. This does not take into account possible synergistic or antagonistic effects among the compounds.

It should be noted that risks as characterized above provide some insight into general effects upon animals in the local population. However, they do not indicate if population-level effects will occur. Such an assessment requires careful consideration of the local factors affecting populations. We assume that if effects are judged to be insignificant at the average individual level they are probably insignificant at the population level. However, if risks are present at the individual level they may or may not be important at the population level.

7.5.1 Goss Cove Landfill

Contaminants in ground water are predicted to be discharging to the Thames River.

However, most of the organic compounds detected in ground water at this location were at concentrations well below their AWQC or NOAELs (Table 7-5). The exceptions were naphthalene and 2,4-dimethylphenol whose maximum concentrations detected in one ground water sample were above their respective NOAELs. The average ground water concentrations of these compounds for this site were below the NOAELs. Since the average ground water concentration is more representative of concentrations discharged to the Thames River from this site, the organic compounds in ground water at Goss Cove Landfill are unlikely to pose a risk to aquatic biota in the river.

Of the metals detected in ground water, maximum concentrations of arsenic, cadmium, copper, iron, and lead and average concentrations of arsenic, cadmium, copper, and iron were above their AWQC. The AWQC for iron, 1000 ug/l, is based on aesthetic reasons rather than on toxicity (EPA, 1986). Therefore, its exceedance does not necessarily result in a toxic risk to aquatic biota. Maximum and average concentrations for the remaining metals were on the same order of magnitude as the AWQC. However, the average concentrations were elevated because they were calculated using one half the CRDL for non-detected concentrations; one half the CRDL for arsenic, cadmium, and copper is above the chronic AWQC. The concentrations discharged to the river are likely to be lower than the average concentrations due to adsorption to soil and sediment. Assuming a the estimated dilution of ground water discharge at the water:sediment interface for this site, the maximum exposure concentration in the river due to ground water discharge from the site will be on the order of 100 times less than the AWQC. Therefore, based on the ground water quality data collected to date, we do not expect the discharge of contaminants in ground water from the Goss Cove Landfill to pose a threat to ecological receptors in the Thames River.

7.5.2 DRMO and Lower Subase

The VOCs in ground water samples from the DRMO and Lower Subase sites were detected at concentrations well below their AWQC (Tables 7-6 and 7-7), and, therefore, their discharge to the Thames River is unlikely to pose an ecological risk.

The metals arsenic, cadmium, copper, iron, lead, nickel, and zinc were detected in ground water samples from these sites above their AWQC. As stated in the previous section, iron is not expected to pose an ecological risk. Although the other metals were detected above the lowest AWQC, average concentrations were on the same order of magnitude as the criteria. As ground water discharges to the Thames River, contaminant concentrations will be much less due to dilution of the ground water discharge at the water:sediment interface. Therefore, we do not expect these metals to pose an ecological risk to biota in the river.

7.5.3 Area A

This section characterizes the ecological risks due to site contaminants in Area A Wetland, Over Bank Disposal Area, and Downstream Watercourses.

7.5.3.1 Terrestrial - Risks to Plants Due to Metals in Soils

As discussed is Section 7.4.1, organic compounds detected in soils in Area A are not

expected to affect plant growth. Therefore, this section focusses on risks to plants in Area A due to metals.

Metals concentrations in soils and sediments in Area A are summarized in Table 7-10 (wetlands soils), Table 7-11 (downstream soils), and Table 7-12 (downstream sediments). Summary tables with the metals concentrations of individual soil samples are in Appendix F-2. These tables do not include metals totally excluded from risk assessment as described in Section (6.1.3). The tables have summary statistics of maxima and averages, and compare these data to what we are considering to be background concentrations (The 95% upper confidence limit on the geometric mean of soils data presented in Shacklette and Boerngen (1984)) and to soil clean-up guidelines based on toxicity to plants and to higher organisms (livestock and humans) that may eat plant products (Rinne, 1986).

Note that the vegetation in Area A is abundant and does not appear to be stressed. Potential risks to wetland plants are likely to be mitigated by the lack of sensitive species in this area. The plant species present in this area, such as the Phragmites in the wetland, are relatively tolerant of contaminants in soil. Phragmites are an opportunistic species that grow well in disturbed soil such as that of the Area A wetland.

The bioavailability of metals in soils and sediments is dependent on soil characteristics including pH, the oxidation/reduction potential of the soil, the presence of available sulfide, and cation exchange capacity. Metals toxicity to plants depends both on these soil characteristics and on the presence of other metals or salts that may prevent the plant from taking up the metal. The phytotoxicity of soil metal concentrations discussed here should be viewed as guidelines for potential toxicity rather than indicators of environmental harm.

The metals not detected in soil or sediments in Area A (from the ground surface to a depth of four feet) or detected at levels below background are aluminum, antimony, manganese, nickel, and the metals excluded from the human health risk assessment. These metals are at levels that can be considered naturally occurring in soils and sediments. Therefore, they do not pose a threat of ecological harm in this area.

The remaining metals to be addressed in this section are arsenic, beryllium, boron, cadmium, copper, iron, lead, mercury, selenium, and zinc. Overall, the risks to plants and higher trophic level organisms eating plants due to these metals appear to be low. The remainder of this section discusses these risks by area and by metal.

<u>Wetland</u>: Metals detected in wetlands soil and sediment samples above background or recommended clean-up levels (Rinne, 1986) included boron, cadmium, lead, and mercury. Boron was detected above the published background concentration of 109 mg/kg in many of the soil and sediment samples from Area A. Boron is an essential nutrient for plants (Buckman and Bradley, 1969). The availability of boron to plants is pH dependent; more boron is available at lower soil pH values. Boron toxicity is related to the water-soluble portion of the soil boron concentration. Depressed seed germination and reduced growth of dwarf beans has been attributed to water soluble boron toxicity (Lepp, 1981). Since we do not know the water soluble fraction of the boron detected in site soils and sediments, we are unable to assess its potential ecological risks. However, since vegetation at the site is not stressed despite the elevated levels

TABLE 7-10
RISKS TO PLANTS AND PLANT-EATING ORGANISMS FROM METALS IN SURFICIAL SOILS
AREA A WETLAND

	Number Analyzed	Number Detected	Minimum Concentration, mg/kg	Maximum Concentration, mg/kg	Average Concentration, mg/kg	Background Concentration, mg/kg	Number of Samples Above Background	Protective Criteria, mg/kg
Aluminum	18	18	4810	22200	16000.56	272000	0	
Arsenic	18	18	0.77	13.9	8.15	31.5	0	25
Beryllium	18	16	0.39	1.8	0.87	3.52	0	
Boron	18	17	71	4400	1385.57	109	16	
Cadmium	18	17	1.2	6.9	4.31	7	0	4
Copper	18	18	6.7	71.5	41.76	102	0	300
Iron	18	18	6540	44000	25802.22	115000	0	
Lead	18	18	3.6	298	72.95	53.2	7	500
Manganese	18	18	121	365	234.72	3794	0	
Mercury	18	12	0.22	0.69	0.29	0.51	2	1
Nickel	18	18	4.4	28.2	20.31	76.7	0	200
Selenium	18	14	0.7	1.6	0.96	1.79	0	2
Zinc	18	18	19.6	127	77.75	178	0	800

Notes:

1)Background concentration is 95% upper limit for Eastern U.S. (Shacklette and Boerngen, 1984); cadmium background concentration is from Dragun (1988) and Lisk (1972).

2) Protective Criteria developed by Rinne (1986).

3) Shading indicates soil concentrations above background.

TABLE 7-11
RISKS TO PLANTS AND PLANT-EATING ORGANISMS FROM METALS IN SURFICIAL SOILS
AREA A - DOWNSTREAM AND OBDA

	Number Analyzed	Number Detected	Minimum Concentration, mg/kg	Maximum Concentration mg/kg	Average Concentration, mg/kg	Background Concentration, mg/kg	Number of Samples Above Background	Protective Criteria, mg/kg
Aluminum	15	15	4080	26200	12773.33	271817	0	
Arsenic	15	15	0.58	39.9	7.94	31.5	1	25
Beryllium	15	14	0.37	1.8	0.81	3.52	0	
Boron	15	13	41	8300	1865.78	109	10	
Cadmium	15	14	1.2	30.1	7.23	7	3	4
Copper	15	15	10.6	118	31.69	102	2	300
Iron	15	15	7220	195000	44663.33	115000	2	
Lead	15	15	5	223	51.07	53.2	4	500
Manganese	15	15	94.6	1020	319.17	3794	0	
Nickel	15	15	4.4	44.6	17.95	76.7	0	200
Selenium	15	9	0.33	3.2	1.04	1.79	2	2
Zinc	15	15	18.2	2720	274.53	178	2	800

Notes:

1)Background concentration is 95% upper limit for Eastern U.S. (Shacklette and Boerngen, 1984); cadmium concentration from Dragun (1988) and Lisk (1972).

2) Protective Criteria developed by Rinne (1986).

3) Shading indicates soil concentration above background.

TABLE 7-12
RISKS TO PLANTS AND PLANT-EATING ORGANISMS FROM METALS IN SEDIMENTS
AREA A

	Number of Samples Analyzed	Number of Times Metal Detected	Minimum Concentration, mg/kg	Maximum Concentration, mg/kg	Average Concentration, mg/kg	Background Concentration, mg/kg	Number of Samples Above Background	Protective Criteria, mg/kg
Aluminum	13	13	1710	33100	12115.38	271817	0	
Arsenic	13	12	0.83	7.5	3.30	31.5	0	25
Beryllium	13	9	0.36	5.4	1.37	3.52	2	
Boron	13	12	60	4100	765.87	109	8	
Cadmium	13	13	1.2	13.8	4.45	7	2	4
Copper	13	13	8.8	94.3	31.62	102	0	300
Iron	13	13	8000	62400	19334.62	115000	0	
Lead	13	13	8.7	64.2	29.80	53.2	2	500
Manganese	13	13	102	657	231.85	3794	0	
Mercury	13	2	0.15	0.26	0.11	0.51	0	1
Nickel	13	13	4.1	27.9	12.92	76.7	0	200
Selenium	13	3	0.28	3	0.65	1.79	1	2
Zinc	13	13	37.7	617	125.32	178	2	800

Notes: 1)Background concentration is 95% upper limit for Eastern U.S. (Shacklette and Boerngen, 1984); cadmium background concentration from Dragun (1988) and Lisk (1972).

2) Protective Criteria developed by Rinne (1986).

3) Shading indicates sediment concentration above soil background.

of boron detected in soil throughout the area, it is likely that the risk to site vegetation due to boron soil and sediment concentrations is low. There is some evidence to suggest that boron concentrations in plant tissues are related to soil concentrations (Lepp, 1981). We are unable to assess whether the levels of boron in surficial soils and sediments in Area A pose a risk to higher trophic level organisms feeding on site vegetation.

Lead was detected above background levels in seven out of 18 samples (up to 298 mg/kg) and mercury was detected above background in two of 18 samples (up to 0.69 mg/kg). However, lead concentrations in these samples were below 500 mg/kg, a concentration toxic to some tree seedlings (Jaworski, 1979). Below a soil mercury concentration of 2 mg/kg, mercury does not build up in plant tissues to levels toxic to the plant (Monenco, 1984). Both these concentrations are considered protective of higher organisms (livestock and humans) feeding on plant tissues. Therefore, we do not expect lead or mercury in wetland soils to pose an ecological risk.

Lower soil cadmium concentrations of 5 to 8 mg/kg have been demonstrated to be phytotoxic (Chaney, 1982; Kabata-Pendias, 1984; Davis et al., 1978). In comparison, soil background concentrations of cadmium may range up to 7 mg/kg (Dragun, 1988). Since phytotoxic cadmium concentrations may be within the range of background concentrations, cadmium toxicity depends on other site specific conditions such as soil pH and the presence of oxygen and on the cadmium tolerance of the plants present. Cadmium concentrations in shallow wetland soils (from the ground surface to a depth of 4 feet) exceeded 5 mg/kg in four samples and ranged up to 6.9 mg/kg. This indicates small potential risks to plants in the wetland. It is uncertain whether cadmium at these concentrations can be transferred to plant tissues at levels toxic to higher organisms (Rinne, 1986). However, vegetation in the wetland does not appear stressed and it is likely that the ecological risk posed by these levels of cadmium in wetland soil are minimal.

Downstream and Over Bank Disposal Area Soil: In surficial soils in the downstream area and the Over Bank Disposal Area, arsenic, boron, cadmium, copper, iron, lead, selenium, and zinc were detected at concentrations above background. Risks to plants due to boron were addressed previously.

Arsenic was detected above background in one soil sample in the Over Bank Disposal Area at a concentration of 39.9 mg/kg. This concentration is above a level reported to reduce crop yields in sensitive plants (25 mg/kg; Walsh and Keeney, 1975). Since sensitive species are unlikely to be present in this area, an elevated arsenic concentration was detected in only one sample, and vegetation on site appears robust, it is unlikely that arsenic in soil in this area is a source of ecological risk.

Although copper, lead, and selenium were detected in several surficial soil samples at concentrations above background in the downstream area, they were below guideline concentrations protective of plants and higher trophic level organisms eating the plants. Therefore, the presence of these metals in soils sediments in this area does not pose an ecological risk.

Eight out of 15 surficial soil samples in this area had cadmium levels potentially toxic to plants, up to 30.1 mg/kg. The cadmium distribution in this area is similar to that in wetland soils. As in the wetland, the lack of stressed vegetation in this area indicates that the ecological risks posed by cadmium to site vegetation are small. In three sediment samples from the Over Bank Disposal Area, however, soil cadmium concentrations were at levels that may pose risks to higher organisms feeding on plant tissues (Monenco, 1984).

Iron was detected above background (115,000 mg/kg) in two sediment samples from the Over Bank Disposal Area. Since iron is an essential element to plant nutrition, is relatively non-toxic (Forstner and Wittmann, 1981), and was detected above background in only two samples, its presence is unlikely to pose an ecological risk in Area A.

Zinc concentrations in soils were above background and phytotoxic levels in two samples from the Over Bank Disposal Area (410 and 2,720 mg/kg). Studies have shown zinc toxicity to plants at 200 to 400 mg/kg (Davis et al., 1978; Monenco, 1984). As with cadmium, the lack of stressed vegetation in this area indicates that risks to site vegetation due to zinc in surficial soils are low. Soil zinc concentrations at these levels could pose risks to higher trophic level organisms feeding on plants (NAS, 1980). However, since only two of 18 soil samples from the downstream area had elevated zinc levels, it is likely that the ecological risks due to zinc in soils in this area are low.

Downstream Area Sediments: Pond and stream sediments in the downstream area had concentrations of beryllium, boron, cadmium, lead, selenium, and zinc above background levels for surficial soils. In general, sediments in the unnamed ponds (Sample designations 2DSD1, 2DSD2, and 2DSD4) had more metals at concentrations above surficial soil background than other sediments. Concentrations were within background in the North Lake sediment sample (2DSD10) and in the downstream outfall sediment sample from the Thames River (2DSD13). Only boron was elevated above background in the upstream outfall Thames River sediment sample (2DSD12).

The elevated boron concentrations were detected in stream sediment samples from the eastern portion of the downstream area. Ecological risks due to soil and sediment concentrations of boron at the site were discussed previously.

Beryllium was detected above the 3.52 mg/kg background concentration for surficial soils in two sediment samples (2DSD1 and 2DSD2) from the easternmost pond. Beryllium was at background levels in stream sediment samples. Since the concentration in these samples was only slightly above background (4.1 and 5.4 mg/kg) and beryllium was not detected in pond water, the ecological risk due to beryllium in these pond sediments appears to be low.

Cadmium was detected in two sediment samples from the eastern pond (2DSD1 and 2DSD2) and in some stream sediments at concentrations above the 4 mg/kg guideline protective of both plants and organisms consuming those plants. The cadmium concentrations in the stream sediment samples were only slightly above this guideline. Although the pond sediment cadmium concentrations were higher (13.8 and 12.3 mg/kg), cadmium was not detected in the pond surface water. Therefore, the ecological risks due to cadmium in downstream sediments is low.

The lead concentration in a sediment sample from the central pond (2DSD4) and one stream sediment sample (2DSD7) exceeded background levels for surficial soils but were well below the 500 mg/kg guideline based on toxicity to plants and higher organisms consuming plants. Lead was not detected in the surface water sample from the central pond but was detected in the corresponding stream sample (2DSW7) slightly above the chronic ambient water quality criterion. Therefore, the ecological risks due to lead in downstream sediments is low.

Selenium was only detected above background level for surficial soils in the sediment sample from the central pond (2DSD4) at a concentrations of 3 mg/kg. This level slightly exceeds the guideline concentration of 2 mg/kg protective of plants and of organisms consuming plants. Selenium was not detected in the surface water sample from the central pond. Therefore, we believe that the ecological risks due to selenium in central pond sediments are low.

Zinc concentrations in sediments above surficial soil background levels were only detected in the two samples from the eastern pond (2DSD1 and 2DSD2). These concentrations of 617 mg/kg and 291 mg/kg were below levels shown to be phytotoxic but were above concentrations that could have potential toxic effects on higher organisms consuming the plants. However, since zinc concentrations in surface water samples from the eastern pond were well below the ambient water quality criteria, we conclude that the risks due to zinc in eastern pond sediments are low.

7.5.3.2 Terrestrial - Risks to Soil Invertebrates

Risks to soil invertebrates (e.g., earthworms, beetle larvae, soil insects) were evaluated using two methods and were examined for soils in Area A wetlands and downstream area. Bear in mind that we are referring to wetland soils; these samples were referred to as "sediments" in the other sections of this report. The methods include evaluation of exposure to contaminants in soil moisture using the Equilibrium Partitioning Approach, and evaluation of exposures to contaminants in ground water that may discharge to the surface of the wetlands.

Equilibrium Partitioning Approach

The Equilibrium Partitioning Method developed by the USEPA was used to evaluate the risks to soil invertebrates. Toxicity quotients that represent a chronic soil quality criterion for soil invertebrates divided by the sample concentration are compared on Figures 7-1A (VOCs), 7-1B (SVOCs), 7-1C (DDTR), and 7-1D (PCBs) for wetland soils and on Figures 7-2A (VOCs), 7-2B (SVOCs), 7-2C (DDTR), and 7-2D (PCBs) for soils in the downstream area. Calculations are in Appendix F-3.

The application of the EP Method to soils assumes that soil invertebrates will be exposed continuously to soil moisture in the same sense that benthic invertebrates may be exposed to interstitial pore water. This assumption is conservative. In recognition of this conservative assumption, we consider that a potential for risk to soil invertebrates exists for locations in the wetlands with toxicity quotients of 10 or greater, i.e., an order of magnitude greater than what is typically evaluated for aquatic sediments. Because of the uncertainty associated with this assessment, results should be viewed as qualitative.

