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# FINAL
# IR Program Site 07, Calf Pasture Point
# Phase III Remedial Investigation

## Volume I: Technical Report

## Naval Construction Battalion Center
## Davisville, Rhode Island

**Contract No. N62472-92-D-1296**
**Contract Task Order No. 0032**

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In compliance with EA's Quality Procedures for review of deliverables outlined in the Program Quality Management Plan, this final deliverable has been reviewed for quality by the undersigned Senior Technical Reviewer. The information presented in this report/deliverable has been prepared in accordance with the approved Implementation Plan for the Contract Task Order (CTO) and reflects a proper presentation of the data and/or the conclusions drawn and/or the analyses or design completed during the conduct of the work. This statement is based upon the standards identified in the CTO and/or the standard of care existing at the time of preparation.

Senior Technical Reviewer

Charles W. Houlik, Ph.D., CPG 11 SEP 98
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# CONTENTS

**Page**

LIST OF ABBREVIATIONS AND ACRONYMS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

1. INTRODUCTION . . . . . 1-1

1.1 Background, Objective, And Scope . . . . . 1-1
1.2 Background . . . . . 1-2

1.2.1 NCBC Description . . . . . 1-2
1.2.2 NCBC Davisville History . . . . . 1-2
1.2.3 Site 07 Description and History . . . . . 1-4
1.2.4 Previous Investigations . . . . . 1-5

1.2.4.1 Pre-CERCLA Investigations—U.S. Navy . . . . . 1-6
1.2.4.2 Previous Investigations—EPA . . . . . 1-7
1.2.4.3 Remedial Investigations . . . . . 1-8
1.2.4.4 Study Area Screening Evaluation-Calf Pasture Point Munitions Bunkers . . . . . 1-12
1.2.4.5 Removal Action and Close-Out-Calf Pasture Point Munitions Bunkers . . . . . 1-12
1.3 Report Organization . . . . . 1-13

2. PHASE III RI FIELD INVESTIGATION . . . . . 2-1

2.1 Introduction . . . . . 2-1
2.2 Previous Investigations . . . . . 2-1
2.3 Phase III RI Field Sampling Program . . . . . 2-2

2.3.1 Historical Data Evaluation for the Phase III RI Strategy/Planning . . 2-2
2.3.2 Onsite Field Program . . . . . 2-3

2.3.2.1 Stage 1 (Seismic Refraction Survey) . . . . . 2-4
2.3.2.2 Stage 2 (Hydroprobe Survey) . . . . . 2-4
2.3.2.3 Stage 3 (Soil Boring and Monitoring Well Installation) . . . 2-6

2.3.2.4 Hydrological Testing . . . . . 2-9

2.3.3. Offshore Field Program . . . . . 2-9
2.3.4 EPA Site Activities . . . . . 2-10

2.4 Field Investigation Procedures . . . . . 2-10

2.4.1 Hydroprobe Sample Collection and Analysis . . . . . 2-10

2.4.1.1 Sample Collection . . . . . 2-10
2.4.1.2 Sample Analysis . . . . . 2-10

2.4.2 Soil Sample Collection . . . . . 2-11
2.4.3 Drilling . . . . . 2-11
2.4.4 Well Installation . . . . . 2-13

2.4.4.1 Riser and Screen Installation . . . . . 2-13
2.4.4.2 Filter Pack . . . . . 2-13
2.4.4.3 Bentonite Seal . . . . . 2-14
2.4.4.4 Grout Seal . . . . . 2-14
2.4.4.5 Surface Completion . . . . . 2-14
2.4.4.6 Well Identification . . . . . 2-15