Figure 7-1A . Chronic Risk to Soil Invertebrates by Sample Location for VOCs in Area A Wetland Soil; Equilibrium Partitioning Method

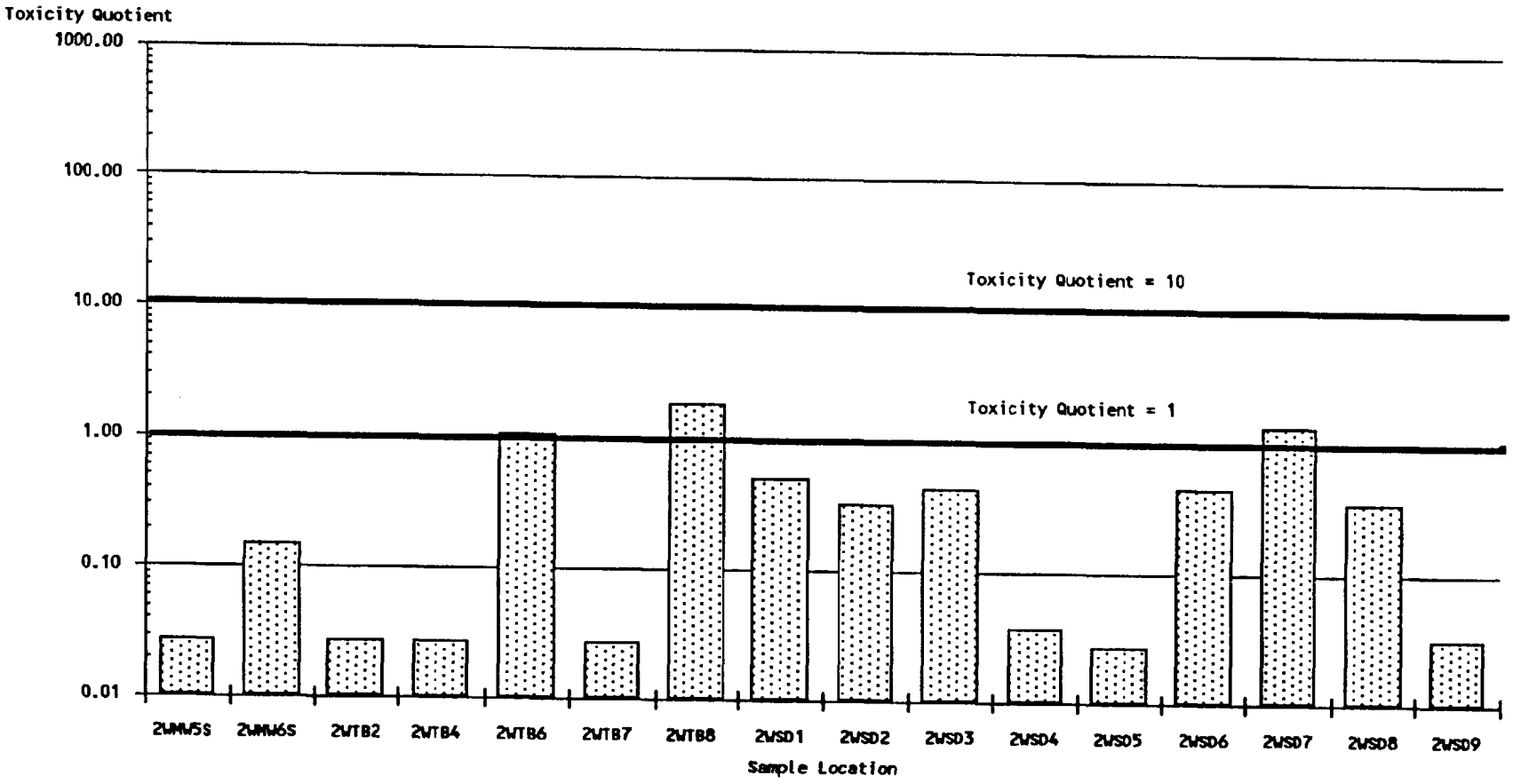


Figure 7-18 Chronic Risk to Soil Invertebrates by Sample Location for SVOCs in Area A Wetland Soil; Equilibrium Partitioning Method

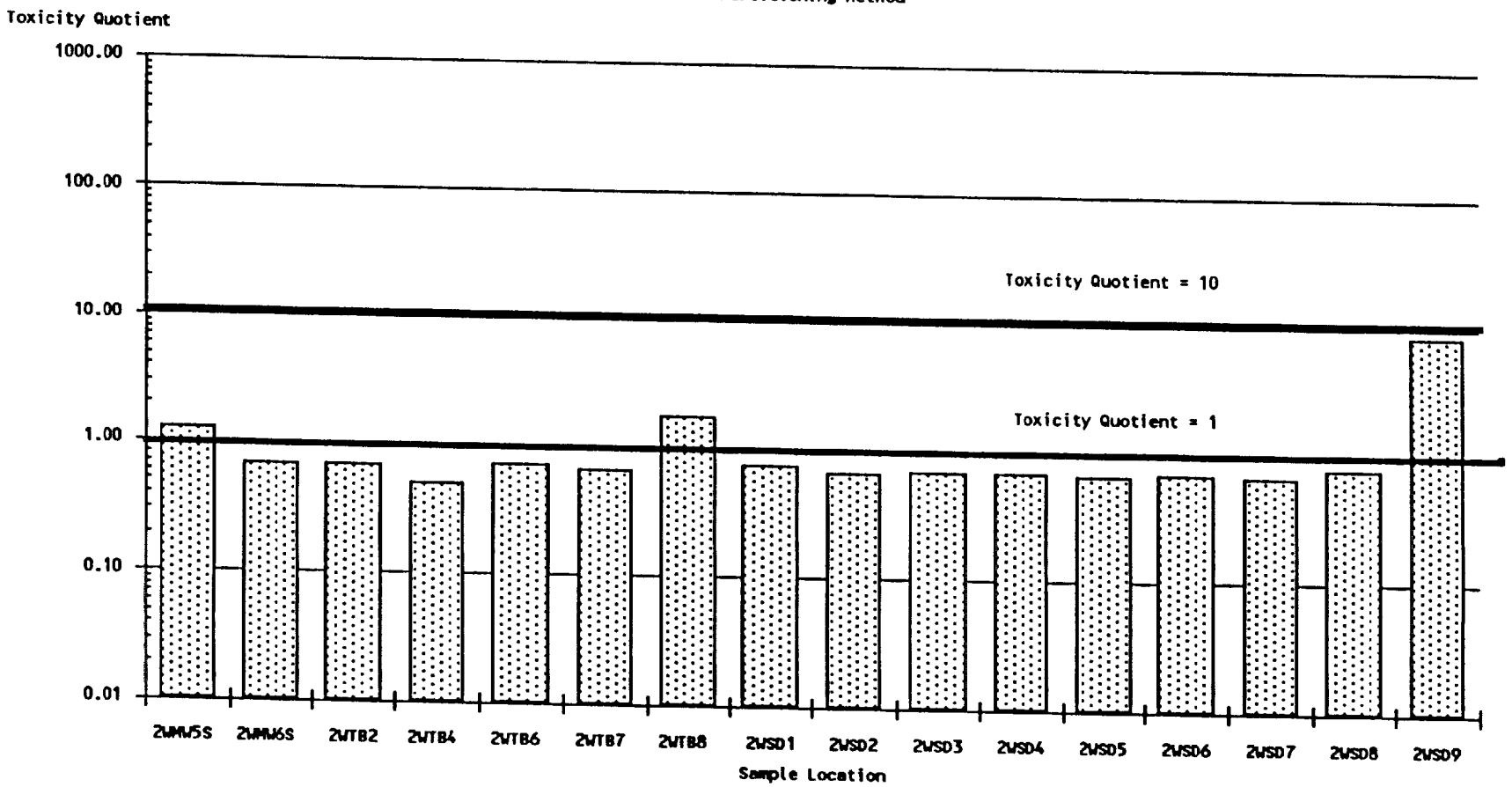


Figure 7-1C Chronic Risk to Soil Invertebrates by Sample Location for DDTR in Area A Wetland Soil; Equilibrium Partitioning Method

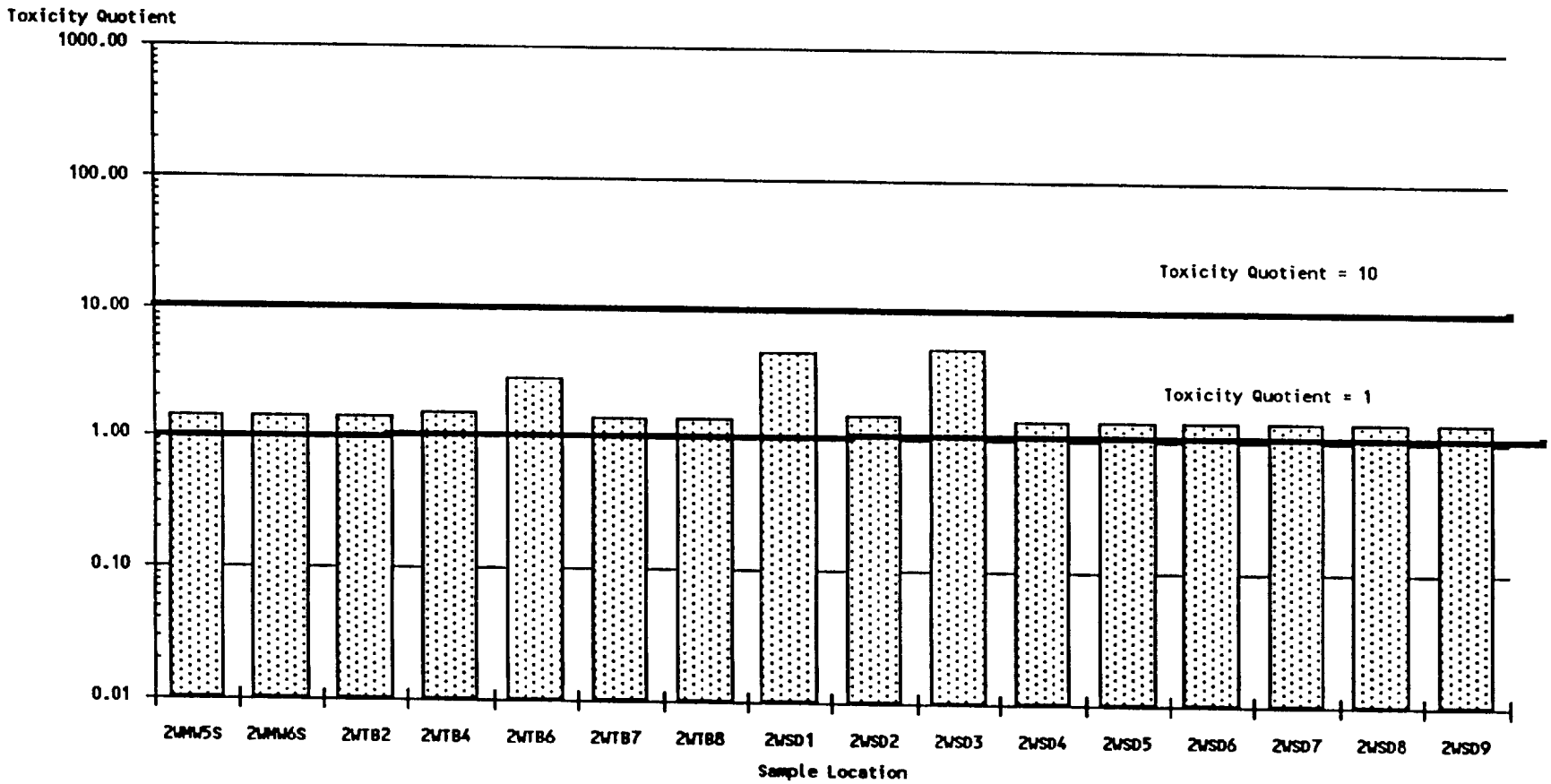


Figure 7-1D Chronic Risk to Soil Invertebrates by Sample Location for PCBs in Area A Wetland Soil; Equilibrium Partitioning Method

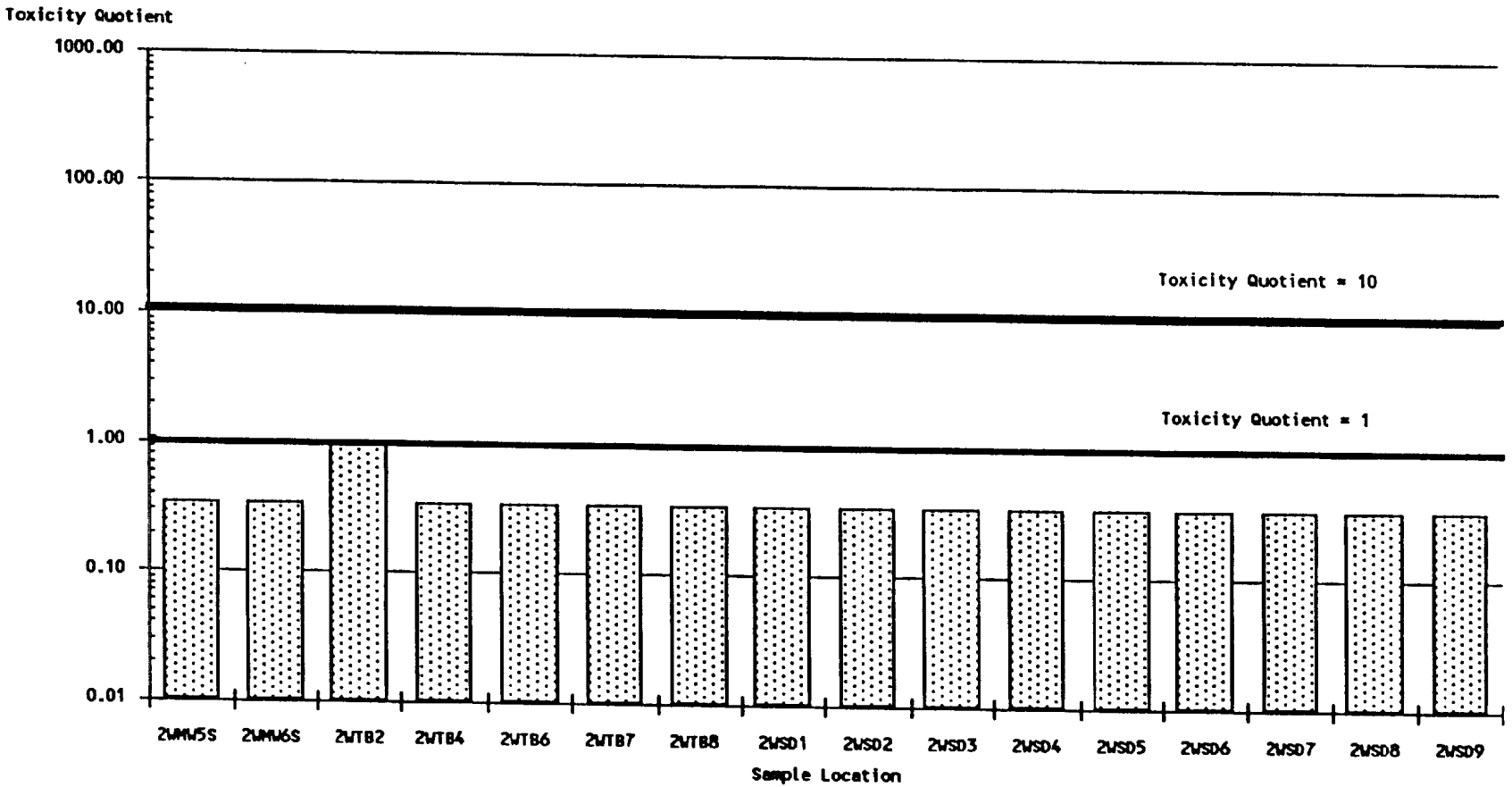


Figure 7-2A. Chronic Risk to Soil Invertebrates by Sample Location for VOCs in Area A Downstream and OBDA Soils; Equilibrium Partitioning Method

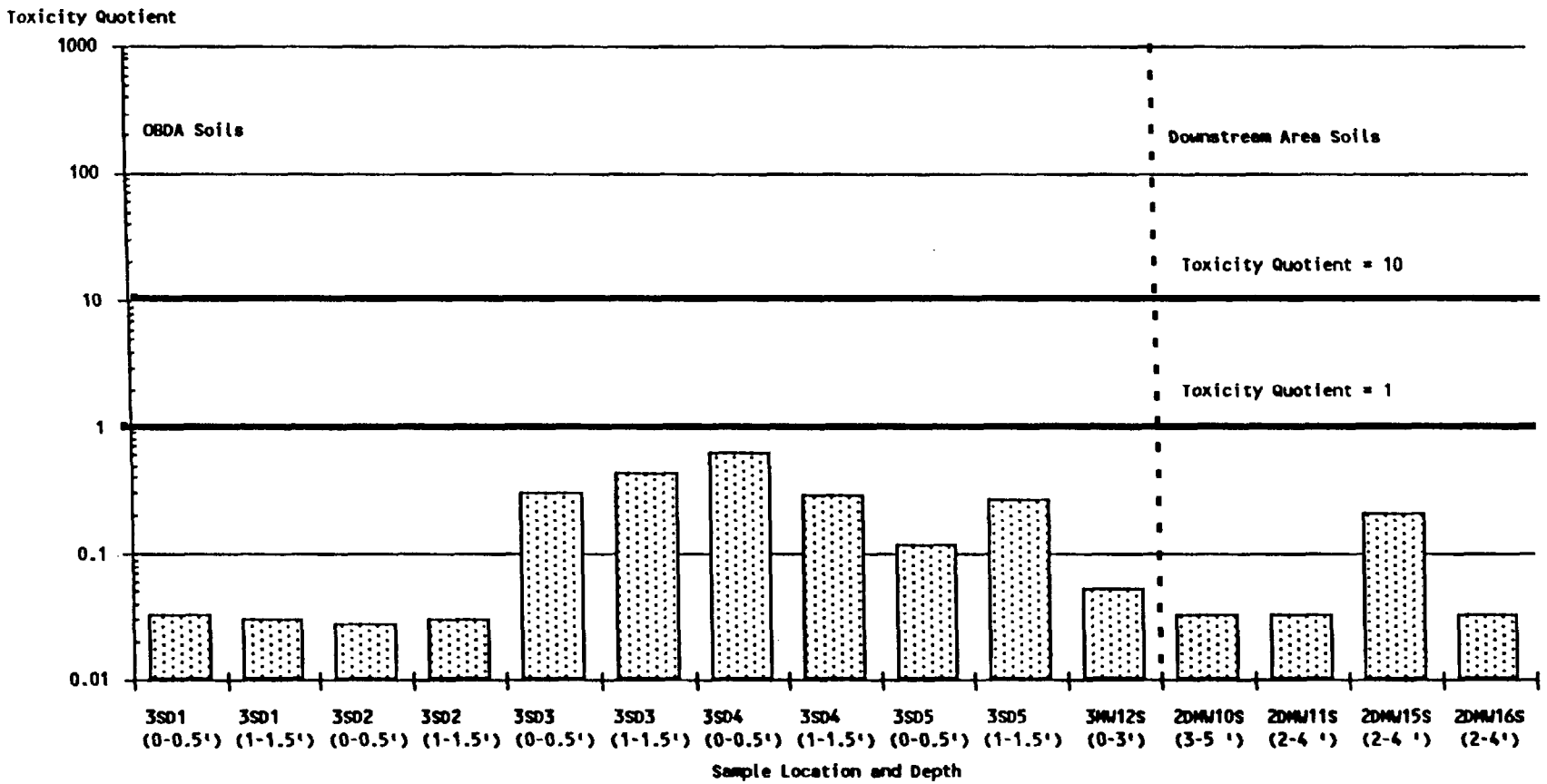


Figure 7-28. Chronic Risk to Soil Invertebrates by Sample Location for SVOCs in Area A Downstream and OBDA Soils; Equilibrium Partitioning Method

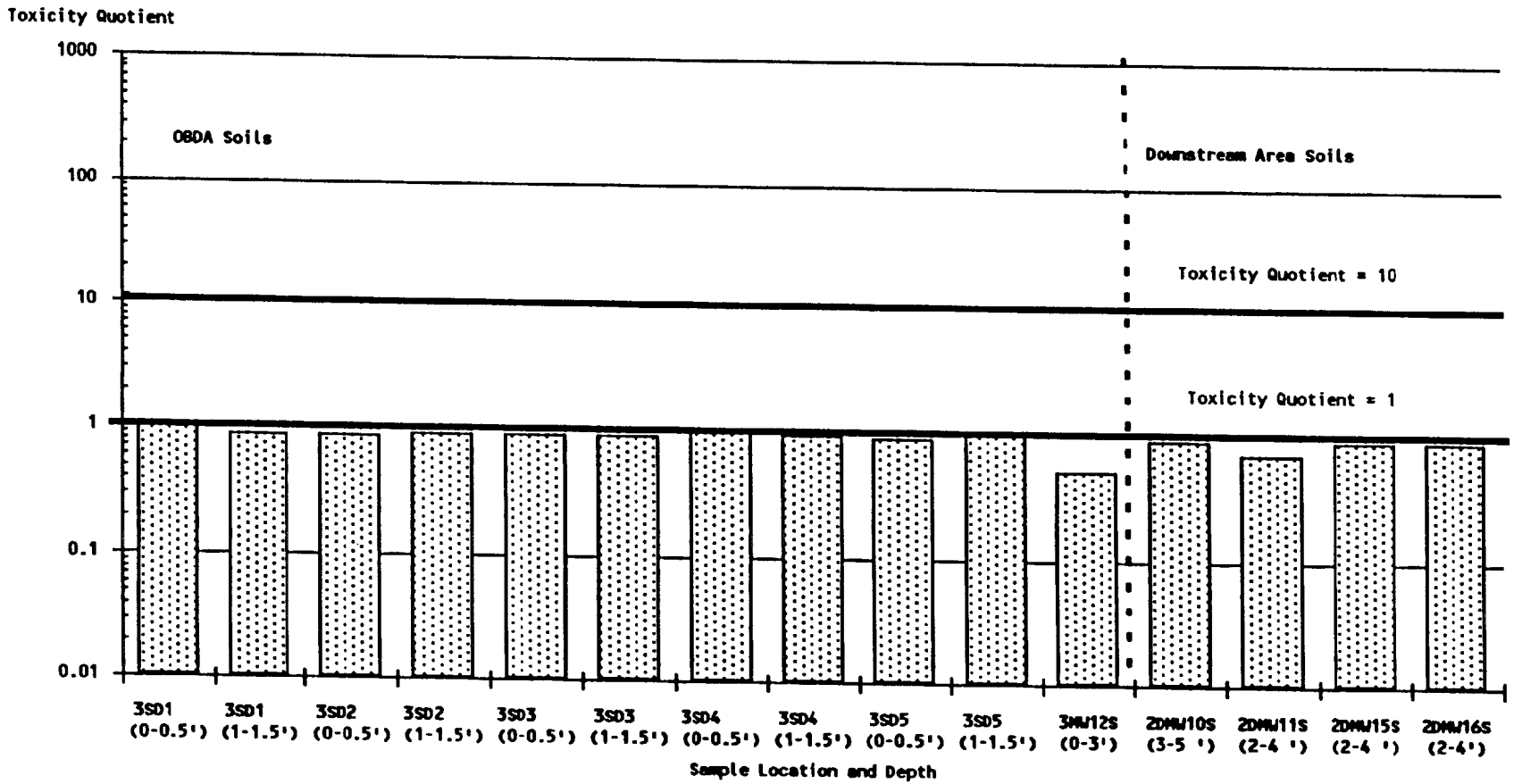


Figure 7-2C. Chronic Risk to Soil Invertebrates by Sample Location for DDTR in Area A Downstream and OBDA Soils; Equilibrium Partitioning Method

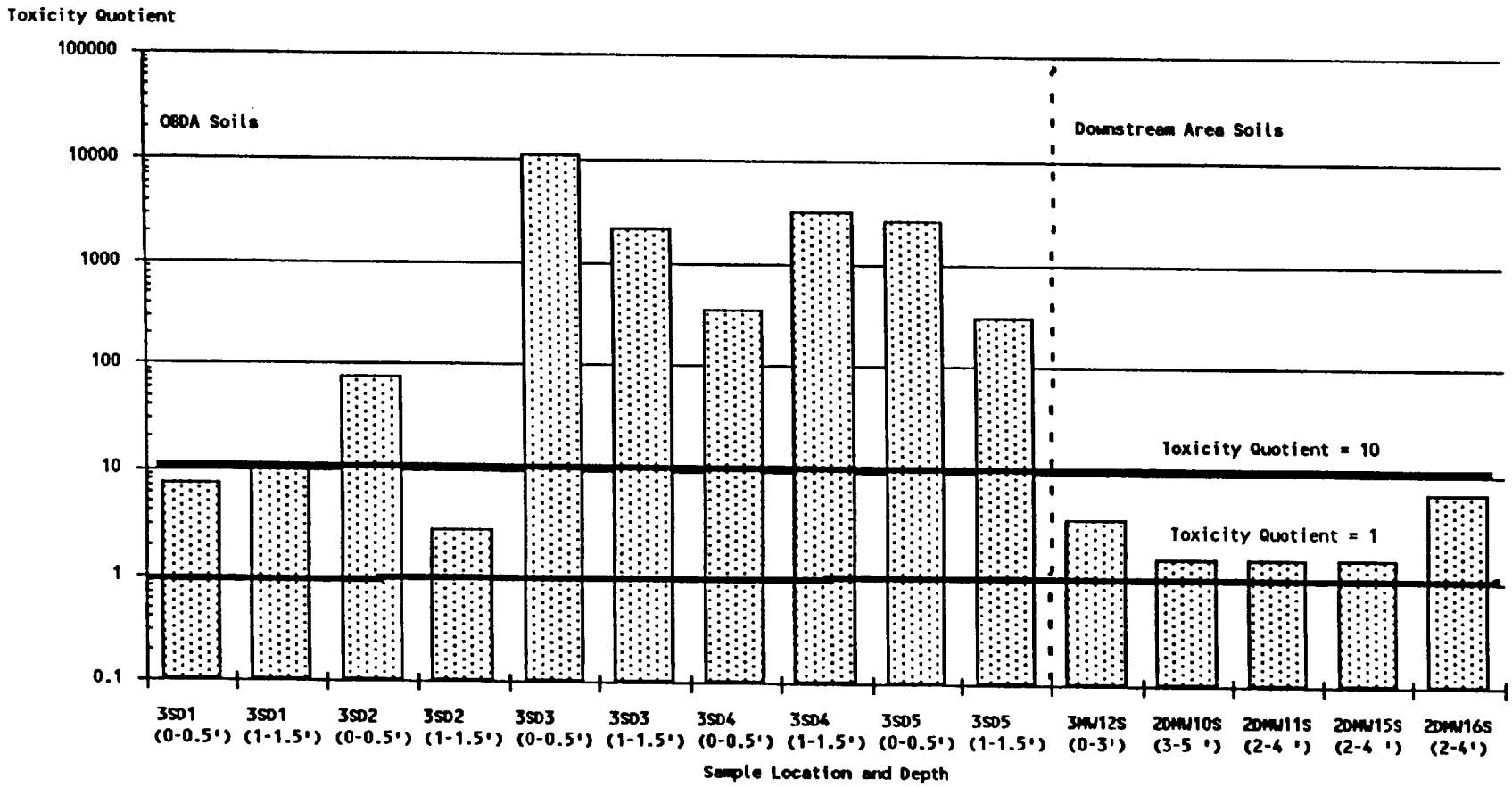
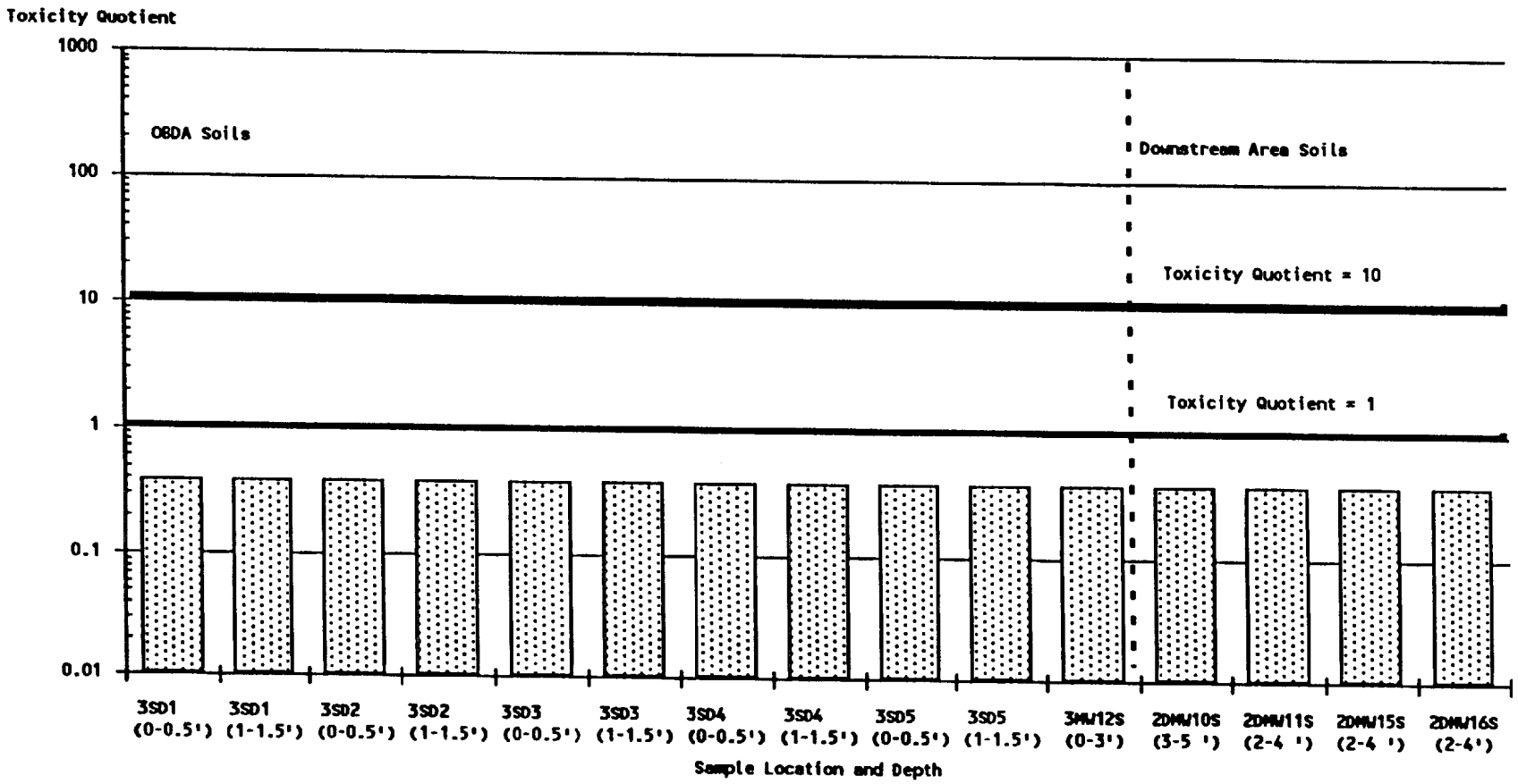


Figure 7-2D. Chronic Risk to Soil Invertebrates by Sample Location for PCBs in Area A Downstream and OBDA Soils; Equilibrium Partitioning Method



Area A Wetland: Toxicity quotients derived by the equilibrium partition method for soil invertebrates in the Area A wetland were generally low indicating a low potential of risk to soil invertebrates, the organisms in this area receiving the greatest exposure to site contaminants. Toxicity quotients in Area A wetland soils were less than ten; a few locations had quotients greater than one. Two sample locations in the northern corner of the wetland, 2WSD7 and 2WTB8, had toxicity quotients slightly greater than 1 for acetone. As discussed in Section 4.0, the detection of acetone in the samples may not have been representative of site conditions as acetone is a possible laboratory contaminant. The remaining toxicity quotients for VOCs were well below 1 indicating that VOCs in Area A Wetland soils do not represent an ecological risk to soil invertebrates. One surficial soil sample location, 2WTB8, had a toxicity quotient slightly greater than 1 for bis(2-ethylhexyl)phthalate and sample 2WMW5S had a toxicity quotient near 1 for this compound. This may not represent a risk as this compound is ubiquitous in the environment due to its use as a plasticizer. Sample location 2WSD9 just to the west of Area A Wetland near the Weapons Center had toxicity quotients above 1 but below 10 for several polynuclear aromatic hydrocarbons (PAHs). The remaining sample locations had toxicity quotients for semi-volatile organic compounds well below one.

The pesticides detected in Area A Wetland soils and sediments were DDT and its breakdown products DDE and DDT (DDTR). Since detection limits for DDTR in soil and sediment were relatively high and we calculated our toxicity quotient based on one half the average sample quantitation limit for sample locations where a compound was not detected,locations where DDTR was not detected had a pesticide toxicity quotient of 1.4. Although a few soil/sediment sample locations in the Area A Wetland had DDTR toxicity quotients greater than 1.4, none had quotients greater than ten.

One wetland soil sample location, 2WTB2, had a toxicity quotient near 1 for PCBs. The remaining soil sample locations in Area A Wetland had PCB toxicity quotients well below 1.

Although the toxicity quotient approach indicates the potential for risk to soil invertebrates in a few locations in Area A Wetland, overall the potential risk appears to be low. However, the previous verification study detected DDTR at some locations within the wetland area at higher concentrations than this study which could suggest a higher potential risk.

Area A Downstream: In Area A Downstream, DDTR poses a slight risk to soil invertebrates at some locations. Toxicity quotients for the other classes of compounds were well below one. Relatively few (5) shallow soil samples were collected from Area A Downstream and of these, only one represents surficial soil (from the ground surface). The other samples came from depths less than 4 feet from the ground surface but greater than 2 feet. As in the Area A Wetlands, some samples (2DMW10S, 2DMW11S, and 2DMW15S) had DDTR toxicity quotients greater than 1 due to high detection limits. Sample locations 3MW12S (the surficial sample) and 2DMW16S had DDTR toxicity quotients greater than 1 but less than 10.

Over Bank Disposal Area: In the Over Bank Disposal Area, toxicity quotients for DDTR ranged up to 11,000 indicating substantial risk to soil invertebrates from DDTR in soil and sediments. Toxicity quotients for the other classes of compounds were well below 1.

Evaluation of Risks to Soil Invertebrates Due to Ground Water Discharge to Surface Soils

The second approach used to evaluate potential risks to soil invertebrates considered periodic discharge of ground water to the ground surface. Concentrations of contaminants in ground water were compared to acute and chronic No Observed Adverse Effect Levels for the compounds derived from reviews of the literature (Table 7-4). Toxicity quotients exceeding "1" were judged to indicate some potential for risk. Toxicity quotients for total metals are compared on Figure 7-3. Calculations of toxicity quotients for individual metals are in Appendix F-4.

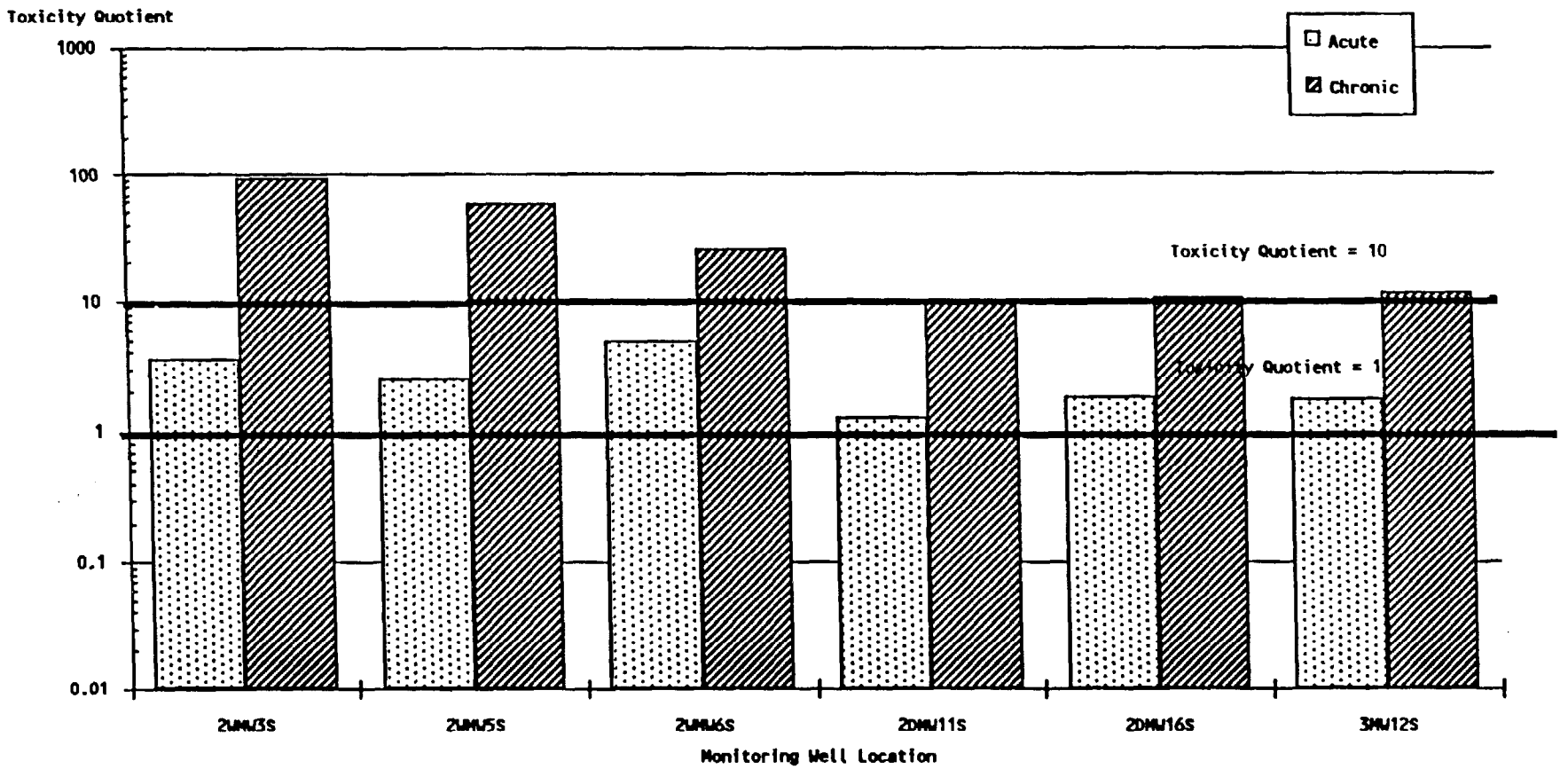
With the exception of a very low concentration of total xylenes detected in one well in the Area A wetland, synthetic organic compounds were not detected in shallow ground water in the Area A Wetland, Downstream, or the Over Bank Disposal Area. Therefore, there is no risk to soil invertebrates in these areas from organic compounds in ground water.

Toxicity quotients for individual metals in ground water discharged to the ground surface exceeded one at several locations but did not exceed ten. Total metal toxicity quotients, assuming additivity, ranged from one to ten for acute risks and ten to 100 for chronic risks. A toxicity quotient in this range may only reflect a slight potential for risk to soil invertebrates since environmental processes may transform metals and reduce their dissolved concentrations when the ground water reaches the ground surface. Ground water in wetland areas which are characterized by organic soils can be anoxic due to microbial degradation of organic carbon. Many metals present in naturally occurring levels in soils are more soluble in an anoxic environment (low Eh). When anoxic ground water discharges to the oxygenated surface environment, some of the metals may precipitate or floc and not be bioavailable in the dissolved form.

Toxicity quotients for metals in ground water that may be discharged to the ground surface in Area A indicate slight potential acute risks to soil invertebrates due to aluminum, cadmium, and zinc, and slight potential chronic risks due to arsenic, beryllium, copper, and mercury. Toxicity quotients for these metals for some ground water samples ranged up to ten. The samples of shallow ground water that had toxicity quotients in this range for aluminum, cadmium, and zinc came from well 2WMW3S (cadmium) in the eastern portion of the Area A Landfill, well 2WMW5S (cadmium) in the center of the Area A Wetland, and well 2WMW6S (aluminum and zinc) just east of the Area A Wetland and south of the Weapons Center. Well 2WMW5S is closer to a ground water discharge area and may better represent risks to soil invertebrates in this area.

In Area A Downstream and the Over Bank Disposal Area, toxicity quotients between 1 and 10 for individual metals in shallow ground water possibly discharging to the ground surface indicate a slight potential for chronic risk due to some metals at a few locations. At well location 2DMW11S on the eastern end of the downstream area, toxicity quotients for arsenic, beryllium, cadmium, and mercury indicate slight potential chronic risk to soil invertebrates. Toxicity quotients also indicate slight potential chronic risks due to these metals plus copper at well locations 2DMW16S east of North Lake and 3MW12S in the Over Bank Disposal Area. As well 3MW12S is close to a ground water discharge area, it may better represent risks to soil invertebrates in this area.

Figure 7-3. Acute and Chronic Risk to Soil Invertebrates by Monitoring Well Location for Total Metals in Area A Ground Water



Overall, risks to soil invertebrates due to the periodic discharge of ground water to the ground surface in Area A are low. The potential slight risks in this area are due to the metals aluminum, arsenic, beryllium, cadmium, mercury, and zinc in ground water.

7.5.3.3 Terrestrial - Risks to Mammals and Birds

Risks to small mammals and birds were evaluated for DDTR and PAHs by estimating the body burdens of soil invertebrates and using this estimate to calculate a daily dose. These estimates were made for maximum and average DDTR and PAH soil concentrations in the Area A Wetland and Area A Downstream. These exposure levels were compared to dose/response thresholds for various biological endpoints (lethality, reproduction/development, and other chronic effects; Table 7-9).

We restricted this analysis to DDTR and PAHs based on professional judgement concerning toxicity of the compounds and concentrations in soil. Other compounds detected in these areas either were at concentrations that did not pose a risk to soil invertebrates, the most exposed biota on site, or were only detected at risk-posing levels in a few locations. Although PAHs were only at levels with toxicity quotients above one in a few locations, we evaluated their risk to small mammals and birds based on their elevated maximum and average soil concentrations and their potential for bioaccumulation in soil invertebrates. The average soil concentrations may be overestimates of actual concentrations since detection limits were high for many samples and averages were calculated using one half the average sample quantitation limit.

Small Mammals that Forage on Soil Invertebrates: In the case of small invertebrate-eating mammals, we assumed that the shrew represents the worst case exposure. Shrews can forage on soils invertebrates throughout the site and can consume up to their body weight per day. Shrews utilize habitat similar to Area A, and although they were not observed at the site, we included them in this analysis because they are likely to be found there and because they would be more likely to be exposed than other small mammals. We assumed that the shrews' diet would consist solely of soil invertebrates either from the Area A wetland or from the downstream watercourse area and that they consume their body weight in soil invertebrates per day. (By comparison, rats eat 5% of their body weight per day and mice 13%). The shrews estimated ingestion rate (dose) of DDTR and PAHs is in Table 7-13.

Comparing our estimated doses with DDTR doses that have been shown to produce toxic effects in small mammals (Table 7-9) shows that risks to shrews in the Area A wetland are minimal. The average estimated dose (0.004 mg/kg/day) and the maximum dose (0.01 mg/kg/day) are well below levels reported to cause toxic effects in small mammals. Similarly, based on the few surficial soil samples collected from Area A Downstream, estimated daily DDTR doses to shrews are at levels well below those shown to have toxic effects (maximum dose of 0.014 mg/kg/day and average dose of 0.006 mg/kg/day). In comparison, risks to shrews in the Over Bank Disposal Area due to DDTR are substantial. The average dose of 5.4 mg/kg/day exceeds reported lethal dose. Note that the assumptions in this estimate, especially the assumption that shrews are consuming only contaminated soil invertebrates from the site, are conservative. Shrews in the Over Bank Disposal Area are likely to consume soil invertebrates

TABLE 7-13 DAILY DOSE OF DDTR AND PAHS TO SMALL MAMMALS AND SONG BIRDS						
	Estimated Soil Invertebrate Body Burden (mg/kg) dry weight		Daily Dose Shrew (mg/kg/day) wet weight		Daily Dose Song Bird (mg/kg/day) wet weight	
	Maximum	Average	Maximum	Average	Maximum	Average
DDTR						
Area A Wetland	0.07	0.02	0.014	0.004	0.0028	0.0008
Over Bank Disposal Area	144	27	28.8	5.4	5.76	1.08
Downstream Area A	0.07	0.03	0.014	0.006	0.0028	0.0012
PAHs						
Area A Wetland	164	10	32.8	2	6.56	0.4
Over Bank Disposal Area	3.9	2.2	0.78	0.44	0.156	0.088
Downstream Area A	0.03	0.11	0.006	0.022	0.0012	0.0044

from a wider area and some of the invertebrates consumed are likely to contain lower body burdens of DDTR. Although our dose estimate is conservative, it serves to indicate the potential for risk to small insectivorous mammals in the Over Bank Disposal Area due to DDTR.