2.4.5 Well Development . . . . . 2-15
2.4.6 Ground-Water Sampling . . . . . 2-16

2.4.6.1 Measurement of Water Level . . . . . 2-16
2.4.6.2 Purging and Sampling . . . . . 2-16

2.4.7 Hydrological Testing . . . . . 2-18
2.4.8 Wetlands Sediment . . . . . 2-19

2.5 Investigation Derived Waste Management . . . . . 2-20
2.6 Health And Safety . . . . . 2-20
2.7 Analytical Procedures . . . . . 2-20
2.8 Field And Laboratory QA/QC . . . . . 2-21

2.8.1 Field QA/QC . . . . . 2-21
2.8.2 Trip Blanks . . . . . 2-21
2.8.3 Field Rinsate Blanks . . . . . 2-21
2.8.4 Duplicate Samples . . . . . 2-22
2.8.5 Source Water . . . . . 2-22

2.9 Data Validation . . . . . 2-22

3. PHYSICAL CHARACTERISTICS . . . . . 3-1

3.1 Introduction . . . . . 3-1
3.2 Physiography . . . . . 3-1
3.3 Meteorology . . . . . 3-1
3.4 Surface Water Hydrology . . . . . 3-2
3.5 Soil . . . . . 3-2
3.6 Geology . . . . . 3-3

3.6.1 Regional Geology . . . . . 3-3
3.6.2 Site Geology . . . . . 3-4

3.7 Hydrogeology . . . . . 3-6

3.7.1 Regional Hydrogeology . . . . . 3-6
3.7.2 Regional Surface Water Quality . . . . . 3-6
3.7.3. Regional Ground-Water Quality . . . . . 3-7
3.7.4 Regional Aquifer Characteristics . . . . . 3-7
3.7.5 Site Hydrogeology . . . . . 3-8

3.7.5.1 Hydrogeological Zones . . . . . 3-8
3.7.5.2 Interpreted Ground-Water Flow Direction . . . . . 3-9
3.7.5.3 Vertical Gradients . . . . . 3-12
3.7.5.4 Hydraulic Testing . . . . . 3-13

3.7.6 Ground-Water/Tidal Monitoring . . . . . 3-13

3.7.6.1 Background . . . . . 3-13
3.7.6.2 Tidal Efficiencies of Different Units . . . . . 3-14
3.7.6.3 Hydraulic Conductivity and Storage . . . . . 3-15
3.7.6.4 Tidal Impacts on Ground-Water Movement . . . . . 3-15

3.7.7 Hydraulic Conductivity and Specific Yield/Storage . . . . . 3-16

4. NATURE AND EXTENT . . . . . 4-1

4.1 Introduction . . . . . 4-1
4.2 Reported Potential Sources . . . . . 4-1
4.3 Water Supply Wells . . . . . 4-2
4.4 Background Results . . . . . 4-2

4.5 Subsurface Soil . . . . . 4-2

4.5.1 Confirmation Study (CS) . . . . . 4-2
4.5.2 Phase I RI . . . . . 4-2
4.5.3 Phase II RI . . . . . 4-2
4.5.4 Phase III RI, Offshore Investigation and Interior Wetland Sampling 4-3

4.5.4.1 Quality Control Summary . . . . . 4-4
4.5.4.2 VOC in Subsurface Soil . . . . . 4-5
4.5.4.3 Acetone Reported in Phase III RI Subsurface Soil Samples 4-7
4.5.4.4 Comparison of Phase I, II, and III RI Soil Sampling Results 4-8
4.5.4.5 Total Organic Carbon (TOC) in Subsurface Soil . . . . . 4-8

4.6 Ground-Water Results . . . . . 4-8

4.6.1 General Water Quality . . . . . 4-9

4.6.1.1 Chloride . . . . . 4-9
4.6.1.2 Sodium . . . . . 4-9
4.6.1.3 Total Dissolved Solids . . . . . 4-10
4.6.1.4 Salinity . . . . . 4-10
4.6.1.5 Source Water . . . . . 4-14