A dose of 0.79 mg/kg/day of PAH has been shown to have potential chronic effects on small mammals (HEAST, 1990). The estimated average dose to shrews feeding exclusively on soil invertebrates in the Over Bank Disposal Area and Downstream Areas are below this number indicating that risks to small insectivorous animals in these area are minimal. The maximum dose due to the ingestion of soil invertebrates in the Over Bank Disposal Area is at the level that has been shown to have potential chronic effects in small mammals. However, the average PAH dose due to ingestion of soil invertebrates is more representative of a shrew's exposure.

The average PAH dose from soil invertebrates in Area A Wetland is 2 mg/kg/day, well above a level shown to cause potential chronic effects in small mammals. However, this elevated average dose is due to one surficial soil sample from just to the west of the wetland (2WSD9) and east of the weapons center that had a PAH concentration 2 orders of magnitude above PAH concentrations in the rest of the wetland soil samples. When the average PAH dose is calculated without this sample, the average dose is a magnitude of order lower, approximately 0.2 mg/kg/day. Since this dose is more representative of PAH exposure concentrations to shrews in Area A Wetland, and it is lower than those causing potential chronic effects, the risk to shrews in this area due to PAHs in soil invertebrates is low.

Small Plant-Eating Mammals that Forage on Plant Matter and Seeds: Most mice and voles fall into this category as do squirrels and rabbits. Muskrats feed primarily on plant matter, although they will occasionally eat aquatic invertebrates. White Footed Mice, Eastern Gray Squirrels, and Muskrats were observed in Area A. Based on the results for small mammals foraging on soil invertebrates, it appears that there would be little risk in the Area A Wetlands to species that are largely herbivorous. None of the site compounds is likely to be biomagnified

in plant tissue. In fact, the main transport routes from soils to plants are via dusts and translocation of ground water into roots and stems. The levels of exposure via plant ingestion are expected to be less than those experienced by invertebrate-eating small mammals. Therefore, little or no risks are expected to these animals in the Area A Wetlands.

In Area A Downstream, although risks to small herbivores from ingestion of contaminated plant matter are small, the potential exists for contact exposure to DDTR and other contaminants in soils and stream sediments.

Larger Mammals with Large (10 acre) Forage Areas That Occasionally Visit the Site and Eat a Range of Foods (e.g., Raccoons): Larger animals such as raccoons and otters which were observed in Area A will have lower ingestion rates of contaminated soil invertebrates than shrews and smaller mammals. Their diet is varied, and they will also eat other site organisms such as aquatic invertebrates, frogs, and small birds and mammals that may accumulate DDTR and PAHs in their tissues. However, their foraging range is large compared to the portions of the wetland and downstream area contaminated with DDTR and PAHs. Therefore, it is likely that contaminated organisms from these areas represent a very small portion of their diet, and that risks to raccoons and otters due to ingestion of these compounds via bioaccumulation from site soils and sediments are low. These organisms may also have contact exposure to contaminated soils and sediments, but risks due to these exposures may be limited if the regions of Area A contaminated with DDTR and PAHs represent only a small portion of the animals range.

Small Song Birds that Feed Primarily on Invertebrates (e.g., Sparrows and Catbirds): In evaluating the dietary dose of DDTR to small invertebrate-eating birds, it was assumed that they would feed exclusively in one of the three areas of the site and that they would eat invertebrates in amounts approximating 20% of their body weight per day. The first assumption is judged to be quite conservative and it is expected based on work elsewhere that birds will not feed exclusively on soil invertebrates nor will they feed exclusively at the site.

Contaminant ingestion rates for these small birds are presented in Table 7-13. Based on these assumptions, we do not expect DDTR or PAHs in Area A Wetland or Downstream soils to pose risks to small birds since estimated daily doses of these contaminants are well below a dose of 0.08 mg/kg/day that may have potential reproductive effects (Garten and Trabalka, 1983). The average and maximum doses (1 and 6 mg/kg/day, respectively) from the ingestion of soil invertebrates from the Over Bank Disposal Area are less than a potentially lethal dose of 8 mg/kg/day (Lamb et al., 1970), but could pose a risk to small birds due to reproductive or developmental effects. However, the assumption that birds will feed exclusively in this small area is very conservative and overall potential risks to small invertebrate-eating birds in Area A are small.

Birds collected from Area A and analyzed for contaminants had low body burdens of DDTR (less than 0.75 to 1 mg/kg) relative to birds collected from other sites with elevated pesticide levels in soils. In a previous study using the same offsite reference area in Plymouth, Massachusetts (Menzie et al., 1991), DDTR concentrations in Gray Catbirds from the reference area ranged up to 0.21 mg/kg and averaged 0.078 mg/kg. The body burden of Gray Catbirds in the previous study from an area with up to 1777 mg/kg DDTR in surficial soil ranged up to

7.1 mg/kg and averaged of 3.7 mg/kg. The DDTR body burdens of Gray Catbirds from Area A were closer to the range of body burdens of the offsite control birds. Based on these low DDTR body burdens in Gray Catbirds, the risks to invertebrate-eating song birds from DDTR in surficial soils in area A are expected to be small.

Small Song Birds that Feed Primarily on Plant Matter and Seeds (e.g., Chickadees): These bird species will be less at risk than species that feed on soil invertebrates. Therefore, little or no risk is expected for plant or seed eating birds.

Aquatic Birds that Occasionally Feed on Submersed Vegetation and Aquatic Organisms in the Ponds (e.g., Mallards, Herons): Ducks and other aquatic birds that visit the ponds in Area A may ingest sediment contaminated by DDTR as they feed on submersed aquatic vegetation. They may also feed on aquatic invertebrates and other small aquatic organisms (e.g. frogs) from the ponds. This exposure is likely to form only a small part of the birds' diet as these species are not resident on the ponds and may feed over a wide geographic area. Therefore, it appears that the risks to these birds due to the presence of DDTR in pond sediments is low.

Birds of Prey with Large Foraging Areas that Occasionally Forage at the Site (e.g., Hawks): Hawks and other birds of prey may occasionally feed on small mammals and birds from the site. We have estimated wet weight concentrations of DDTR in invertebrate-eating birds and mammals that feed in the three subregions of the site (Table 7-14). The results indicate that there is some potential for appreciable amounts of DDTR to bioaccumulate in small birds (on the order of 60 mg/kg in small birds) and mammals assuming that they feed exclusively on a diet of soil invertebrates from the Over Bank Disposal Area. In comparison, Gray Catbirds collected from Area A did not have detectable levels of DDTR in their tissues. The Over Bank Disposal Area is likely to represent only a very small part of a hawk's foraging area. If the hawk fed exclusively on birds and mammals that fed exclusively on contaminated soil invertebrates from the Over Bank Disposal Area, the DDTR concentration in the diet of the hawk could be substantial. However, since a hawk's diet would include only occasional small birds or mammals that feed occasionally on soil invertebrates from the Over Bank Disposal Area, the ecological risk to birds of prey who use the area as part of their foraging territory is expected to be insignificant.

TABLE 7-14
BIOACCUMULATION OF DDTR IN SMALL MAMMALS AND SONG BIRDS

	Estimated Soil Invertebrate Body Burden (mg/kg) dry weight		Daily Dose Shrew (mg/kg/day) wet weight		Daily Dose Song Bird (mg/kg/day) wet weight	
	Maximum	Average	Maximum	Average	Maximum	Average
Area A Wetland	0.07	0.02	0.014	0.004	0.0308	0.0088
Over Bank Disposal Area	144	27	28.8	5.4	63.36	11.88
Area A Downstream	0.07	0.03	0.014	0.006	0.0308	0.0132

7.5.3.4 Aquatic - Risks to Benthic Invertebrates in Streams and Ponds in Area A Downstream

The Equilibrium Partitioning approach was used to evaluate the risks to benthic invertebrates from contaminants in sediments in streams and ponds in Area A Downstream. Toxicity quotients are compared on Figures 7-4A (VOCs), 7-4B (SVOCs), 7-4C (DDTR), and 7-4D (PCBs). Calculations are in Appendix F-5.

Downstream Ponds: Two of the sediment samples, 2DSD1 and 2DSD2 were collected from the eastern pond; one sediment sample came from the center pond (2DSD4); and one came from the center of North Lake (2DSD4). For the pond sediment samples, toxicity quotients indicated risks to benthic invertebrates for DDTR but not for VOCs, SVOCs, or PCBs.

Toxicity quotients indicate substantial risks to benthic invertebrates in the eastern and central ponds due to DDTR. The toxicity quotients in these locations range from 630 for a sample from the eastern pond to 64,000 for a sample from the central pond.

Chemical analysis did not detect DDTR in the sediment sample collected from North Lake. The DDTR toxicity quotient for this sample was 1.6 due to elevated detection limits. Therefore, based on the analytical results from one sample, risks to benthic invertebrates in North Lake are minimal.

Downstream Area Streams: Downstream of the eastern and central ponds, toxicity quotients for VOCs, SVOCs, and PCBs do not indicate risks to benthic invertebrates for these compounds.

Toxicity quotients for DDTR in the downstream area streams range up to 890 in the northernmost stream and up to 28 in the southern stream. The risk to benthic invertebrates in the streams is high based on available data. Additional field observations would be needed to make a more definitive statement concerning the nature and condition of invertebrates in the streams. Sediment samples at the outlet of the streams in the Thames River had toxicity quotients for DDTR of 6 (2DSD12) and 10 (2DSD13) indicating transport of DDTR at levels that pose potential risks to benthic invertebrates from the downstream area to the outfall area in the Thames River.

7.5.3.5 Aquatic - Risks to Fish in Area A Ponds

Fish were not observed but may be present in the ponds in Area A. We assessed risks to fish that may reside in the Area A ponds by comparing surface water concentrations with Ambient Water Quality Criteria (AWQC) or literature toxicity values (Table 7-8). Fish are not anticipated to be present in the downstream watercourses due to low and intermittent flow; therefore, risks to fish in these streams were not evaluated. We are unable to assess potential risks to fish that may reside in the pond in the Area A wetland, because surface water samples were not collected there. Of the compounds analyzed for, only the metals cadmium, copper, lead, and mercury exceeded AWQC or toxicity values in surface water samples. In the eastern pond in the Area A downstream watercourse area, the chronic AWQC for copper and lead were slightly exceeded in one out of two samples. A surface water sample from the central pond in

Figure 7-4A. Chronic Risk to Benthic Invertebrates by Sample Location for VOCs in Area A Pond and Stream Sediments; Equilibrium Partitioning Method

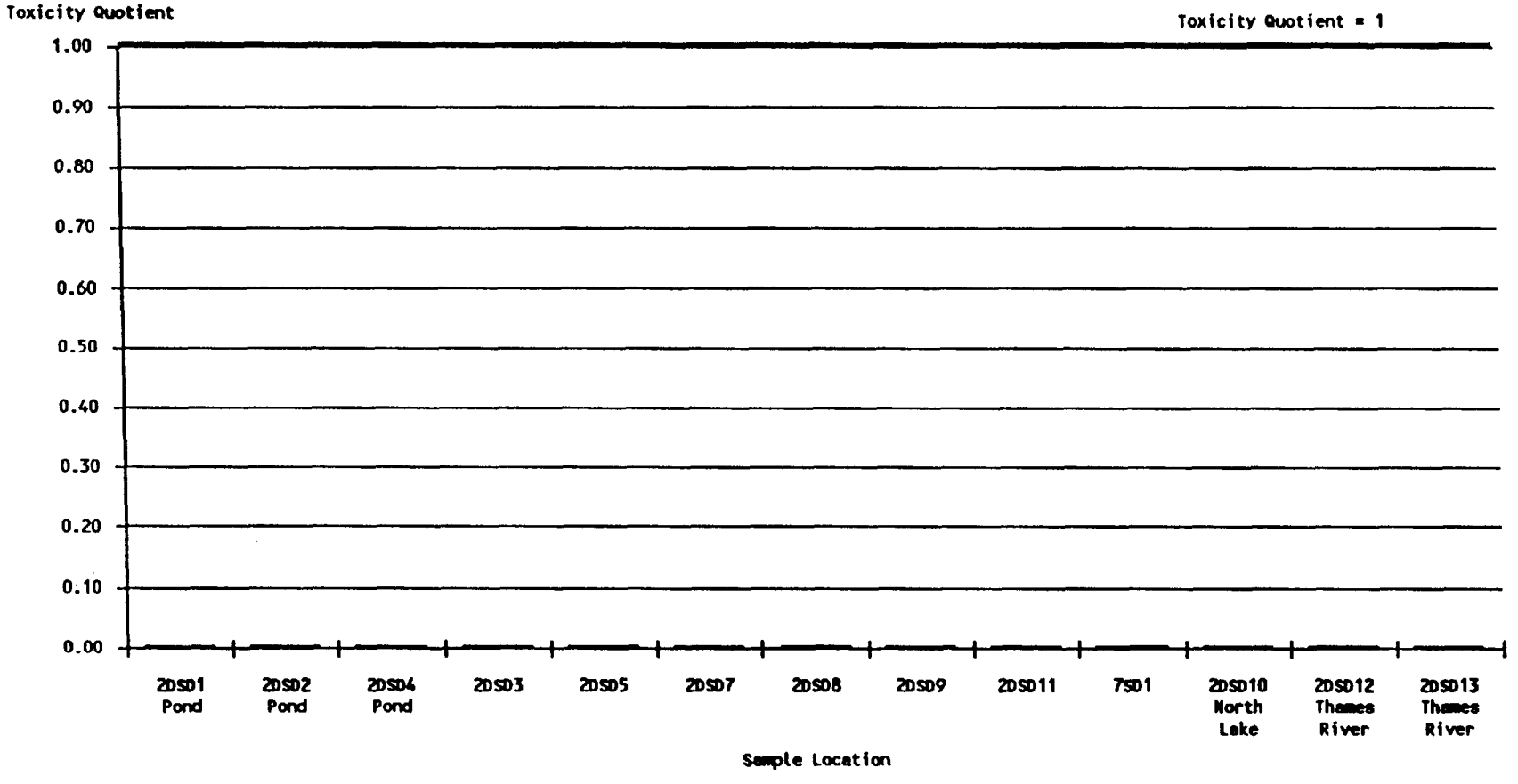


Figure 7-4B. Chronic Risk to Benthic Invertebrates by Sample Location for SVOCs in Area A Pond and Stream Sediments; Equilibrium Partitioning Method

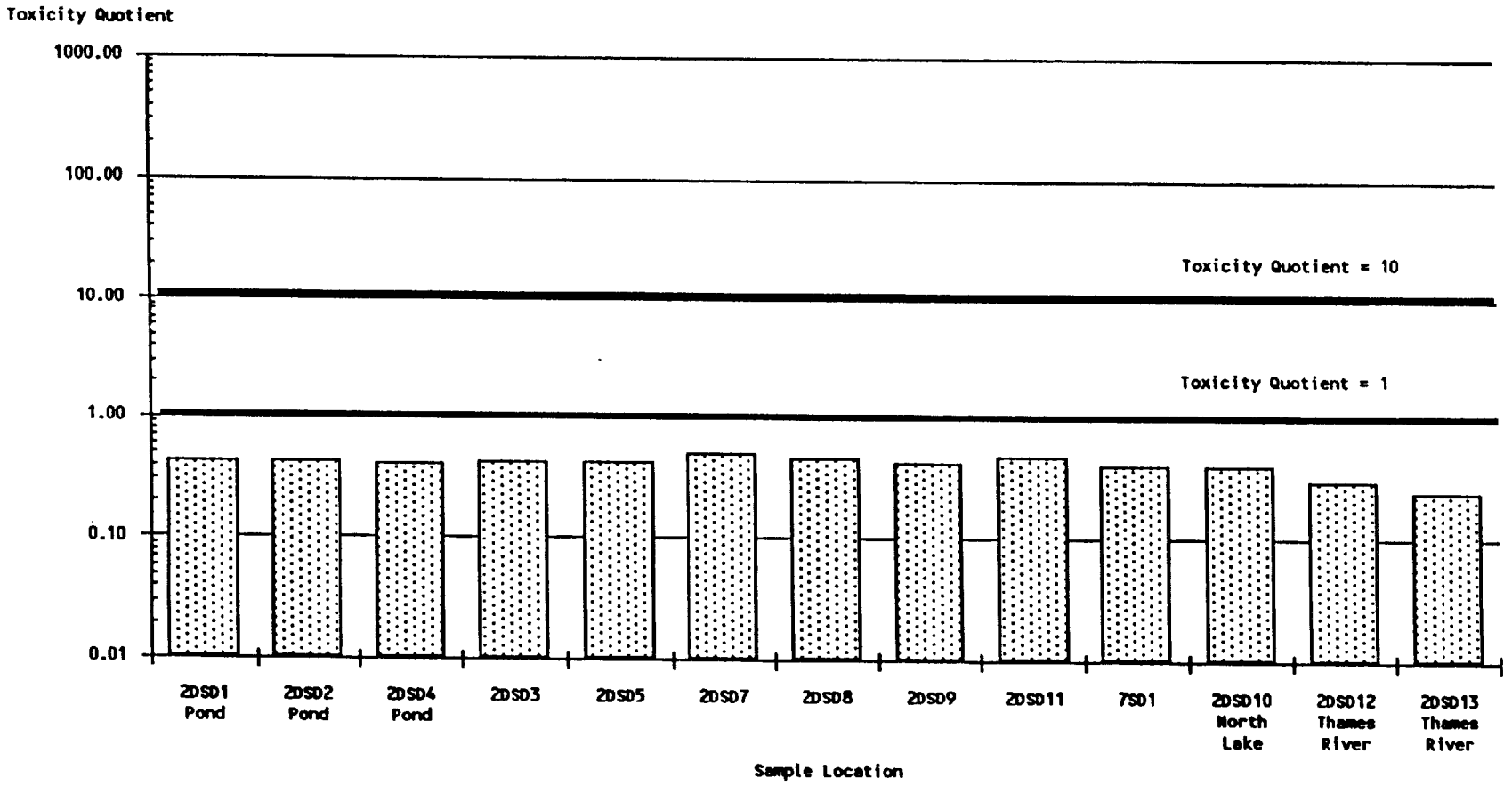


Figure 7-4C. Chronic Risk to Benthic Invertebrates by Sample Location for DDTRs in Area A Pond and Stream Sediments; Equilibrium Partitioning Method

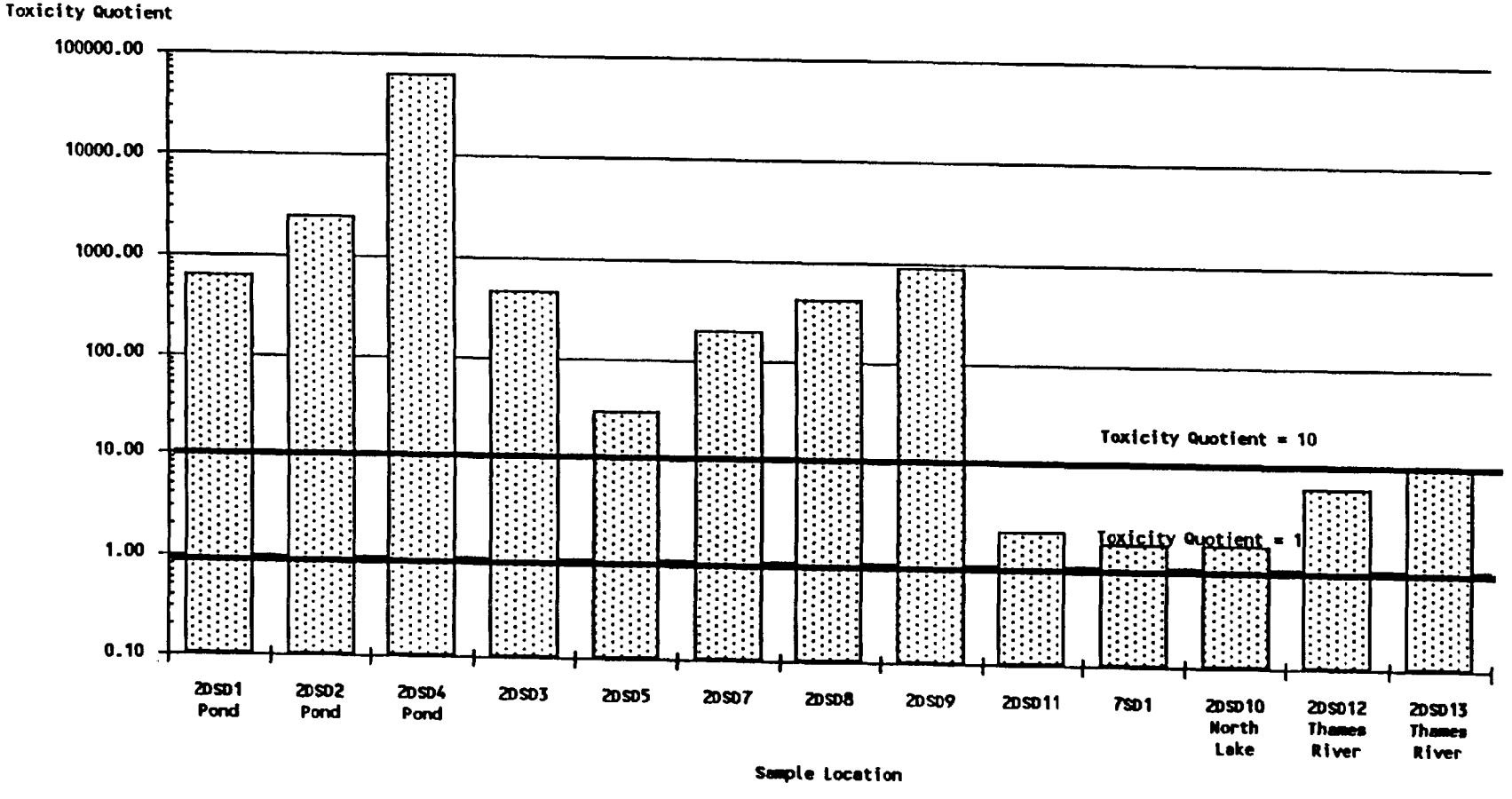
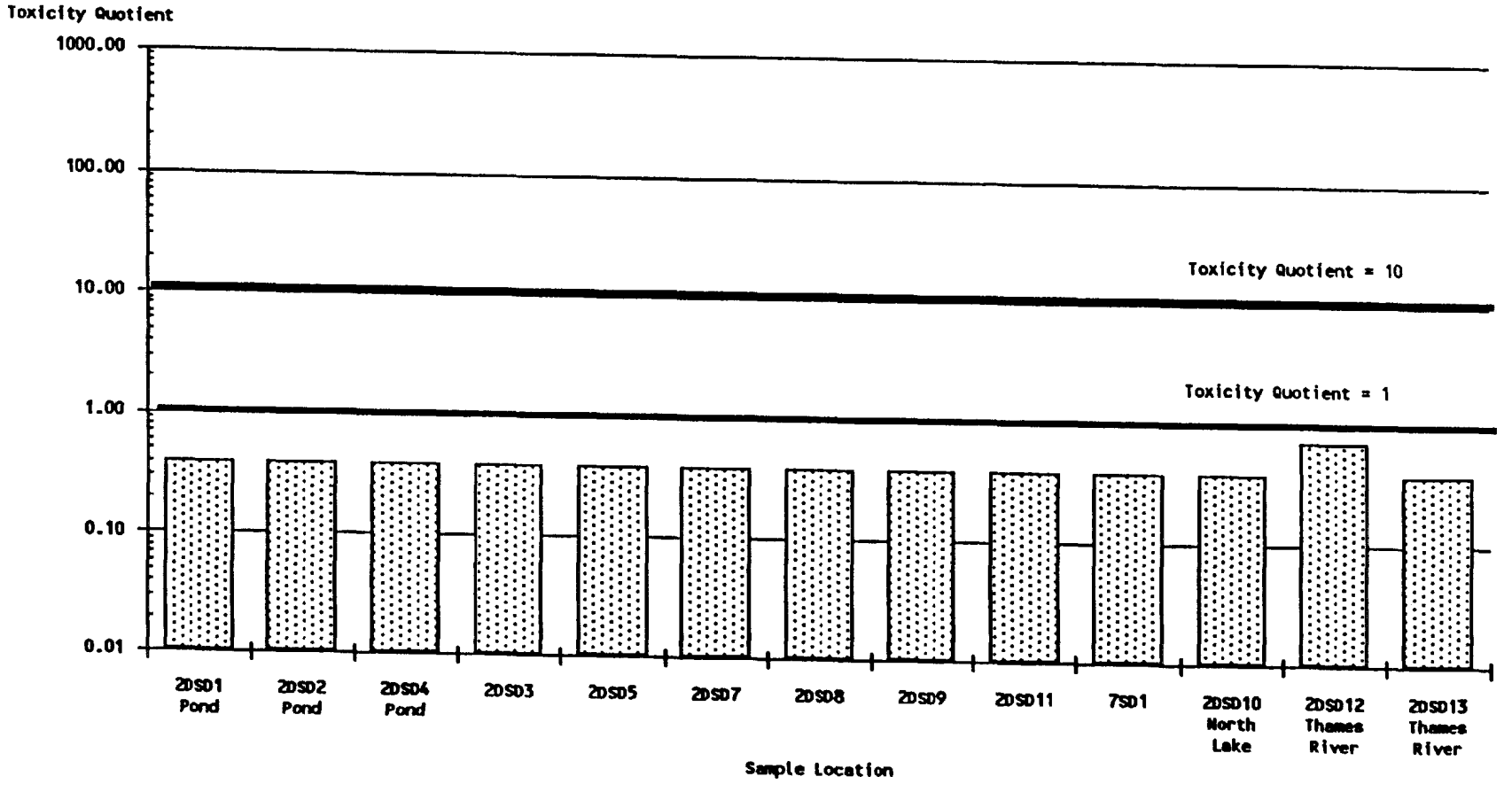


Figure 7-4D. Chronic Risk to Benthic Invertebrates by Sample Location for PCBs in in Area A Pond and Stream Sediments; Equilibrium Partitioning Method



this area had a cadmium concentration that slightly exceeded the chronic AWQC. The sample from North Lake had a lead concentration slightly above the chronic AWQC. However, since North Lake is drained periodically, it is unlikely that fish reside there. We conclude that risks to fish due to site contaminants in surface water are low. Although some metals slightly exceeded their AWQC, it is unlikely that sensitive species reside in the ponds in Area A.

Fish possibly living in Area A ponds may also be exposed to site contaminants via ingestion of benthic invertebrates. We do not have surface water or sediment data to assess these risks for the Area A wetland pond. Due to the elevated DDTR concentrations in the sediments of the eastern and central downstream ponds, risks to fish that may live there and ingest bioaccumulated DDTR in benthic invertebrates may be substantial.

7.5.3.6 Aquatic - Risks to Frogs

Risks to frogs will be similar to risks to fish in Area A assuming that frogs have a similar sensitivity to contaminants as fish. Frogs will have greater exposure to contaminated sediments as they overwinter in sediments. Frogs in the wetland pond and streams immediately below the wetland dike had low body burdens of DDTR indicating low risks to frogs due to DDTR in these areas. However, sediment from the wetland pond was not analyzed for DDTR and sediments from the streams immediately below the dike had low levels of DDTR, so that we can only conclude that risks to frogs are low in these areas. Frogs were not collected from the eastern and central ponds where elevated levels of DDTR were detected in sediments. However, we expect low risks due to exposure to contaminants in surface water and elevated risks due to exposures to DDTR in sediments in these areas.

7.5.3.7 Uncertainties in Estimates

The uncertainties in these estimates are based on uncertainties in the estimates of exposure concentrations and in the development of toxicity data and criteria. These were discussed previously in Sections 7.3.4 and 7.4.5.

7.6 Summary of Risks

7.6.1 Goss Cove Landfill, DRMO, and Lower Subase

Ground water from Goss Cove Landfill (a Step I site) and the Step II sites DRMO and the Lower Subase discharges to the Thames River. Based on the data presented in this report, contaminants concentrations in ground water at these sites are expected to be below AWQC after further dilution in ground water, attenuation due to adsorption to soils, and dilution in the much greater flow (compared to ground water flow) in the Thames River estuary. Risks to fish due to contaminants in ground water discharge from these site are expected to be low.

7.6.2 Area A

Our ecological risk assessment addressed risks to a variety of trophic levels in the terrestrial and aquatic food chain in Area A. On the lower level of the food chain, risks to plants were low. Plants are unlikely to accumulate organic compounds to a great degree.

Metals concentrations in soils and sediments were in general below levels that may adversely affect plants or higher trophic level organisms that feed on plants. However, cadmium concentrations in soil samples from the OBDA exceeded recommended levels protective of plants and organisms consuming plants.

Risks to terrestrial organisms due to DDTR in soil were greatest for soil invertebrates in the OBDA. (Note that in this section, the term "soil" is used for soil and sediment samples other than those that are constantly underwater in streams and ponds.) The results of estimating contaminant concentrations in soil moisture by the equilibrium partitioning method indicated that risks to soil invertebrates in the wetland and downstream areas due to contaminants were low. Small risks due to exposure to PAHs were indicated in a few wetland soil samples. However, elevated DDTR levels in the OBDA are expected to pose a potential risk to soil invertebrates. Soil invertebrates may be occasionally exposed to ground water when it discharges to the ground surface in parts of Area A, particularly in the wetland. However, risks to these organisms from this source appear to be low due to the low concentrations of contaminants in ground water in this area.

Our assessment indicates that DDTR in sediments of streams and ponds in the Downstream Watercourse Area poses a potentially great risk to biota. Organisms with the greatest exposure to DDTR contaminated sediments are benthic invertebrates. Frogs are also directly exposed to sediment during winter months. Fish, if they are present in the ponds, may ingest DDTR via bioaccumulation in benthic invertebrates. Ducks may ingest sediment while feeding on submersed vegetation. Other birds such as heron and mammals such as raccoons and otter may be exposed to DDTR by feeding on contaminated aquatic invertebrates and frogs. However, the ingestion of DDTR by ducks, heron, raccoons, and otter in Area A will only account for a small part of their diet because they are likely to feed over a much greater geographical area.

Higher level organisms in the food chain may be exposed to the DDTR and to a lesser extent to PAHs bioaccumulated in soil invertebrates. The greatest potential risks are to small mammals such as the shrew that consume a diet consisting mainly of soil invertebrates at a rate equivalent to their body weight per day. Based on the assumption that they consume only contaminated soil invertebrates, there are potential risks to these animals. Risks to herbivorous birds and small mammals are much smaller than for the maximally exposed shrew since they have much less exposure to DDTR. Based on the low body burdens of DDTR in catbirds collected from Area A, risks to birds feeding on soil invertebrates appear to be low. This may be because the area they feed in is large in comparison to the portion of the OBDA with elevated levels of DDTR in soil.

The aquatic organisms in Area A at greatest risk are those exposed to elevated levels of DDTR in pond and stream sediments in the Downstream Watercourse Area. Therefore, benthic invertebrates and possibly frogs are at greatest potential risk. DDTR contaminated sediments have been transported by the streams in the downstream portion of Area A to the Thames River. However, DDTR concentrations and therefore potential risks due to DDTR are lower at the stream outfalls than at upstream locations.

7.7 Recommendations

This assessment was based on a limited number of surficial soil samples from the Area A Downstream Watercourse Area. The presence of elevated levels of DDTR in stream and pond sediments in this area was not known at the time the sampling program was designed. Based on the few soil samples collected, risks to biota in this area due to contaminants in soil appear to be low. To gain a greater level of confidence in this assessment, we recommend additional surficial soil sampling and analysis in the Downstream Watercourse Area.

Additional information is required on biological conditions in the Area A downstream watercourses where elevated levels of DDTR were detected in pond and stream sediments. No biota sampling was performed in these areas. Our assessment predicts risks to benthic invertebrates and possibly to frogs in these areas. To supplement this assessment with actual field data, we recommend additional field work to assess the biological community in the ponds and streams where DDTR was detected at elevated levels in sediments.

Sediment quality data were not collected during this study from the pond in the Area A wetland or from the ponded area at the outlet of the Area A wetland near the dike. This information would better allow us to assess risks to biota in these areas and to compare measured body burdens of DDTR in frogs from the wetland pond to sediment DDTR concentrations.

Although the Thames River has been studied extensively in conjunction with proposed dredging work, limited data are available on biological conditions in the Thames River adjacent to NSB-NLON. Therefore, it is difficult to assess the potential effects of transport of DDTR contaminated sediments downstream to the Thames River outfall. Also, the assessment presented here of risks to Thames River biota from contaminants in ground water discharging from the Goss Cove Landfill, DRMO, and Lower Subase to the river was qualitatively based on an order of magnitude estimate of dilution. We recommend additional sediment sampling and analysis in the vicinity of the outfalls and ground water discharge areas and an assessment of biological conditions including biota sampling in these areas be performed to provide greater assurance regarding our assessment of ecological risks in these areas.

8.0 SUMMARY AND RECOMMENDATIONS

This section discusses the summary and conclusions of the investigations and evaluations at each site. Included are overviews of site background, nature and extent of contamination, and health and ecological risk assessment. Based on this information, for Step I sites, a recommendation is provided for proceeding to Step II, or for no further action. A no further action recommendation is based on identification of no significant contamination, exceedances of ARARs, and no health and ecological risk. Recommendations to proceed from Step I to Step II are based on identification of contaminants above applicable ARAR/TBC values, and where health and ecological risks are of concern. **ARAR/TBC values are detailed in Section 4.0.** In some cases, recommendations to proceed from Step I to II are based on the need for further delineation of the extent of contamination (e.g., Battery Acid Disposal Area), or to define the source of contaminants (e.g., Torpedo Shops).

Risk estimates for human health effects associated with exposure to potential carcinogens are expressed as the lifetime probability of excess cancer associated with the given exposure (e.g., a lifetime incremental risk of one in ten thousand). Risks above 1.0E-4 are described here as "generally unacceptable for environmental risks to humans, and risks below 1.0E-6 are described here as generally considered *de minimus* for environmental risk to humans. Risk estimates for human health effects associated with exposure to non-carcinogens are evaluated by using the total hazard index ratio. The total hazard index ratio is estimated by summarizing the hazard index ratios for each compound. The hazard index ratio for a compound is the ratio of its exposure dose to its reference dose. Ratios in excess of "1" are viewed here as benchmarks with regard to the potential for chronic, generally sublethal, effects. Risk characterization for the ecological risk assessment relies upon the toxicity quotient approach as well as on direct observations of conditions in the field. These approaches provide an overall "weight of evidence" approach for the assessment. The toxicity quotient is the ratio of a compound's exposure dose to its effects level, normally its NOAEL. Values above 1 indicate some potential for environmental effects. Values above 10 indicate good potential that greater exposure could result in effects based on experimental evidence, and values above 100 indicate effects may be expected based on the fact that this represents an exposure level at which effects have been observed in other species. In some cases, assessments regarding environmental risk were made by directly comparing exposure point concentrations to known toxicity data or developed criteria.

Step II sites will now proceed to the Feasibility Study (FS). The Feasibility Study is a detailed evaluation of remedial (clean-up) alternatives at each Step II site, including no action.

The following discussion of summary and recommendations is provided for each site.

8.1 Step I Sites

8.1.1 CBU Drum Storage Area

8.1.1.1 Summary

Background: The CBU Drum Storage Area is located in the northern section of NSB-NLON, adjacent to the deployed parking lot, and within the Area A Landfill. Twenty-six 55 gallon drums of waste oil, lube oil, and paint materials were previously located at this site.

Nature and Extent of Contamination: Seven (7) surface soil samples were collected from three sample locations to screen for potential contamination. Low concentrations of VOCs and SVOs were detected in the surface soils at this site. However, concentrations were below TBC values. Lead exceeded the TBC values for TCLP analysis, and was also slightly above the established background concentration at two sample locations. The pesticide DDD was also detected at a low concentration, consistent with the past application of pesticides within Area A. The chemicals detected at this site are generally consistent with the past storage of oil and indicate that a small release may have occurred.

Health and Ecological Risk Assessment: The low concentrations of chemicals detected at this site do not cause a risk with respect to health or ecological impact.

8.1.1.2 Recommendations

Supplemental Step I investigations are recommended to determine if Step II investigations are necessary or to support a no further action recommendation.

8.1.2 Rubble Fill at Bunker A-86

8.1.2.1 Summary

Background: Bunker A-86 is located on a dirt road off of Wahoo Avenue in the north central section of NSB-NLON. Area A Landfill is adjacent to the north, and the NSB-NLON hazardous waste storage facility is adjacent to the south. The rubble fill area is located to the north of the dirt access road and to the west of the bunker.

Discarded construction material is present at this site including concrete, asphalt, an electric motor, wood and gravel. Chemical containers found at this site included an empty 5-gallon container of monothanolanine (labelled as corrosive product), an empty 5-gallon container of thorite (labelled as non-shrinking compound for patching concrete), and a 55-gallon drum of lube oil that was approximately ten percent full.

Nature and Extent of Contamination: Five (5) surface soil samples were collected for analysis from this site from two sample locations to screen for contamination. Solvents (trichloroethene, tetrachlorethane) were detected in the 1-2 ppb range, below TBC values. One sample was analyzed for SVOs and contained elevated concentrations of PAHs, possibly indicative of an oil release or combustion by-products. Low concentrations of pesticides (delta-

BHC, methoxychlor) were detected which are likely associated with past Area A applications. Arsenic was present at a concentration well above background levels at the one sample analyzed on a mass weight basis. The concentration of arsenic (127 ppm) was one of the highest detected compared with all other sites investigated.

Health and Ecological Risk Assessment: Activity in this area is negligible. However, based on the elevated levels of PAHs and arsenic, there could be potential health risks if exposures were to occur under some future use condition.

8.1.2.2 Recommendations

It is recommended that this site proceed to the Step II phase of the IR program. Additional soil sampling and potential ground water monitoring is recommended at this site to further characterize the nature and extent of contamination and to conduct a quantitative health and environmental risk assessment.

In the interim, it is recommended that the containers at this site be removed and properly disposed.

8.1.3 Torpedo Shops

8.1.3.1 Summary

Background: The Torpedo Shops are located in the northern portion of NSB-NLON on the north side of Triton Avenue. The two buildings onsite (Nos. 325 and 450) are torpedo overhaul/assembly facilities. These facilities were connected to an onsite septic system leachfield until 1983, when they were connected to municipal sewers. A variety of fuels, solvents and petroleum products are used in these buildings. Direct disposal of these wastes to the septic system was reported not to be a routine practice, although sporadic, inadvertent chemical discharges to the subsurface septic system is of concern.

Nature and Extent of Contamination: Nine surface soil samples and three ground water samples were collected and analyzed to screen for potential contamination at the former subsurface septic systems.Low concentrations of VOCs and SVOs were detected in the north and south septic systems. Only one detection of benzene (4 ppb), was slightly above the TBC value of 1 ppb. Antimony exceeded background levels at the majority of sample locations in the south septic system, and silver was present close to or above background levels at the same sample locations. It is possible that the elevated antimony and silver are associated with a by-product of the torpedo overhaul process which occurred in Building 325. PCB was detected at 600 ppb (below TBC values) in a soil sample from the north septic system. DDE was detected at 210 ppb in a soil sample from the south septic system. The source of the PCB and DDE is unknown.

No primary drinking water standards were exceeded in the three ground water samples for VOCs or metals. No SVOs, pesticides/PCBs were detected in the ground water. Several VOCs were detected in the overburden ground water in the south septic system. These included 1,1,1 trichloroethane (42 ppb), 1,1 dichloroethene (30 ppb), and 1,1 dichloroethane (1 ppb),

which were present below applicable drinking water standards. Because the soil gas survey and subsurface soil sampling within the septic leaching field did not indicate the presence of significant levels of VOCs, the presence of these solvents in the ground water suggest the potential for an undefined source. It is possible that the source of these solvents is upgradient of this location, in the vicinity of the Torpedo Shop buildings. The former hazardous waste sump, Otto fuel storage tanks, and drum storage are possible sources. Also, due to the density of these solvents, higher concentrations may be present in the bedrock aquifer. Antimony exceeded the USEPA health advisory standard in the ground water (south septic system) by over 20 times. This correlates with the elevated levels of antimony detected in the soils at this site. Because the antimony was present in the upgradient soil sample (7MW1), but not necessarily a background sample, it is unclear if the antimony in the soil/ ground water is related to septic system discharges.

Health and Ecological Risk Assessment: The potential exposure scenario relates to utility repairs/installations within the former septic system area. Based on the relatively low levels of chemicals present at the site, and the health risk calculations made for utility workers at other sites (Area A Landfill, Lower Subase), the health risks associated with this exposure scenario are qualitatively predicted to be negligible. Based on the lack of potable water supply wells for existing and projected future land use in the area, there is no exposure, therefore, no human health risks are associated with the chemical constituents in the ground water. The site is developed, therefore there are no significant ecological risks.

8.1.3.2 Recommendations

It is recommended that this site proceed to the Step II phase of the IR program. Further soil and ground water investigation is recommended at this site to define the source, nature and extent of VOC contamination, and to further address the elevated antimony at this site. No further action is required relative to the septic systems, except as they may relate to the antimony issue. The testing will be in the vicinity of the buildings and at the Otto fuel sump.

8.1.4 Goss Cove Landfill

8.1.4.1 Summary

Background: The Goss Cove Landfill site is located in the southwest portion of NSB-NLON, adjacent to the Thames River. The Nautilus Museum and a paved parking lot are constructed directly over the former landfill. The Nautilus Museum is a submarine museum operated by the Navy and open to the public.

The landfill reportedly operated from 1946 until 1957 and filled in the northern portion of Goss Cove. The southern portion of Goss Cove remains. Incinerator ash, inert rubble, and potentially other unknown materials were disposed at the site.

Nature and Extent of Contamination: A radiation, geophysical, and soil gas survey were conducted. No radiation above background was detected. The geophysical survey identified several suspected buried metal objects, which were avoided during drilling operations. The soil gas survey assisted in defining elevated VOCs in several areas.

Seven subsurface soil samples, four ground water and one surface water sample were collected and analyzed to screen for potential contamination.

The subsurface test boring program indicated that landfill material consisted of sand and gravel with small quantities of brick, glass, ash, wood, and metal. Minor oil stains or sheens were observed in approximately one-half of the borings, indicating some petroleum disposal/spills took place.

VOCs were detected in five of seven soil samples. Xylene was the most prevalent constituent, detected in four samples, indicative of a petroleum product. Trichloroethene and tetrachlorethene were detected in one soil sample each. Petroleum hydrocarbons (benzene, toluene), and tetrachlorethene were detected above TBC values in one soil sample each.

SVOs, predominantly PAHs, were detected at all seven subsurface soil samples, several at relatively high levels. The PAHs are likely associated with the disposal of incinerator ash and potentially associated with the presence of petroleum hydrocarbons.