4.6.2 VOC in Ground Water . . . . . 4-14

4.6.2.1 Phase I RI . . . . . 4-14
4.6.2.2 Phase II RI . . . . . 4-14
4.6.2.3 Phase III RI and Offshore Investigation . . . . . 4-14
4.6.2.4 Acetone Reported in Phase III RI Ground-Water Samples . 4-19
4.6.2.5 Comparison of Phase I, II, and III RI Ground-Water Sampling Results . . . . . 4-20

4.6.3 Metals in Ground Water . . . . . 4-20

4.6.3.1 Phase I RI . . . . . 4-20
4.6.3.2 Phase II RI . . . . . 4-21
4.6.3.3 Phase III RI . . . . . 4-21

4.6.4 SVOC, Pesticides, and PCB In Ground Water . . . . . 4-24

4.6.4.1 Phase I RI . . . . . 4-24
4.6.4.2 Phase II RI . . . . . 4-24
4.6.4.3 Phase III RI and Offshore Investigation . . . . . 4-24

4.7 Site Conceptual Model . . . . . 4-24

5. FATE AND TRANSPORT . . . . . 5-1

5.1 Processes And Properties Affecting Fate And Transport . . . . . 5-1

5.1.1 Partitioning . . . . . 5-1

5.1.1.1 Aqueous-Solid Phase Partitioning . . . . . 5-1
5.1.1.2 Aqueous-Vapor Phase Partitioning . . . . . 5-2
5.1.1.3 Solid-Vapor Phase Partitioning . . . . . 5-2

5.1.2 Transformations . . . . . 5-3

5.1.2.1 Chemical-induced Transformations . . . . . 5-3
5.1.2.2 Photochemical Transformations . . . . . 5-4
5.1.2.3 Biotransformation . . . . . 5-5

5.1.3 Non-aqueous Phase Layers . . . . . 5-5

5.1.3.1 NAPL Properties . . . . . 5-6
5.1.3.2 NAPL Processes . . . . . 5-7
5.1.3.3 Site Evaluation . . . . . 5-8

5.1.4 Dissolved Phase . . . . . 5-9

5.1.4.1 Dissolved Phase Properties . . . . . 5-9
5.1.4.2 Dissolved Phase Processes . . . . . 5-10

5.1.5 Gaseous and Vapor Phases . . . . . 5-10

5.1.5.1 Vapor and Gaseous Phase Properties . . . . . 5-11
5.1.5.2 Vapor and Gaseous Phase Processes . . . . . 5-11

5.2 Site Environmental Characteristics Affecting Chemical Fate And Transport 5-11

5.2.1 Soil . . . . . 5-11

5.2.1.1 Porosity . . . . . 5-11
5.2.1.2 Permeability . . . . . 5-12
5.2.1.3 Organic Carbon Content . . . . . 5-12
5.2.1.4 Density . . . . . 5-12

5.2.1.5 pH and Eh . . . . . 5-13

5.2.2 Ground Water . . . . . 5-13

5.2.2.1 Salinity . . . . . 5-13
5.2.2.2 pH and Eh . . . . . 5-14
5.2.2.3 Temperature . . . . . 5-14
5.2.2.4 Dissolved Oxygen . . . . . 5-15
5.2.2.5 BOD/COD . . . . . 5-15

5.2.3 Atmosphere . . . . . 5-15

5.2.3.1

Meteorological Data . . . . . 5-15
5.2.3.2 Site Topography and Atmospheric Mixing . . . . . 5-15

5.3 FATE AND TRANSPORT SCREENING PROCESS . . . . . 5-16

5.3.1 Purpose, Limitations and Introduction of Work Performed . . . . . 5-16
5.3.2 Screening Criteria And Partitioning Coefficients . . . . . 5-18
5.3.3 Detection Frequency . . . . . 5-19
5.3.4 First-Step Screening - Shallow Wells . . . . . 5-20