PCBs or pesticides (predominantly DDT, DDD and DDE) were present individually at all sample locations. All concentrations were below TBC values except for DDT at one sample location. The presence of PCBs and pesticides are likely associated with past landfill disposal.

Many inorganic constituents exceeded established background levels, and exceed TBC values based on TCLP analysis. Arsenic, cadmium, chromium, and lead exceed both background levels and TCLP TBC values. Mercury consistently exceeded background levels at most sample locations. Elevated metals are anticipated to be related to past landfilling activities and, potentially, battery related disposal (lead/cadmium).

The highest levels of VOCs in the ground water were detected in the two downgradient wells. Vinyl chloride or benzene were present individually in the ground water at a downgradient well above ARAR values. Petroleum hydrocarbons detected (which were detected in subsurface soils) included benzene, toluene, ethylbenzene, and xylene; trichloroethene and tetrachlorethene were not present in the ground water. Low levels of SVOs are present in the ground water, primarily the more soluble PAHs, including naphthalene. Naphthalene exceeded the TBC values (USEPA Health Advisory) in a downgradient monitoring well.

Barium exceeded the primary MCL at one well; secondary MCLs were exceeded in all wells for sodium, iron, and manganese. The sodium is related to the brackish water conditions.

Gross alpha and/or gross beta radiation screening values were exceeded in two ground water monitoring wells within the landfill. These elevated readings could be the result of naturally occurring radioisotopes, but further analysis is required for confirmation.

The one surface water sample collected in the Thames River adjacent to the site did not contain VOCs, SVOs, pesticides or PCBs. Inorganic constituent values appear consistent with brackish water. **Copper was present above water quality standards.**

In summary, the levels of VOCs and SVOs in the subsurface soils are having some impact on ground water quality (some slightly above ARARs/TBCs), but overall the concentrations are relatively low. The elevated inorganics in soils, principally arsenic, cadmium, chromium, lead and mercury, are not adversely impacting ground water quality.

Health and Ecological Risk Assessment: Future construction and excavation activities in the parking lot could result in some risk to workers, if proper health and safety procedures are not followed. There is some potential that vapors from within the landfill could enter the museum building, however, this possibility has not been fully investigated. There is also a possibility that children could come in contact with sediments in Goss Cove. At present there are no data on the level of contaminants in these sediments.

Although ground water quality exceeded drinking water standards, no drinking water wells are within the affected area, nor could they be due to the proximity to the brackish Thames River.

Ground water from Goss Cove Landfill discharges to the Thames River. Based on the data presented in this report, a qualitative assessment indicates that contaminant concentrations in ground water at these sites are expected to be below water quality criteria after further dilution in ground water, attenuation due to adsorption to soils, and dilution in the Thames River estuary. Risks to aquatic life due to contaminants in ground water discharge from the site are also expected to be low.

8.1.4.2 Recommendations

It is recommended that this site proceed to the Step II phase of the IR program. Specifically, the following recommendations are provided.

1. Specific worker health and safety provisions are recommended for all future subgrade construction projects at the site. Prior to construction in specific areas, further subsurface investigation should be conducted to characterize the quality/ disposal and health and safety requirements of the material to be encountered. **It should be noted that some utility reconstruction is being designed.**

2. The geophysical survey indicated the presence of buried metal objects at three locations as specified in Section 4.0. Any future planned construction near these areas should include exploratory excavation in these areas to identify construction health and safety requirements.

3. It is recommended that several borings/soil analyses be conducted in the area closer to the Nautilus Museum and remaining Goss Cove. This should be performed in conjunction with indoor air quality measurements within the Nautilus Museum building to assess potential health risks.

4. A quantitative health and environmental risk assessment of the potential impact of the site on the Thames River should be conducted to verify the

qualitative assessment that impacts appear negligible. This would include surface water samples at low tide (ground water discharge) conditions, sediment sampling, and biota survey/sampling along the Thames River and Goss Cove shoreline.

5. Conduct another ground water sampling and analysis round for TCL organics and TAL inorganics to confirm the analytical results. Also, perform specific radiological isotope ground water analysis to determine the source of the radiological constituents (natural or otherwise).

8.1.5 OBDANE

8.1.5.1 Summary

Background: The Over Bank Disposal Area Northeast (OBDANE) site is located in a heavily wooded area on the edge of a ravine northwest of Area A Landfill, and south of the Torpedo Shops. Inspections of this site have indicated the presence of several empty fiber drums in this area. No visual staining or stressed vegetation was observed.

Nature and Extent of Contamination: Five (5) surface soil samples were collected for analysis from this site, from two sample locations, to screen for potential releases at this site. One surface soil sample contained tetrachlorethene at 2 ppb, below the TBC value. No SVOs, PCBs, or pesticides were present. No inorganic compounds exceeded established background levels or TBC levels based on TCLP analysis.

Health and Ecological Risk Assessment: This site appears to pose a negligible risk based on the lack of activity and the low concentration of chemicals.

8.1.5.2 Recommendations

Supplemental Step I investigations are recommended to determine if Step II investigations are necessary or to support a no further action recommendation.

8.1.6 Spent Acid Storage and Disposal Area

8.1.6.1 Summary

Background: This site is located in the southeastern section of NSB-NLON, between the southern side of Buildings 409 and 410. A 4' x 4' x 12' long rubber-coated underground tank was used for temporary storage of waste battery acid around World War II. The tank top is still visible, but has been filled with earth and capped with concrete.

Nature and Extent of Contamination: Seven subsurface soil samples were collected to screen for potential release of battery acids from the subsurface tank. High levels of lead were present in six of seven soil samples based on TCLP analysis. Four samples are classified as a RCRA hazardous waste due to the lead concentrations. These samples were collected at the 0-4 foot depth interval. Several soil samples also had low pH values. The elevated levels

of lead and low pH values substantiate that a release of battery acid likely occurred. The present level of subsurface investigation has not defined the extent and degree of contamination.

Health and Ecological Risk Assessment: The area between Buildings 409 and 410 is scheduled for construction of a new building. There may be some risk to construction or utility maintenance personnel associated with contact with contaminated subsurface soils if they do not follow appropriate health and safety procedures. Based on similar levels of lead at DRMO, and the resulting risk for construction workers (Hazardous Waste Storage Building Construction), the risks at this site to unprotected construction workers could be above acceptable levels. The site is developed, therefore, there are no significant ecological risks.

8.1.6.2 Recommendations

It is recommended that this site proceed to the Step II phase of the IR program. Further subsurface soil investigation is recommended to characterize the extent of contamination in this area for possible remediation. A ground water quality investigation is also recommended to assess potential lead contamination, particularly in light of the low soil pH values, which may tend to make the lead more mobile. Should construction in the area be required, appropriate worker health and safety procedures should be developed.

8.1.7 Former Gasoline Station

8.1.7.1 Summary

Background: The former gasoline station site is located in the roadway and parking area just south of Building 164 (Dealey Center). The gasoline station operated from 1940 to the early 1960s. Several underground gasoline tanks and a waste oil tank existed onsite.

Nature and Extent of Contamination: The geophysical investigation identified the potential presence of one underground gas tank which appears to remain on the site. The soil gas survey did not detect the presence of significant VOC constituents, although organic vapor field measurements of subsurface soil samples indicated levels above background.

Five subsurface soil samples were collected from five test borings to screen for potential releases from the former gasoline station. Only one soil sample, located adjacent to the identified gas tank, contained VOCs. Trichloroethene and benzene were detected below TBC values. No metals exceeded established background concentrations, although three soil samples contained arsenic exceeding the TBC value based on TCLP analysis. The arsenic TCLP results do not appear significant, as arsenic concentrations do not exceed background values based on mass weight analysis.

Health and Ecological Risk Assessment: No risks are identified under existing conditions based on available data. Appropriate health and safety precautions should be followed during tank removal to confirm that no contamination is present. The site is developed, therefore, there are no significant ecological risks.

8.1.7.2 Recommendations

It is not recommended that this site proceed to the Step II phase of the IR program. However, it is unlikely that the potentially identified underground gasoline tank was abandoned in accordance with current requirements (e.g., cleaning/filling with inert material). It is recommended that the tank be removed, and at the time of removal, confirmation soil samples be collected from the tank grave. **Samples should be collected from excavation sidewalls, at a depth just below the tank bottom and at the depth of the ground water table interface.** If no contamination is identified at that time, then no further action would be recommended at this site. **If contamination is detected, corrective actions should be taken in accordance with the underground storage tank regulations.**

8.2 Step II Sites

8.2.1 Area A/OBDA

8.2.1.1 Summary

Background: The **Area A Landfill** is located in the northeastern and north-central section of NSB-NLON. It is approximately seven acres in size. Access is via a dirt road off Wahoo Avenue. The Area A Landfill is a relatively flat area bordered by a steep, wooded hillside that rises to the south, a steep wooded ravine to the west, and the Area A Wetland to the north. Aerial photographs show that the landfill appears to have extended east along the wetland to as far as the present position of the tennis courts. Runoff from the landfill drains as overland flow north into the Area A Wetland, which subsequently discharges to the Area A downstream watercourses and into the Thames River.

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

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

Sand bags and contractors' supplies and equipment have, in recent years, been stored over the former landfill. Several transformers, removed underground storage tanks, crane weights, and other equipment are stored on the concrete pad in the southwest portion of the landfill. The specific items stored in this area vary. The remainder of the landfill is not paved.

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

The **Area A Wetland** abuts the north side of the landfill and is approximately 30 acres in size. The maximum wetland sediment thickness is approximately 35 feet, based on boring information. Until 1957, this portion of the site was undeveloped, wooded land. In 1957, dredge spoils from the Thames River were pumped to this area and contained within an earthen dike that extends from the Area A Landfill to the south side of the Weapons Storage Area. Atlantic learned during the course of this study that, previously, pesticide "bricks" were placed on the wetland ice during winter and allowed to melt and discharge into the wetland for mosquito control.

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

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

Ground water also discharges from Area A to a small wetland at the base of the dike and the Over Bank Disposal Area site. A stream flows from this wetland west toward North Lake, a recreational swimming area for Navy officers. Under normal flow conditions, the stream enters a culvert which bypasses the pond and discharges to a stream below the outfall of the pond. This stream flows west under Shark Boulevard and through the golf course to the Thames River. There is a manhole adjacent to North Lake, that connects to another pipe, which was designed to discharge overflow water from North Lake. Under substantial runoff conditions, however, it is possible that some water discharges to the pond from this stream.

Further development is not planned for this area.

The Over Bank Disposal Area (OBDA) is located on the slope of the dike below and adjacent to the Area A Landfill. A small wetland exists at the base of the dike.

This area was a disposal site after the earthen dike was constructed in 1957. In 1982, it was the finding of the previous studies that the material had been there for many years and included 30 partially covered 200-gallon metal fuel tanks and scrap lumber.

Atlantic personnel inspected the site in September 1988, and observed approximately 30 empty, unlabeled 200-gallon tanks, old creosote telephone poles, several empty unlabeled 55-gallon drums, and rolls of wire. Bright orange, organic sediments were observed in the water discharging from the base of the dike embankment, apparently leachate from the landfill.

Area A Landfill - Nature and Extent of Soil Contamination: A radiation, geophysical and soil gas surveys were conducted. No radiation above background was detected. The

geophysical survey identified several suspected buried metal objects, which were avoided during drilling operations. The soil gas survey detected VOCs, predominantly petroleum hydrocarbons, in the deployed parking area.

VOC concentrations in the subsurface soil within Area A Landfill are generally low. No TBC values for VOCs in soil samples were exceeded. One surface soil sample collected near the concrete storage pad did contain elevated levels of petroleum hydrocarbons. SVOs, principally PAHs, were detected at relatively low levels in some of the landfill subsurface soil samples. The results of the SVOs analyses at Area A Landfill are significantly lower than at the DRMO and Goss Cove former landfill sites. The organic results, in general, do not indicate significant disposal of organic chemicals within the Area A Landfill.

No PCBs were detected in the subsurface soils within Area A Landfill. One surface soil sample contained PCBs above the TBC concentration of 10,000 ppb. This soil sample was collected adjacent to the concrete storage pad where drum storage, PCB transformers, and electric switches were once stored. The potential extent of the PCBs in this area was not defined based on the two surface soil sample locations.

Pesticides were detected at three subsurface sample locations (2LMW7S, 2LMW8S, and 2LMW18S) at Area A Landfill. DDTR were detected at these locations at relatively low concentrations and are below TBC values. The DDT was present above the TBC value of 500 ppb at one surface soil sample near the concrete storage pad.

Out of the 12 subsurface samples analyzed by TCLP analysis procedures, ten contained one or more metals exceeding TBC values. Metals exceeding TBC values included arsenic, cadmium, lead, and selenium. TCLP hazardous waste characteristic values were not exceeded for any samples. Some inorganic constituents exceeded established background levels based on mass weight analysis, including beryllium, cadmium, lead, and mercury. Other metals exceeding background levels included copper, nickel and boron. The majority of these elevated metals are likely related to a past landfill disposal.

The lead and cadmium values are generally low, and are not indicative of the existence of a significant source such as the reported historical battery acid disposal in this area. Levels of cadmium, and particularly lead, were much higher at the Former Acid Storage and Disposal Site and DRMO, where battery acid storage tanks existed.

Area A Wetland - Nature and Extent of Soil and Sediment Contamination: VOC concentrations in the subsurface soil and sediment within Area A Wetland are in the low to moderate range. VOCs are generally spatially distributed throughout the wetland area and generally present at uniform concentrations with depth. This is consistent with the origin of the sediments, from the Thames River dredge materials, deposited in the wetland. VOC TBCs exceeded included benzene (one sample), trichloroethene (three samples) and tetrachloroethene (four samples). The source of the VOCs in the wetlands subsurface soils would appear to be associated with sediments originally contained from the Thames River, and/or absorption of ground water chemicals onto the sediments. The origin of the VOCs in the sediments could be from several sources, including those mentioned above, runoff from the Weapons Center, and

general urban runoff. The samples collected near the landfill did not contain any VOCs above TBC values.

SVOs, principally PAHs, were detected at generally low levels in most of the wetland sediment and subsurface samples. Overall SVO concentrations were slightly higher in the 0-2 and 10-22 feet reporting intervals, although this may be attributable to the smaller number of samples collected in the 2-10 foot interval. The highest concentration of SVOs was detected within a drainage swale at a stormwater discharge location of the Weapons Center. The Verification Study sediment sampling of another stormwater culvert discharge location near the Weapons Center also indicated the presence of PAHs. Sediment samples recently collected from the Thames River also contain low levels of PAHs, consistent with the levels in the Area A Wetland.

PCBs (Arochlor 1260) were detected at two sample locations, but were below the TBC value. The source of the PCBs in the wetland near the landfill appears related to transport of contaminated surface soils from Area A Landfill. The source of the PCBs detected at the Weapons Center is unknown.

Pesticides (DDTR) were detected at five sample locations in the 0-2 foot reporting interval. Based on detection in the 0-2 foot interval, these appear to be related to the past reported surface application of pesticides at the wetland area. The pesticide detections were less frequent and the concentrations much less than for the samples from the Area A downstream watercourses. This may be related to the potential for higher concentration of pesticides present at locations not sampled (pesticide bricks were reportedly applied at point locations), and/or due to compositing of the samples. This may be supported by previous sediment sampling conducted within the wetland near its outlet and at an upgradient location (east side), which contained DDTR in the 17,000 ppb range. Alternatively, it could indicate more substantial application of pesticides in the downstream watercourse area.

In general, metal concentrations within the wetland subsurface soil and sediment samples were low. A total of 35 soil and sediment samples were collected within the wetland proper, with the remainder collected at adjacent locations. Several samples contained slightly elevated levels of lead (7), mercury (3), cadmium (1), and silver (2). Several samples exceeded TBC values based on TCLP extraction procedure. These included arsenic, cadmium, chromium, lead, selenium, and silver. Only two samples had metal values (lead, silver) which exceeded both established background concentrations and TBC values based on TCLP analysis. The elevated metals are likely associated with the origin of the sediment from the Thames River. Cyanide was detected at the drainage outlet from the Weapons Center. The previous Verification Study also reported cyanide at another surface water discharge location from the Weapons Center. These detections of cyanide, and the elevated PAHs, suggest a possible source of contaminants at the Weapons Center. The elevated levels of cyanide and PAHs suggest that spent Otto fuel may be the cause of this contamination, however, the specific source is unknown.

Area A Downstream/OBDA - Nature and Extent of Soil and Sediment Contamination: The subsurface soil samples were collected at well locations which were in wooded undeveloped areas where no past disposal was reported or apparent. The exception was

3MW12S, which was located adjacent to the wetland at the Over Bank Disposal Area, where past disposal is evident.

Trichloroethene (24 ppb) and tetrachloroethene (58 pp) were detected at a subsurface soil sample location near North Lake, both of which are above TBC values of 5 ppb. Low levels of toluene and 1,1-dichloroethene were also detected. The source of the solvents detected near North Lake is unknown. One possibility is an unconfirmed report from a retired Navy employee who stated that there was a past disposal area in this general vicinity. This could not be confirmed based on review of aerial photographs and discussions with other Navy personnel.

No SVO compounds were detected in subsurface soils, except for low levels of phthalates at one sample location. Low levels of SVOs, principally PAHs, were present in a subsurface soil sample at OBDA, which correlates with SVOs detected in the sediment samples at OBDA.

No PCBs were detected in the subsurface sample points. Pesticides, DDT and its derivatives, were detected in a subsurface soil sample near OBDA and at a sample near North Lake. The detection of pesticides at these locations appears related to past pesticide application in Area A. No significant detections of inorganics were noted in the subsurface soil samples.

Twenty-three sediment samples were collected for analysis from the OBDA wetland, the Area A downstream watercourses and associated ponds, and North Lake. The purpose of the sediment sampling and analysis programs was to assess the extent of sediment contamination (principally pesticides) within this area, due to past application and sediment transport from potential source areas. Previous analysis of sediments in this area indicated the presence of pesticides and metals.

No VOCs were detected above TBC values for samples collected. At sample locations near the outlet of Area A wetland, low levels of VOCs (methylene chloride, trichloroethene) were detected, indicating some limited migration of VOCs via sediment transport from Area A wetland. Within OBDA, all sediment samples contained low levels of VOCs, but below TBC values. VOCs detected include methylene chloride, 2-butanone (methyl ethyl ketone), tetrachloroethene, toluene, ethylbenzene, and xylene. This indicates that some past releases of solvents and petroleum hydrocarbons occurred at the OBDA site. These VOCs could also be partially attributable to adsorption of chemicals to the sediments from ground water. Low to moderate levels of SVOs were detected in most sediment samples.

The only detection of PCBs was at 2DSD12, which is at the outlet of the downstream watercourse, at the Thames River, adjacent to DRMO. Based on the elevated levels of PCBs at the DRMO site, it appears likely that this is associated with surface water runoff from the DRMO site and not Area A.

Pesticides (DDTR) were detected at moderate to very high concentrations within the Area A downstream watercourses and ponds. No pesticides were detected in the North Lake sediments. The TBC value was exceeded at ten of the 23 sample locations. The highest concentrations were detected in the two ponds below the Area A dike, and within the OBDA sediments. Based on these concentrations being much higher than those found within Area A wetland, this may be due to pesticides application rather than sediment transport. High

concentrations in these areas suggest that substantial quantities of pesticides were applied in this area. Lower concentrations downstream of these areas and extending to the Thames River are likely attributable to sediment transport from the higher concentration areas. The data indicates that some ongoing migrations of pesticides, due to sediment transport, to the Thames River is occurring from the pond source areas.

Several metals were detected above established background levels. These occurred in samples closest to the Area A wetland area. They included beryllium, cadmium, lead, selenium, zinc and boron. Cadmium was not detected above background levels in the Area A wetland sediments, therefore, the cadmium source does not appear to be related to sediment transport from the wetland. No metals were detected above background levels in North Lake sediments.

Ten sediment samples were collected from the OBDA area. Sediment samples contained metals above established background levels for cadmium (3), iron (2), lead (4), selenium (2), and zinc (2). Cadmium results based on TCLP analysis correlated with mass weight analysis for two samples. TCLP analysis detected no lead. The elevated iron concentration may partially explain the rust colored leachate that is visible in this wetland area and within the stream bed. The lead and cadmium may suggest battery/battery acid disposal in this area, which were the highest concentrations recorded throughout Area A. Alternately, it could be related to the cadmium present in the ground water at this location, and adsorption onto the sediments as it discharges to OBDA.

Area A - Nature and Extent of Ground Water Contamination: Twenty-eight ground water monitoring wells were installed and sampled within Area A, which includes the landfill, wetland, and downstream areas. Eleven were water table overburden wells and 17 wells were installed and screened in the bedrock aquifer.

VOCs were detected in only six of 28 monitoring wells within Area A. Of the six, only three locations exceeded TBC/ARAR values for drinking water. The solvent trichloroethene was detected above drinking water standards (ARARs) at 2LMW13D (10 ppb) at the west end of the landfill, and 2DMW16D (17 ppb) upgradient of North Lake. These are both bedrock wells. This suggests a low concentration plume of solvents within the bedrock aquifer extending from the western portion of the former landfill downgradient to the North Lake area. The ground water does not appear to discharge to North Lake, based on the vertical head gradient information at 2DMW16S&D. The plume appears to be fairly narrow, as no solvents were detected in the Area A downstream wells to the north. This is supported by review of the ground water specific conductivity data which is used as a landfill leachate indicator. Solvents were not detected in downgradient well 3MW12D (OBDA), suggesting preferred fracture flow is occurring in the bedrock aquifer. However, this does not correlate with the cadmium data, which indicated elevated levels of cadmium at 2LMW13S and 3MW12D. The downgradient extent of the solvent plume is undefined, which is flowing in a westerly direction. Benzene was detected at 10 ppb, above drinking water standards (5 ppb) at 2LMW18S, which may be related to the parked vehicles in this area; it was not detected in any other well in Area A.

Overall, the VOC concentrations for those wells where detected are low, given the historical use of Area A as a landfill. Although drinking water ARAR/TBC values are exceeded in three wells, the results do not indicate any significant ongoing release of VOC contaminants.

Based on the soil gas and subsurface soil data, low levels of petroleum hydrocarbons and solvents are present throughout much of the Area A landfill area. This suggests a generally uniform-low level of soil contamination within the landfill, and no substantial source area. The deployed parking area and adjacent area to the east (also used for automobile storage/parking) exhibited the most uniform level of petroleum hydrocarbons based on soil gas data.

PCB was detected in the ground water at one location within the landfill. The concentration exceeded its solubility and further sampling of the well would be required for confirmation of the result.

Cadmium was the only inorganic compound which exceeded primary drinking water standards (ARARs) within Area A. Cadmium was also detected in one instance above drinking water standards at a residential well located east of Area A. Cadmium was detected above the 5 ppb drinking water standard at **2LMW18D (7.2 ppb), 2WMW3D (7.7 ppb), 2WMW5S (6.4 ppb),** 2WMW3S (10.6 ppb), 2LMW18S (29.1 ppb), 2LMW13D (44.8 ppb), and 3MW12D (16 ppb). The source of these elevated levels of cadmium may be related to soils within the landfill and, possibly, OBDA. However, cadmium soil concentrations in the landfill only exceeded established background levels at one sample location (2LMW8S). It is possible that higher concentrations of cadmium exist in the landfill, at locations other than the sample points. Dissolved cadmium levels in Area A ground water may be partially attributable to low pH values for some wells. The upward ground water vertical head gradient within most of the landfill should minimize the transport of cadmium to the bedrock aquifer from an apparent landfill source. However, at bedrock well 2LMW13D, where there is a strong upward vertical head, the cadmium is present in the bedrock system, from a source either upgradient within the landfill, or another unknown upgradient source. The former Weapons Center is upgradient of this area along Wahoo Avenue, however, the lack of elevated levels of cadmium in other nearby bedrock wells (2LMW9D, 2LMW17D, and 2LMW14D) does not strongly support an offsite source, but rather a landfill source.

The overburden ground water flow along the central and eastern portion of the landfill is toward the wetland, and along the western portion of the landfill to the northwest, down the Area A downstream watercourse valley. Therefore, the cadmium ground water contamination appears confined to the landfill and the OBDA area. Cadmium was only detected in well 3MW2D in the OBDA, suggesting a potential confined plume to the northwest although, due to preferred bedrock flow patterns, other wells may not have intercepted the cadmium and, therefore, the cadmium plume may be undefined.

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

or downgradient of the western portion of the Area A Landfill, however, cadmium does not exceed drinking water standards in these wells.

Iron and manganese exceeded secondary drinking water standards in many Area A wells. The results for 2WMW1D and 2WMW2D (upgradient wells) and the residential well analytical results were much lower for iron and manganese, which indicates a source of these inorganics within the Area A landfill material and wetland sediments.

Radiological screening parameters were exceeded in nine of the 20 samples. These occurred at three within the landfill area; one near the Weapons Center; and four within the Area A downstream area. These elevated readings could be the result of naturally occurring radioisotopes which do not meet the gross screening criteria. Further sampling and analysis is required for confirmation.

Residential Well Analytical Results: A residential well sampling and analysis program was conducted to assess ground water quality in offsite areas near Area A.

The first round sampling indicated low levels of chloromethane, methylene chloride, and xylene at OSW15 (16 Sleepy Hollow), but below drinking water standards. This well was resampled for VOCs in the second round and none were detected. The first sampling round indicated the presence of cadmium at OSW6 (1458 Route 12) above primary drinking water standards (10 ppb) at a concentration of 26.3 ppb. Other compounds (iron, manganese, aluminum and sodium) were detected in other wells which exceeded secondary drinking water standards, and are attributable to natural ground water conditions.

Due to the presence of cadmium, second **and third** sampling rounds **were** conducted to expand the sampling program to areas east of Area A on Route 12, North Pleasant Valley Road, and Baldwin Hill Road. The second **and third** sampling rounds did not detect any metals above primary drinking water standards. Also, cadmium was not detected at 1458 Route 12, where it was previously present. Cadmium was detected at low levels at five of 13 wells sampled in the 2.1-3.1 ppb range, below the 10 ppb standard. As previously discussed, an assessment of the ground water hydrogeology of this area indicates that the presence of cadmium in the offsite residential wells is not attributable to the detection of cadmium within Area A at NSB-NLON, with the possible exception of well OS25 to the southeast, which contained cadmium below standards, but could be downgradient of Area A Landfill.

The cadmium detected within the residential sample area appears to be a natural background concentration in the ground water. A further round of residential well sampling is planned to further confirm the analytical results.

Boron was found in all residential wells above the TBC value of 600 ppb, which is based on an EPA health advisory. Concentrations of boron ranged from 770 to 2,000 ppb. The source of this boron is unknown.

Nature and Extent of Area A Surface Water Contamination: Fifteen surface water samples were collected within Area A, including the wetland, downstream areas and Thames River. These samples were collected to assess the surface water quality.

Low levels of VOCs were detected at several sampling points 2DSW5, 2DSW7, 2DSW8, 2DSW12, and 2DSW13. Except for one sample, constituents detected are petroleum hydrocarbons and could be associated with runoff. One sample near Triton Avenue contained 3 ppb of tetrachlorethene and 2 ppb of styrene. No ARARs or TBCs were exceeded for the VOCs. No SVOs were detected at any of the sampling locations.

No pesticides or PCBs were detected at any of the sampling points except for 2DSW4, which contained 1.9 ppb of DDD. This sample is in the area where high levels of DDTR, including DDD, were detected in sediments. It is likely that the origin of DDD in the surface water is from the sediments.

ARARs/TBCs for inorganics were exceeded at several sample locations for cadmium (3 of 15), copper (**15** of 15), iron (11 of 15), lead (**11** of 15), manganese (13 of 15), **zinc (14 of 15),** and mercury (1 of 15). These ARARs are based upon in-stream water quality criteria **and standards** to protect aquatic life and may not be appropriate to the wetlands and small drainage streams. The presence of iron and manganese in surface water may be a result of the low pH and reduced conditions created by the Area A Landfill. Some of the iron and manganese may originate from wastes, however, the majority of what is detected in surface water is probably being leached from native soils. Of note are the ARAR exceedances in the Thames River at sample locations 2DSW12 for manganese and iron, and at 2DWS13 for manganese. Area A upstream surface water samples also contained elevated levels of iron and manganese, whereas surface water samples in the Thames River at DRMO and Goss Cove did not contain levels above ARARs. The iron standard of 1000 ppb is based on chronic aquatic toxicity water quality criteria and the manganese standard is based on water quality criteria for human health risks from fish consumption.

Copper **and zinc**, which exceeded water quality criteria **or standards, were** also detected in concentrations above background **in soils at** the Area A Landfill soils. It is assumed that the elevated concentrations originate from the Area A Landfill.

Cadmium and lead are present above ARARs and levels normally seen in natural surface waters and are present both in the Area A wetlands and landfill soils and sediments. The presence may be the result of historical disposal activities. However, cadmium and lead were also detected in the upgradient sample location (2LSW1) above ARARs.

Mercury was only detected in one surface water sample (2DSW9). This location (adjacent to Triton Road) is immediately downgradient of two sediment sampling locations where mercury was found. Although these two sediment mercury concentrations were below background, mercury was not detected in any other sediment samples. There was one occurrence of mercury above background concentrations in Area A Landfill soils. Mercury is rarely found in natural surface waters above 1 ppb. The source of the mercury in sediments is not apparent, however, historical disposal in Area A Landfill is possible. However, it is more likely that a past release upgradient of sample locations 2DSD7 and 2DSD8 along Triton Road occurred. It is noted that sediment sample 7SD1, within a runoff swale from the Torpedo Shop, contained no mercury, nor did any other soil or ground water sample at the Torpedo Shop, which implies that the Torpedo Shop is not the source.

All of the radiological results were below ARAR screening values.

Human Health Risk Assessment: Several identified exposure pathways were evaluated for Area A. They are listed as follows:

- Workers repairing utilities within Area A;
- Weapons Center personnel exposed to fugitive dusts from Area A Landfill;
- Workers moving pallets within Area A Landfill;
- Navy personnel exposed to fugitive dust while engaged in recreational activities near Area A Landfill;
- Groton/Ledyard residents exposed to fugitive dust from Area A Landfill;
- Citizens attending car auctions at Area A Landfill;
- Subase children exploring woods within Area A;
- Subase children exploring streambeds and Area A Wetland; and
- Children swimming in North Lake.

Negligible or *de minimus* risks were calculated for workers repairing utilities within Area A, Weapons Center personnel exposed to fugitive dust, Navy personnel exposed to fugitive dust while engaged in recreational activities, citizens attending car auctions, and children swimming in North Lake.

The following exposure scenarios did exhibit risks which fell within the one in one hundred thousand to one in one million excess cancer risk range:

- Workers moving pallets within Area A Landfill (risk due to presence of PCBs in landfill surface soils);
- Subase children exploring woods within Area A (risk due to PCBs in landfill surface soils); and
- Subase children exploring streambeds and Area A Wetland (risk due to pesticides in stream sediments).

Ground water within Area A contains VOCs and cadmium above ARAR and TBC drinking water standard/guidance values, indicating a potential health risk if the water were to be consumed. No potable water supply wells exist, or are planned by the Navy, in the potentially affected downgradient area. The Navy owns the land within the potentially affected area. Therefore, under existing and projected future land use conditions, no exposure pathways exists for human consumption of degraded ground water.

Ecological Risk Assessment: The ecological risk assessment addressed risks to a variety of trophic levels in the terrestrial and aquatic food chain in Area A. On the lower level of the food chain, risks to plants were low. Plants are unlikely to accumulate organic compounds to a great degree. Metals concentrations in soils and sediments were, in general, below levels that may adversely affect plants or higher trophic level organisms that feed on plants. However, cadmium concentrations in soil samples from the OBDA exceeded recommended levels protective of plants and organisms consuming plants.

Risks to terrestrial organisms due to DDTR in soil were greatest for soil invertebrates in the OBDA. The risks to soil invertebrates in the wetland and downstream areas due to contaminants were low.

The assessment indicates that DDTR in sediments of streams and ponds in the Downstream Watercourse Area poses a potentially great risk to biota. Organisms with the greatest exposure to DDTR contaminated sediments are benthic invertebrates. Frogs are also directly exposed to sediment during winter months. Other organisms potentially affected by these sediments are fish, if they are present in the ponds. Birds such as ducks, heron, and mammals such as raccoons and otter, may be exposed to DDTR by feeding on contaminated aquatic invertebrates and frogs, but this exposure will only account for a small part of their diet because they are likely to feed over a much greater geographical area than Area A.

Higher level organisms in the food chain may be exposed to the DDTR and, to a lesser extent, to PAHs bioaccumulated in soil invertebrates. The greatest potential risks are to small mammals such as the shrew that consume a diet consisting mainly of soil invertebrates at a rate equivalent to their body weight per day. Based on the assumption that they consume only contaminated soil invertebrates, there are potential risks to these animals. Risks to herbivorous birds and small mammals are much smaller than for the maximally exposed shrew since they have much less exposure to DDTR. Based on the low body burdens of DDTR in catbirds collected from Area A, risks to birds feeding on soil invertebrates appear to be low. This may be because the area they feed in is large in comparison to the portion of the OBDA with elevated levels of DDTR in soil.

The aquatic organisms in Area A at greatest risk are those exposed to elevated levels of DDTR in pond and stream sediments in the Downstream Watercourse Area. Therefore, benthic invertebrates and possibly frogs are at greatest potential risk. DDTR contaminated sediments have been transported by the streams in the downstream portion of Area A to the Thames River. However, DDTR concentrations and, therefore, potential risks due to DDTR are much lower at the stream outfalls than upstream.

8.2.1.2 Recommendations

It is recommended that this site proceed to the Feasibility Study phase to address the health and ecological risks identified. Additional data is recommended to be collected concurrent with the Feasibility Study to further assess several site conditions for input to the FS. Recommendations and data requirements are provided below.

Landfill Soils

- Further soil sampling is recommended around the Area A concrete pad (former hazardous waste storage area) to define the full extent of contamination identified in that area.

Wetland Sediments

- Further sediment sampling is recommended in the Area A Wetland to confirm the relatively low levels of pesticides detected compared with Area A Downstream sediments. Sampling in the pond and open water area near the wetland outlet is also recommended. These data are required for the Feasibility Study and further ecological assessment. The pond information would better allow assessment of risks to biota in these areas and to compare measured body burdens of DDTR in frogs from the wetland pond to sediment DDTR concentrations.

Ground Water

- Conduct another ground water sampling and analysis round for TCL organic and TAL inorganic parameters to confirm the analytical results. Also, perform specific radiological isotope ground water analysis to determine the source of the radiological constituents (natural or otherwise).

- The extent of VOC and cadmium ground water contamination in Area A Downstream should be defined and monitored.

- Further assessment of the ground water flow direction in the area of the southeastern portion of the landfill is required with respect to the homes served by private wells near NSB-NLON east gate. This would require the installation of additional monitoring wells in this area, and surveying the elevation of the water in the private wells.

Residential Wells

- **A further investigation of the sources of boron in residential wells is recommended.**

Weapons Center

- Further assessment of the source of elevated levels of cyanide and PAHs adjacent to the Weapons Center is recommended.

North Lake

- Surface soil sampling around the North Lake area is recommended to determine if contamination is present due to past pesticide application in the

general area. This is recommended to assure the safety of use of North Lake as a recreational area. Continued monitoring of North Lake is recommended should the lake remain open for public use. Should the lake remain open, access to the downstream watercourse areas should be restricted.

- **Long-term ground water elevation monitoring is recommended in this area to better determine ground water flow directions.**

- **The overflow pipe from North Lake to the stream which flows to the south of North Lake will be eliminated to prevent the possibility of water from the stream discharging into North Lake.**

<u>Downstream Watercourses and Pond</u>

- The ecological assessment was based on a limited number of surficial soil samples from the Area A Downstream Watercourse Area. At the time of designing the sampling program, it was unknown that DDTR levels would be the most elevated in this area. To gain a greater level of confidence in this assessment, we recommend additional surficial soil sampling and analysis in the downstream watercourse area.

- Additional information is required on biological conditions in the Area A Downstream Watercourses where elevated levels of DDTR were detected in pond and stream sediments. No biota sampling was performed in these areas. The assessment predicts risks to benthic invertebrates and possibly to frogs in these areas. To supplement this assessment with actual field data, additional field work is recommended to assess the biological community in the ponds and streams where DDTR was detected at elevated levels in sediments.

<u>Thames River</u>

- Pesticides are being transported to the Thames River. Although the levels in the river sediments detected to date are not high, further delineation is recommended to further evaluate this condition. Manganese has also been detected in the Thames River surface water samples at the outlet of Area A in concentrations above water quality criteria. In light of these facts, further ecological assessment of the Thames River, similar to that recommended at Goss Cove, DRMO, and Lower Subase is recommended to provide greater assurance regarding the current assessment of ecological risks. This assessment should consider the potential cumulative effects of NSB-NLON on the river.

8.2.2 DRMO

8.2.2.1 Summary

Background: The Defense Reutilization and Marketing Office (DRMO) site is adjacent to the Thames River in the northwest section of NSB-NLON. The DRMO is the storage and collection facility for items to be sold at auction sales held periodically through the year. Scrap metal is also temporarily stored prior to being transported off this site.

The DRMO site was used as a major base landfill and burning ground from 1950 to 1969. The materials burned and landfilled included construction materials, combustible scrap, and other non-salvageable waste items. These materials were reportedly burned on the shoreline, and disposed over the riverbank and partially covered. Also, a former battery acid handling facility was located adjacent to Building 491. An in-ground rubber-lined tank and associated pumping facilities were present, similar to the Spent Acid Storage and Disposal Area site.

DRMO operations at this site, after the closing of the landfill, include storage of various items, including submarine batteries, white goods, and empty drums.

Future plans for this site include the construction of a Conforming Storage Facility for the temporary storage of hazardous waste generated at NSB-NLON. Other routine grading and minor excavation occurs in the northern portion of the site.

Nature and Extent of Contamination: Radiation, geophysical and soil gas surveys were conducted. No radiation above background was detected. The geophysical survey identified several suspected buried metal objects, which were avoided during drilling operations. The soil gas survey assisted in defining VOCs in several areas.

Twenty-four soil samples were collected, from 12 test boring/monitoring well locations. Four surface soil samples were also collected. Six ground water samples were also collected and analyzed. These samples were analyzed to define the nature and extent of contamination at the former landfill site.

Some evidence of the former landfill was encountered during the drilling, including wood fragments, brick, metal, but predominantly earth fill material. The depth of fill varied from zero to eight feet.

VOC concentrations in soil at DRMO are generally low. However, many soil samples exceed TBC values for VOCs. Elevated VOCs were detected at 6TB4 (6-8'), where the following was found: vinyl chloride (1300 ppb), trichloroethene (20,000 ppb), and tetrachlorethene (210 ppb). The contamination appears to be generally isolated at the site based on results of the soil gas survey and other soil samples collected in this area.

SVOs were present in most samples collected in the former landfill area. The SVOs were predominantly comprised of PAH compounds, many of which were at elevated levels. The spatial density of the sample locations indicates that PAHs are likely present throughout the

DRMO site limits. Based on the former use of the site as a landfill, and an area where material was burned, the PAHs are likely a result of incomplete combustion and, perhaps to a lesser degree, due to petroleum releases.

PCB Arochlor 1260 is present at almost all sample locations except 6MW5S (background), and 6MW1S and 6MW2S (rear of office and storage building). Concentrations range from 52 ppb to 12,000 ppb. It is generally present in both the 0-2' and 2-6' depths. The presence of PCBs at this site is most likely associated with scrap metal storage (e.g., white goods) and associated capacitor leaks, and past storage of transformers, and not necessarily due to landfill disposal. PCB (Arochlor-1260) was also detected at sediment sample location 2DSD12, at the outfall of the storm drainage system from Area A, to the rear of Building 397 at DRMO. It was not present in other upgradient sample points along the Area A downstream watercourses, and may be a result of surface soil transport via surface water runoff from DRMO.

Pesticides were detected at one sample location at elevated concentrations; no other pesticides were detected at other sample locations. Total pesticide concentration was 57,800 ppb, consisting of DDT, DDD and DDE. The DDT concentration was detected above the TBC value. Due to pesticide detection at only one sample location and at a depth of 2-6 feet, it was likely associated with past landfilling rather than application.

Out of 24 samples analyzed for TCLP metals, 21 contained one or more metals exceeding TBC values. Metals exceeding TBC values included barium, cadmium, chromium, lead, mercury and silver. TCLP hazardous waste characteristic values were exceeded for lead (5 ppm) at 6MW3S (2-4') 52 ppm, at 6TB5 (2-6') 32 ppm, and at 6SS3 (0-0.5') 6.2 ppm. Lead values were generally elevated around Building 491 (former battery acid handling), indicating battery acid releases occurred in this area. Many inorganic constituents exceeded established background levels based on mass weight analysis. These included antimony, beryllium, cadmium, cobalt, copper, lead, mercury, nickel, zinc and boron. The majority of these elevated metals are likely related to a combination of past landfill disposal and scrap metal storage.

No petroleum hydrocarbons were detected in the ground water samples. Trichloroethene and 1,2 dichloroethene were present in three downgradient wells (6MW2S, 6MW3S, and 6MW4S). Trichloroethene exceeded the ARAR value (5 ppb) with a concentration of 8 ppb at well 6MW4S. The primary source of the solvents in the ground water, based on the soil analytical results and the soil gas data, is projected to be in the area of 6TB4, 6MW4S, 6TB6 and 6TB7.

No SVOs, PAHs, pesticides or PCBs were detected in any wells at the DRMO site. Low levels of phthalates and benzoic acid were detected in the upgradient well 6MW5D. The inorganic ground water analysis results indicate that selenium exceeds the primary drinking water standards (ARARs) at wells 6MW2S, 6MW3S, and 6MW4S. The cause of the selenium levels in the ground water is unclear, but appears to be site related. Radiological screening values were exceeded in two of the ground water sample locations for gross beta. The elevated readings could be the result of naturally occurring radioisotopes which do not meet the regulatory screening criteria, but further analysis is required for confirmation.

No VOCs, SVOs, pesticides, or PCBs were detected in the upgradient surface water sample. Comparison of the inorganic results for this sample with the downgradient water sample (Goss Cove) did not suggest any detectable impact on the Thames River from NSB-NLON based on this limited data set.

Human Health Risk Assessment: Several identified exposure pathways were evaluated for Area A. They are listed as follows:

- Citizens attending auctions and public sales at DRMO;
- Navy workers sorting scrap metal;
- Workers repairing/installing utilities;
- Construction of a Hazardous Waste Storage Facility; and
- Exposure to fugitive dust from DRMO.