5.3.4.1 VOC . . . . . 5-20
5.3.4.2 Metals . . . . . 5-21

5.3.5 First-Step Screening Of Deep/Rock Wells . . . . . 5-22

5.3.5.1 VOC . . . . . 5-22
5.3.5.2 Metals . . . . . 5-23

5.3.6 Second-Step Screening Of Shallow Wells . . . . . 5-24

5.3.6.1 Set Up of the AT123D Model . . . . . 5-24
5.3.6.2 Estimated Shoreline Concentration - VOC . . . . . 5-25
5.3.6.3 Limitations of the Results . . . . . 5-27
5.3.6.4 Estimated Shoreline Concentration - Metals . . . . . 5-27
5.3.6.5 Assessment of Potential Impact on Allen Harbor Entrance Channel Surface Water from Site 07 Shallow Ground- Water. . . . . 5-27

5.3.7 Second-Step Screening of Deep Rock Wells . . . . . 5-30

5.3.7.1 Set Up of the AT123D Model . . . . . 5-30
5.3.7.2 Estimated Near-Shore Concentrations - VOC . . . . . 5-31
5.3.7.3 Limitations of the Results. . . . . .5-33

5.3.8 Screening Process Conclusions . . . . . 5-33

6. HUMAN HEALTH RISK ASSESSMENT . . . . . 6-1

6.1 Introduction . . . . . 6-1

6.1.1 Organization of the Chapter . . . . . 6-2
6.1.2 Site Characterization . . . . . 6-3

6.1.2.1 Site Description . . . . . 6-3
6.1.2.2 Media Sampling . . . . . 6-4

6.2 Hazard Identification . . . . . 6-6

6.2.1 Selection of Chemicals Used to Estimate Human Health Risks . . . . 6-7

6.2.1.1 Data Quality Evaluation . . . . . 6-7
6.2.1.2 Environmental Sampling Data Management and Evaluation 6-9
6.2.1.3 Risk-Based Concentration Screening . . . . . 6-11
6.2.1.4 Additional Screening of COCs . . . . . 6-14
6.2.1.5 Uncertainty in Application of a Risk-Based Screening Level Approach . . . . . 6-17

6.2.2 Hazard Identification of Chemicals Selected for Assessment of Human Health Risk at Site 07 . . . . . 6-17

6.3 Dose-response Assessment . . . . . 6-47

6.3.1 Establishing Toxicity Values for Health Effects Other than Cancer (Systemic Toxicity) for the Chemicals of Concern . . . . . 6-48
6.3.2 Establishing Toxicity Values for the Carcinogenic Effects of the COCs . . . . . 6-49
6.3.3 Toxicity Values for COCs at NCBC Davisville . . . . . 6-50

6.4 Assessment Of Human Exposure . . . . . 6-69

6.4.1 Potential Receptor Populations . . . . . 6-71
6.4.2 Exposure Pathways . . . . . 6-71

6.4.2.1 Chemical Release Source . . . . . 6-72
6.4.2.2 Environmental Transport Media . . . . . 6-72
6.4.2.3 Exposure Points . . . . . 6-72
6.4.2.4 Human Exposure Routes . . . . . 6-72
6.4.2.5 Human Exposure Pathways . . . . . 6-73

6.4.3 Estimating Exposure Point Concentrations . . . . . 6-77

6.4.3.1 Soil Exposure Point Concentrations . . . . . 6-77
6.4.3.2 Sediment Exposure Point Concentrations . . . . . 6-78
6.4.3.3 Ground Water Exposure Point Concentrations . . . . . 6-78
6.4.3.4 Surface Water Exposure Point Concentrations . . . . . 6-79
6.4.3.5 Shellfish Exposure Point Concentrations . . . . . 6-79

6.4.4 Estimating Intakes for Contaminants of Concern at Site 07 . . . . . 6-80
6.4.5 Exposures to Lead . . . . . 6-81

6.5 Characterization of the Nature and Magnitude of Human Health Risks at NCBC Davisville Site 07 and Adjacent Offshore Media . . . . . 6-81

6.5.1 Methodology for Quantitative Risk Estimation . . . . . 6-82

6.5.1.1 Hazard Index for Noncarcinogenic Effects . . . . . 6-82
6.5.1.2 Risk for Carcinogenic Effects . . . . . 6-83

6.5.2 Risk Characterization . . . . . 6-83

6.5.2.1 Future Remediation/Construction Workers . . . . . 6-83
6.5.2.2 Future Recreational Users . . . . . 6-84
6.5.2.3 Shellfish Consumers . . . . . 6-86
6.5.2.4 Hypothetical Future Residents . . . . . 6-87
6.5.2.5 Risks Associated with Lead . . . . . 6-88
6.5.2.6 Risk Associated with Butyltin . . . . . 6-89

6.5.3 Uncertainties and Limitations in Estimating Health Risks . . . . . 6-89

6.5.3.1 Sampling and Analysis Uncertainties . . . . . 6-90
6.5.3.2 Chemical Fate and Transport Modeling Uncertainties . . . 6-90
6.5.3.3 Toxicological Assessment Uncertainties . . . . . 6-90
6.5.3.4 Exposure Assessment Uncertainties . . . . . 6-93

6.6 Summary And Conclusions . . . . . 6-95

6.6.1 Summary . . . . . 6-95

6.6.1.1 Summary of Cancer Risk Estimates . . . . . 6-96
6.6.1.2 Summary of Risks for Health Effects Other than Cancer . 6-97
6.6.1.3 Summary of Risks Due to Lead . . . . . 6-99

6.6.2 Conclusions . . . . . 6-99

7. CONCLUSIONS AND RECOMMENDATIONS . . . . . 7-1

7.1 Geology And Hydrogeology . . . . . 7-1
7.2 Nature And Extent of VOC . . . . . 7-4
7.3 Nature And Extent Of Metals . . . . . 7-8
7.4 Potential Impact On Adjacent Surface Water Bodies By Migration Of Solutes In Ground Water From Site 07 . . . . . 7-9
7.5 Potential Impact Of Solutes In Ground Water From Site 07 On Adjacent Intertidal Sediment . . . . . 7-9
7.6 Terrestrial Ecological Risk Assessment . . . . . 7-10
7.7 Marine Ecological Risk Assessment . . . . . 7-10
7.8 Human Health Risk Assessment . . . . . 7-10
7.9 Recommendations . . . . . 7-11

REFERENCES

APPENDIX A: Selected Data From Previous Investigations
APPENDIX B: Report of Seismic Refraction Surveys, IR Site 07
APPENDIX C: Ground-Water Data Report, IR Program Sites 03 and 07
APPENDIX D: Phase III RI Boring Logs
APPENDIX E: Phase III RI Monitoring Well Diagrams
APPENDIX F: Phase III RI Slug Test Data
APPENDIX G: Phase III RI Packer Test Data
APPENDIX H: Phase III RI Well Development Forms
APPENDIX I: Phase III RI Field Sampling Forms
APPENDIX J1: Salinity and Ground-Water Flow Path Modeling
APPENDIX J2: Phase III RI Ground-Water/Tidal Monitoring Data
APPENDIX J3: Raw Borehole Geophysical Logs From the USGS
APPENDIX K: Data Validation Reports
APPENDIX L: Toxicity Profiles for Chemicals of Concern, NCBC Davisville Site 07
APPENDIX M: Intake Models and Exposure Assumptions for All Exposure Pathways in the Human Health Risk Assessment

# APPENDIX N: Summary of Cancer and Noncancer Risks via Surface Water (The Entrance Channel) Exposure Pathways for Recreational Users