Negligible or *de minimus* risks were calculated for Citizens attending auctions and public sales, Utility workers repairing/installing utilities, and Exposure to fugitive dust from DRMO. The following exposure scenarios did exhibit risks which fall within the one in ten thousand and one in one million excess cancer risk range:

- Navy workers sorting scrap metal (risk due to PCBs, PAHs, and beryllium in surface soils); and

- Construction of a Hazardous Waste Storage Facility (risk due to elevated level of **lead** at northern portion of site).

Although ground water quality exceeds drinking water standards, no drinking water wells are within the affected area, nor could they be due to the proximity of the brackish Thames River.

Ecological Risk Assessment: Ground water from this site discharges to the Thames River. Based on the available data, contaminant concentrations in ground water are predicted to be below water quality criteria after further dilution in ground water, attenuation due to adsorption to soils, and dilution in the Thames River estuary. Risks to fish due to contaminants in ground water discharge from these sites are expected to be low.

8.2.2.2 Recommendations

It is recommended that this site proceed to the Feasibility Study phase. In the interim, specific health and safety provisions are recommended for all future subgrade construction projects at the site. Prior to construction in specific site areas, further subsurface investigation may be required to characterize the quality, health and safety, and potential disposal requirements of the material. The geophysical survey indicated the presence of buried metal objects at three locations as defined in Section 4.0. Any future construction planned near these areas should include exploratory excavation to identify health and safety construction requirements.

Due to the potential risks to site workers resulting from contaminated surface soils, it is recommended that worker health and safety procedures be developed to mitigate this risk. The risks are primarily related to incidental oral and dermal exposure. It is suggested that coveralls and gloves be worn during these activities and that hands be cleaned following working.

The following additional data requirements are recommended to be developed during the Feasibility Study phase.

1. Further environmental risk assessment of the potential impact of the site on the Thames River should be conducted, to verify that the impacts are negligible. This would include surface water samples at low tide (ground water discharge conditions), sediment sampling, and biota survey/sampling along the Thames River shoreline.

2. Conduct another ground water sampling and analysis round for TCL organic and TAL inorganic parameters to confirm the analytical results. Perform specific radiological isotope ground water analyses to determine the source of the radiological constituents (natural or otherwise).

8.2.3 Lower Subase

8.2.3.1 Summary

Background: The Lower Subase is located along the western edge of NSB-NLON, adjacent to the Thames River. It is bounded by the Thames River to the west and by the Penn Central Railroad to the east. The Lower Subase is the original subase and, therefore, its history dates back to 1867. Most of the construction took place in the early 1900s with major expansion between 1935 to 1945. Extensive portions of this area have been filled. The Lower Subase has always been used for operations and maintenance functions. Those functions typically generate industrial and hazardous wastes such as petroleum oils and cleaning solvents. Also located at the Lower Subase are two sets of concrete underground storage tanks located at the northern end of the study area. Four USTs are located just north of the powerhouse, and seven USTs are located just south of Building 107. In addition, there is an extensive underground fuel oil and diesel oil distribution system at the Lower Subase.

Previous investigations (NESO, 1979 and Wehran, 1987) have identified subsurface oil contamination associated with both sets of underground storage tanks, a waste oil pit in Building 79, in which historically, diesel train engines were serviced, and the underground fuel oil distribution system.

The Navy has implemented a substantial program to replace these underground tanks and the fuel oil distribution system. Of the ten concrete underground storage tanks, six now serve as spill contaminant for new steel tanks, three have been properly abandoned, and one is out-of-service. The Navy, while retrofitting or abandoning these tanks, did not detect any major structural defects or cracks. The underground #6 oil lines will be abandoned in the future based upon present Navy plans. All of the subsurface #2 oil lines, which are direct buried, were replaced or installed in 1980.

Nature and Extent of Contamination: To determine the extent and degree of contamination at the Lower Subase, investigations included the installation of 17 new wells and five soil borings. Soils from the five soil borings were only field screened for contamination. Soil samples were collected from all monitoring well installations. Ground water from all 17 wells and seven existing wells were sampled. All soil and ground water samples were analyzed for TCL volatile organics, TAL inorganics, total petroleum hydrocarbons, and fluorescence "fingerprint" analysis. In addition, soils were also analyzed for TCLP metals.

The following findings and conclusions are provided.

- Ground water at the Lower Subase is relatively clean with only slight exceedances of ARAR values at **six** locations. VOC standards were exceeded at 13MW2 and 13MW13, and metal standards were exceeded at **13MW8,** 13MW9, NESO10 **and NES011**. These ARARs are based on standards for drinking water.

- No free product was detected in the subsurface, other than very thin layers in 13MW5 and MH83. No oil releases were observed along the bulkhead at the Thames River.

- A large area of subsurface soil near of Building 29 contains petroleum hydrocarbons which apparently originate from both sets of underground storage tanks. Although petroleum contamination is evident, no ARAR/TBC values for soils are exceeded.

- Ground water near Building #29 had a pH ranging from 9-11. This high pH is indicative of an ongoing release, and is apparently due to the discharge of boiler blowdown to the subsurface.

- A smaller area of subsurface soil adjacent to Building 79 contains petroleum oils and low levels of organic solvent. TBC values for organics are only slightly exceeded at one sample location 13MW13. The apparent source of this contamination is the former onsite oil pit in Building 79.

- Low levels of petroleum products are ubiquitous in the Lower Subase soils and ground water. The apparent source of this contamination is the accumulation over the years of minor spills and leaks.

- Elevated lead levels in soils were detected in several locations scattered across the site. Of these, two locations had TCLP lead levels high enough to classify the soils as a hazardous waste (13MW11 and 13MW15). The lead contamination may have resulted from former lead-acid battery management operations that used to be performed at the Lower Subase. Lead was not detected in ground water above ARARs.

- The subsurface free product detected in previous studies is no longer present. It is concluded that some of this oil has migrated to the Thames River, and the

remainder has been adsorbed to soils.

- Low levels of thallium were detected in ground water at wells 13MW15 and 13MW16.

Human Health Risk Assessment: Several identified exposure pathways were evaluated for the Lower Subase. They are listed as follows:

- Utility workers exposed to soils and ground water in utility vaults;
- Utility workers exposed to soils and ground water during utility excavation work;
- Future construction of buildings in Lower Subase; and

Negligible or *de minimus* risks were calculated for these exposure scenarios.

Although ground water quality exceeds drinking water standards in a few wells, no drinking water wells exist in the affected area, nor could they due to the proximity of the site to the brackish Thames River.

Ecological Risk Assessment: Ground water from the Lower Subase discharges to the Thames River. Based on available data, contaminant concentrations in ground water are projected to be below water quality criteria after further dilution in ground water, attenuation due to adsorption to soils, and dilution in the much greater flow (compared to ground water flow) in the Thames River estuary. Risks to aquatic life due to contaminants in ground water discharge from these sites are expected to be low.

8.2.3.2 Recommendations

It is recommended that this site proceed to the Feasibility Study phase.

The following additional data requirements are recommended to be developed during the Feasibility Study.

- Further subsurface soil sampling with testing for total and TCLP lead should be performed in areas of elevated lead levels in soils to define the extent of soil that is classified as a hazardous waste.
- Conduct another ground water sampling and analysis round for TCL and TAL parameters detected to confirm analytical results and TCL SVOs to confirm the assumptions made in the risk assessment. The risk assessment estimated SVO concentrations based upon total petroleum hydrocarbon concentrations.
- A health and environmental risk assessment of the potential impact of the site on the Thames River should be conducted, to verify the qualitative assessment that impacts are negligible. This would include surface water samples at low

tide (ground water discharge conditions), sediment sampling, and potentially biota survey/sampling along the Thames River shoreline.

- A testing program should be developed for the buried #2 fuel oil lines (installed in 1980) to insure that they are not leaking and do not leak in the future.

- The abandonment of the #6 oil lines should be done in a manner to prevent any future subsurface release of #6 oil.

- The one tank (H) that is out-of-service should be properly abandoned.

- The apparent release of boiler blowdown to the subsurface at Building #29 should be investigated and corrected.

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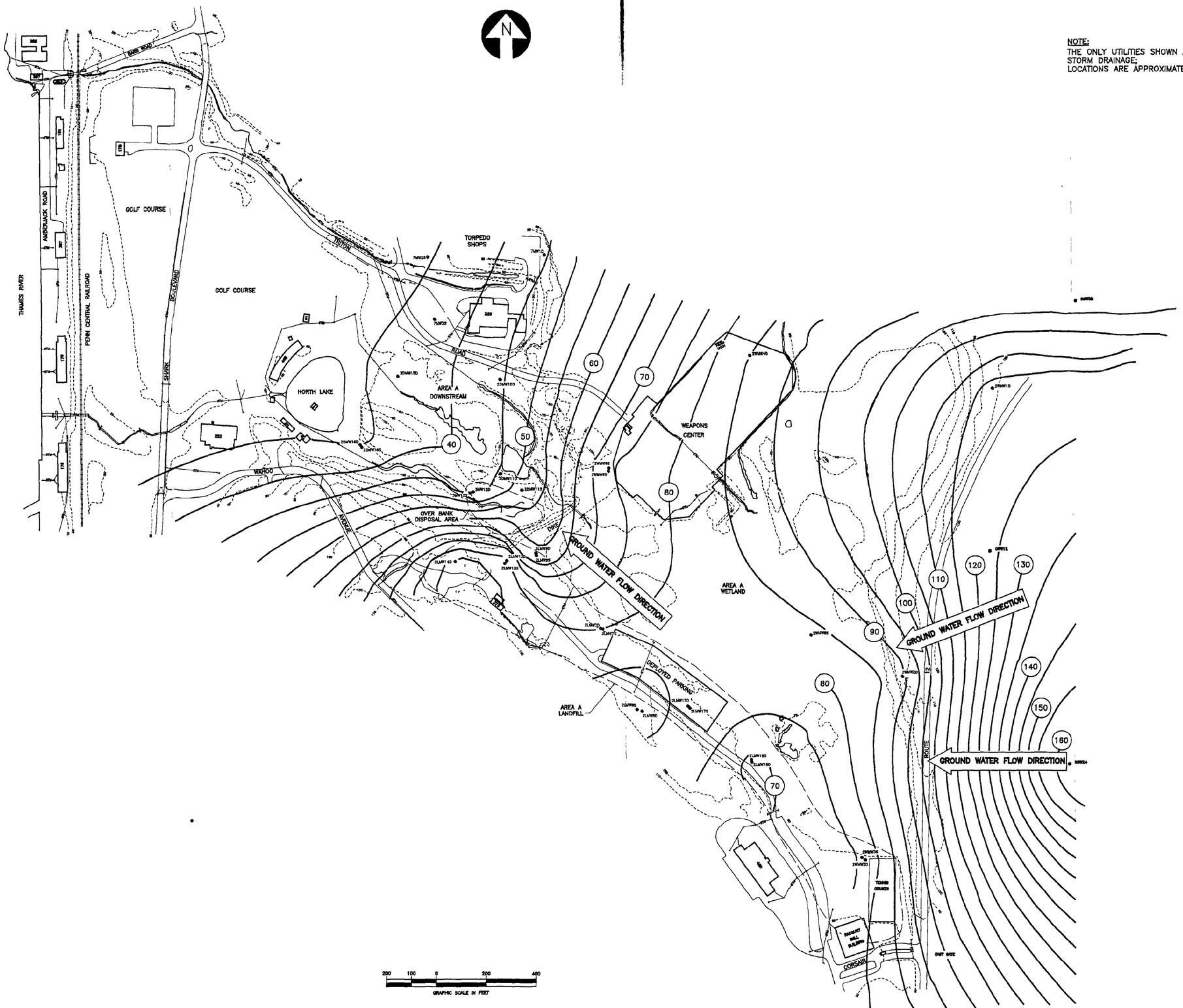
NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE; LOCATIONS ARE APPROXIMATE.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE–NEW LONDON GROTON, CONN.	LEGEND		PLATE 3–2 GROUND WATER CONTOUR MAP OVERBURDEN AQUIFER AREA A
	GROUND WATER CONTOUR	EXISTING CONTOUR	ATLANTIC ENVIRONMENTAL SERVICES, INC
	MONITORING WELL	BUILDING NUMBER	
	OFFSITE RESIDENTIAL WELL	WATERCOURSE	
		STORM SEWER	

0017217X

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



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

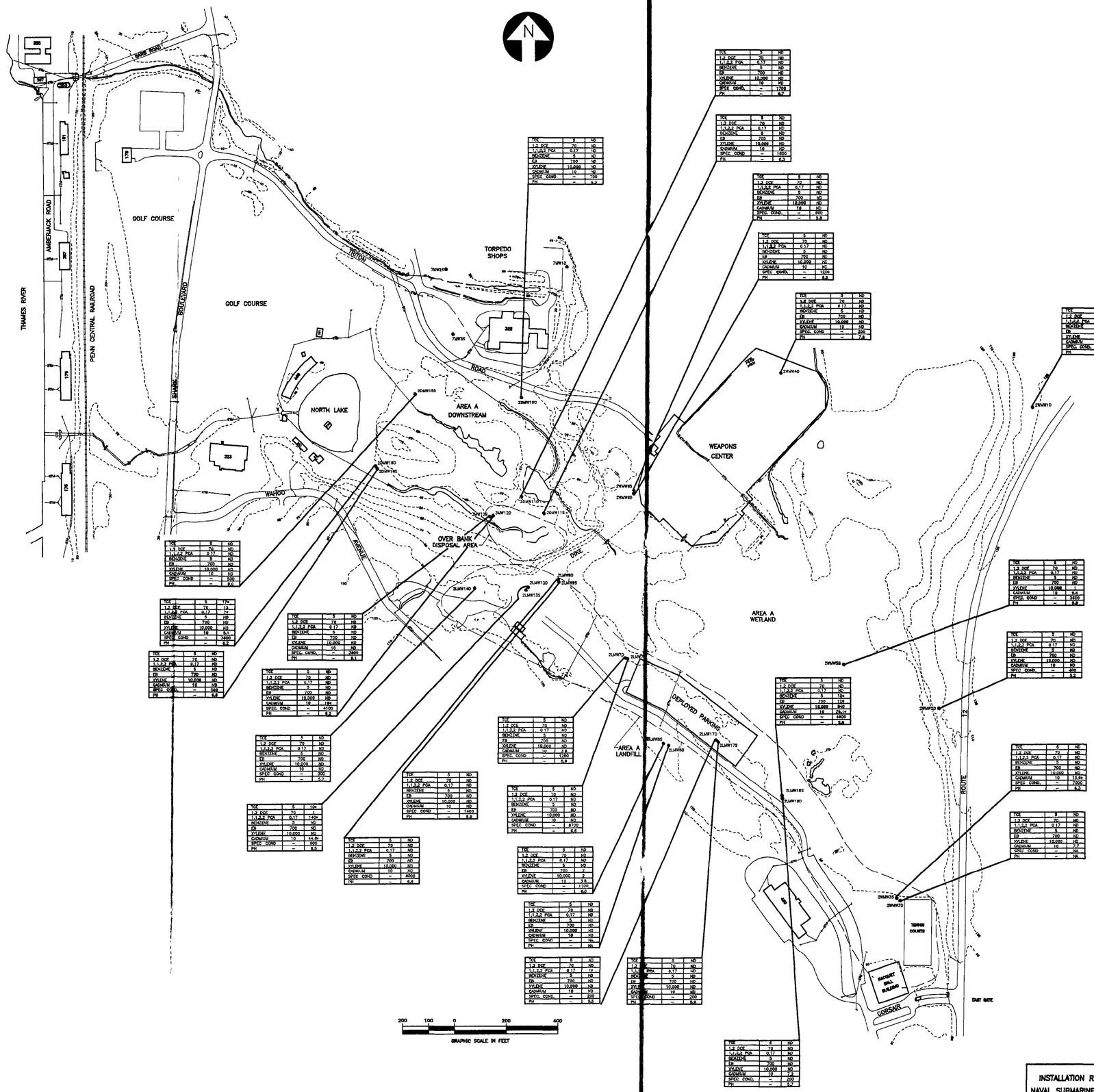
LEGEND

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

PLATE 3-3
POTENTIOMETRIC SURFACE CONTOUR MAP
BEDROCK AQUIFER
AREA A

ATLANTIC ENVIRONMENTAL SERVICES, INC.

00172184



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

CONSTITUENTS	ARAR/TBC	CONCENTRATIONS
TRICHLOROETHENE	5	ND
1,2 DICHLOROETHENE	70	ND
1,1,2,2 TETRACHLOROETHANE	0.17	1
ETHYL BENZENE	5	ND
	700	ND
	10,000	ND
SPECIFIC CONDUCTIVITY	10	ND
	–	200
	–	5.2

ND=NOT DETECTED
NA=NOT ANALYZED
* EXCEEDANCE OF ARAR/TBC

LEGEND

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

LEGEND

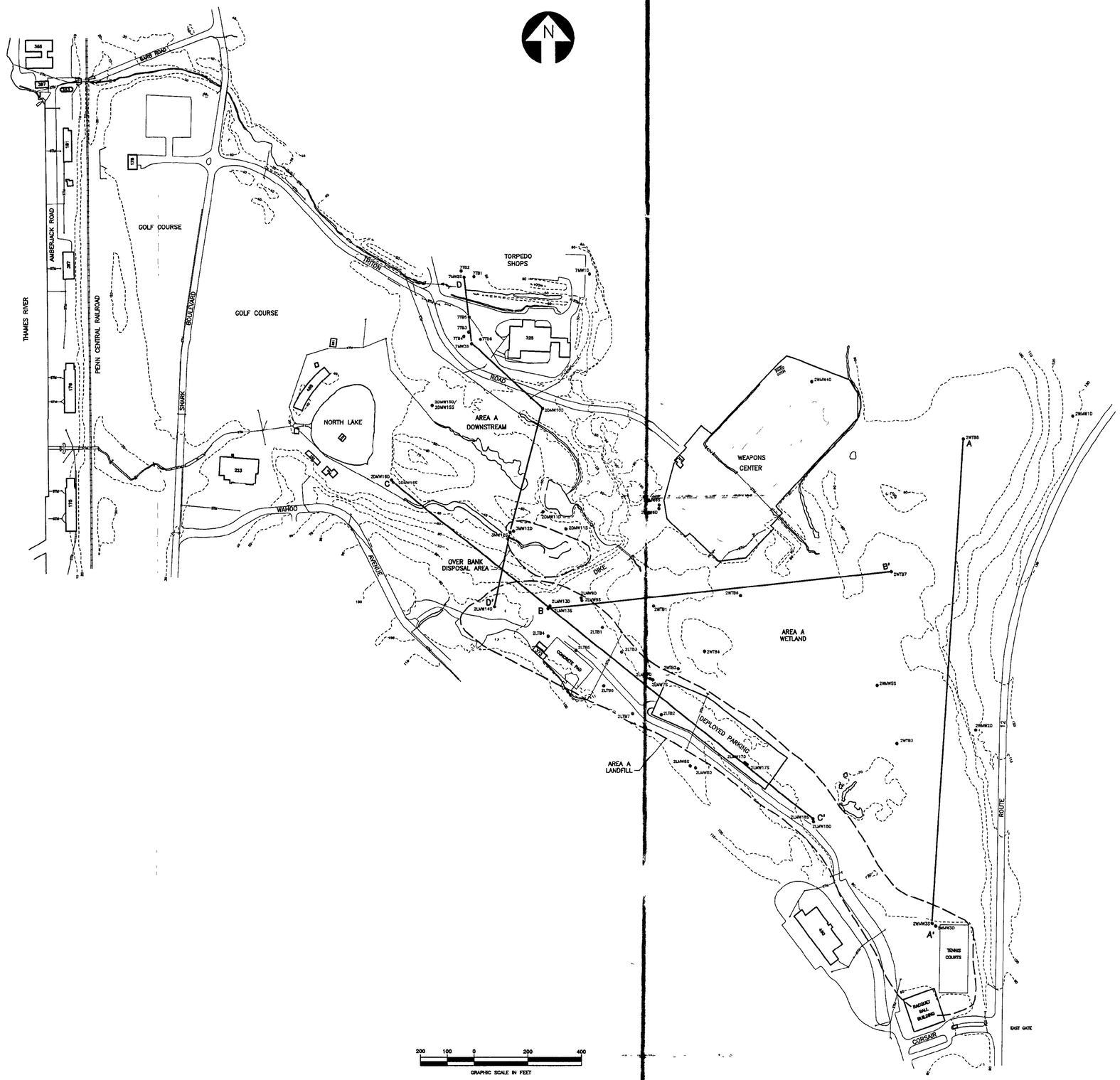
- MW1 MONITORING WELL
- 10 EXISTING CONTOUR
- 123 BUILDING NUMBER
- WATERCOURSE
- STM STORM SEWER

PLATE 4–2
SUMMARY OF GROUND WATER QUALITY
AREA A

ATLANTIC ENVIRONMENTAL SERVICES, INC.

0017219X

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



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

LEGEND

A — A'	CROSS-SECTION
6MW1	MONITORING WELL
6TB1	TEST BORING
—10—	EXISTING CONTOUR
123	BUILDING NUMBER
	WATERCOURSE
—STM—	STORM SEWER

PLATE 3-1
GEOLOGIC CROSS-SECTION LOCATIONS
AREA A

ATLANTIC ENVIRONMENTAL SERVICES, INC

0017 2 20X