# LIST OF FIGURES


| Number | Title |
|---|---|
| 1-1 | Site Locus Map |
| 1-2 | Site Map |
| 1-3 | Site Topographic Map |
| 2-1 | Interpretive Contour Map of the Upper Surface of the Bedrock and Seismic Refraction Survey Lines |
| 2-2 | Total Chlorinated VOC Detected ($\mu$g/L) at Hydroprobe Locations - Shallow Zone |
| 2-3 | Total Chlorinated VOC Detected ($\mu$g/L) at Hydroprobe Locations - Deep Zone |
| 3-1 | Generalized Geologic Map of Rhode Island |
| 3-2 | Location of Geologic Cross Sections |
| 3-3 | Geologic Cross Section A-A′ |
| 3-4 | Geologic Cross Section B-B′ |
| 3-5 | Geologic Cross Section C-C′ |
| 3-6 | Geologic Cross Section D-D′ |
| 3-7 | Geologic Cross Section E-E′ |
| 3-8 | Geologic Cross Section F-F′ and G-G′ |
| 3-9 | Geologic Cross Section H-H′ |
| 3-9A | Geologic Cross Section I-I' |
| 3-10 | Interpretive Contour Map of the Upper Surface of the Silt Unit |
| 3-11 | Interpretive Contour Map of the Upper Surface of the Till Unit |

3-12 Shallow Well Head Distribution at Low Tide

3-13 Shallow Well Head Distribution at Mid Tide

**LIST OF FIGURES** (continued)

| Number | Title |
|---|---|
| 3-14 | Shallow Well Head Distribution at High Tide |
| 3-15 | Deep Well Head Distribution at Low Tide |
| 3-16 | Deep Well Head Distribution at Mid Tide |
| 3-16A | Consolidated Deep Head Distribution at Mid-Tide |
| 3-17 | Deep Well Head Distribution at High Tide |
| 3-18 | Bedrock Well Head Distribution at Low Tide |
| 3-19 | Bedrock Well Head Distribution at Mid Tide |
| 3-20 | Bedrock Well Head Distribution at High Tide |
| 4-1 | VOC Detected in Soil Samples ($\mu$g/kg) From Upper Sand Unit |
| 4-2 | VOC Detected in Soil Samples ($\mu$g/kg) From Silt Unit |
| 4-3 | VOC Detected in Soil Samples ($\mu$g/kg) From Lower Sand and Till Units |
| 4-4 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section A-A′ |
| 4-5 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section B-B′ |
| 4-6 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section C-C′ |
| 4-7 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section D-D′ |
| 4-8 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross |

Section E-E′

4-9 Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section F-F′ and G-G′

**LIST OF FIGURES** (continued)

| Number | Title |
|---|---|
| 4-10 | Total Chlorinated VOC Detected in Soil Samples, Geologic Cross Section H-H′ |
| 4-11A | Chloride Detected (ppm) in Shallow Wells, December 1995 |
| 4-11B | Salinity (ppt) Detected in Ground-Water Samples from Shallow(S) Monitoring Wells, Allen Harbor and Narragansett Bay, December 1995 |
| 4-12A | Chloride Detected (ppm) in Deep Wells, December 1995 |
| 4-12B | Salinity (ppt) Detected in Ground-Water Samples from Deep(D) Monitoring Wells, Allen Harbor and Narragansett Bay, December 1995 |
| 4-13A | Chloride Detected (ppm) in Bedrock Wells, December 1995 |
| 4-13B | Salinity (ppt) Detected in Ground-Water Samples from Bedrock(R) Monitoring Wells, Allen Harbor and Narragansett Bay, December 1995 |
| 4-14 | VOC Detected in Ground-Water Samples ($\mu$g/L) - Shallow (S) Wells |
| 4-15 | VOC Detected in Ground-Water Samples ($\mu$g/L) - Deep (D) Wells |
| 4-16 | VOC Detected in Ground-Water Samples ($\mu$g/L) - Bedrock (R) Wells |
| 4-17 | Total Chlorinated VOC Detected in Ground-Water Samples - Shallow (S) Wells |
| 4-18 | Total Chlorinated VOC Detected in Ground-Water Samples - Deep (D) Wells |

## LIST OF FIGURES (continued)


| Number | Title |
|---|---|
| 4-19 | Total Chlorinated VOC Detected in Ground-Water Samples - Bedrock (R) Wells |
| 4-20 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section A-A′ |
| 4-21 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section B-B′ |
| 4-22 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section C-C′ |
| 4-23 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section D-D′ |
| 4-24 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section E-E′ |
| 4-25 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section F-F′ and G-G′ |
| 4-26 | Total Chlorinated VOC Detected in Ground Water - Geologic Cross Section H-H′ |
| 4-26A | VOC and Salinity Detected in Ground Water Samples |
| 4-27 | Total VOC Detected in Ground-Water Samples ($\mu$g/L) Shallow Wells and at Marine Sediment E.R.A. Sample Locations ($\mu$g/g), December 1995 and May 1996 |
| 4-28 | VOC Detected in Ground-Water ($\mu$g/L) Deep Wells and at Marine Sediment E.R.A. Sample Locations ($\mu$g/g), December 1995 and May 1996 |
| 4-29 | VOC Detected in Ground-Water ($\mu$g/L) Bedrock Wells and at Marine Sediment E.R.A. Sample Locations ($\mu$g/g), December 1995 and May 1996 |

4-30 Iron, Manganese, and Thallium Detected (μg/L) in Shallow Ground-Water Wells (12/95)

**LIST OF FIGURES** (continued)

| Number | Title |
|---|---|
| 4-31 | Iron, Manganese, and Thallium Detected (μg/L) in Deep Ground-Water Wells (12/95) |
| 4-32 | Iron, Manganese, and Thallium Detected (μg/L) in Bedrock Ground-Water Wells (12/95) |
| 4-33 | Arsenic Detected at Marine Sediment E.R.A. Sample Locations (μg/g) and Shallow Wells (μg/L) |
| 4-34 | Arsenic Detected at Marine Sediment E.R.A. Sample Locations (μg/g) and Deep Wells (μg/L) |
| 4-35 | Arsenic Detected at Marine Sediment E.R.A. Sample Locations (μg/g) and Bedrock Wells (μg/L) |
| 4-36 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section A-A′ |
| 4-37 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section B-B′ |
| 4-38 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section C-C′ |
| 4-39 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section D-D′ |
| 4-40 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section E-E′ |
| 4-41 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in |

Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section F-F′ and G-G′

## LIST OF FIGURES (continued)


| Number | Title |
|---|---|
| 4-42 | Interpretive Total Chlorinated VOC Plume with Salinity Detected in Ground Water (December 1995, January 1996 and May 1996), Geologic Cross Section H-H′ |
| 5-1 | Finite Element Grid Used for the RMA-2 Surface Water Model of Allen Harbor |
| 5-2 | Predicted TCE Ground-Water Concentration Beyond the Entrance Channel Shoreline, Deep Wells (Till Unit) |
| 5-3 | Predicted TCE Ground-Water Concentration Beyond the Entrance Channel Shoreline, Rock Wells (Bedrock Unit) |
| 6-1 | Conceptual Site Model for NCBC Davisville Site 07 |

# LIST OF TABLES


| Number | Title |
|---|---|
| 1-1 | List of TCL Volatile Compounds |
| 1-2 | List of TAL Metals |
| 2-1 | Summary of Field and Laboratory Results for Hydroprobe Samples ($\mu$g/L) |
| 2-2 | Monitoring Well Data |
| 2-2A | Summary of VOC in Hydroprobe Samples ($\mu$g/L) |
| 2-3 | Well Development Ground-Water Quality Field Data |
| 2-4 | Well Sampling Ground-Water Quality Field Data |
| 3-1 | Depth and Elevation of Top of Geologic Units |
| 3-2 | Summary of Ground-Water Elevations |
| 3-2B | Summary of Ground Water Laboratory Analytical Program |
| 3-3 | Vertical Hydraulic Gradients |
| 3-4 | Summary of Hydraulic Conductivity Calculated From Phase II RI Monitoring Well Slug Test Results |
| 3-5 | Summary of Hydraulic Conductivity Calculated From Phase III RI Monitoring Well Slug Test Results |
| 3-6 | Hydraulic Conductivity Calculated From Phase III RI Monitoring Well Packer Test Results |
| 3-7 | Tidal Efficiencies for the Monitoring Wells in Various Geological Units |
| 3-8 | Hydraulic Conductivity and Storage Based on the Ground-Water Level and Tidal Monitoring Data |
| 3-9 | Hydraulic Conductivity and Specific Yield Estimated From Description of Material Comprising a Lithologic Unit |

3-10 Hydraulic Conductivity, Storage, and Specific Yield for the Geological Units at Various Well Clusters/Sites Based Upon Slug Test, Packer Tests Geologic Log, and Tidal and Ground-Water Monitoring Data

**LIST OF TABLES** (continued)

| Number | Title |
|---|---|
| 4-1A | Location of Private Use Ground-Water Wells Near Site 07 |
| 4-1B | Proposed Background Inorganics Concentrations ($\mu$g/L) in Ground Water |
| 4-2 | Summary of Volatile Organic Compounds in Soil ($\mu$g/L) |
| 4-2A | Wetlands Sediment Samples, Site 07 |
| 4-3 | Summary of Total Organic Carbon Detected in Soil Samples |
| 4-4 | Summary of Volatile Organic Compounds in Ground Water ($\mu$g/L) |
| 4-5 | Summary of Total Metal and Wet Chemistry Detected in Ground Water Samples ($\mu$g/L) |
| 5-1 | Physical and Chemical Properties of VOC |
| 5-2 | Environmental Fate Parameters of VOC |
| 5-3 | Comparison of Calculated Flux Rates for VOC Present in the Vadose Zone |
| 5-4 | Estimated Half-Lives of VOC in Various Media |
| 5-5 | Summary of Site Data for NAPL Evaluation |
| 5-6 | Screening Criteria for Partitioning Coefficients for VOC and Metals detected at Site 07, Calf Pasture Point |
| 5-7 | Detection Frequency, Site-Wide Geometric Mean and Site-Wide Maximum Concentrations of VOC, Phase II RI and Phase III RI Ground-Water Samples |
| 5-8 | Detection of Frequency, Site-Wide Geometric Mean, and Site-Wide Maximum Metal Concentrations, Phase II RI and Phase III RI Ground-Water Samples |
| 5-9 | First-Step Screening of VOC Detected in Ground-Water Samples from Site 07 |

Shallow Wells

5-10 Detected Metal Concentrations at Six selected Shallow Wells Near the Allen Harbor Entrance Channel

5-11 First-Step Screening of Metals Detected in Ground-Water Samples from Site 07 Shallow Wells

**LIST OF TABLES** (continued)

| Number | Title |
|---|---|
| 5-12 | First-Step Screening of VOC detected in Ground-Water Samples from Site 07 Deep/Rock Wells |
| 5-13 | First-Step Screening of Metals Detected in Ground-Water Samples from Site 07 Deep/Rock Wells |
| 5-14 | Estimated Shoreline Concentrations of VOC Using the AT123D Model Based on Ground-Water Sample Data for MW07-19S and MW07-21S |
| 5-15 | Estimated Allen Harbor Surface Water Concentrations Resulting From Near Shore Shallow Site Ground Water |
| 5-16 | Second-Step Screening of VOC Detected in Site 07 Deep/Rock Wells Based on AT123D Model Prediction from MW07-04D/05D to Near Entrance Channel Shoreline |
| 5-17 | Predicted TCE Ground-Water Concentrations Beyond the Shoreline of the Allen Harbor Entrance Channel Using the AT123D Model |
| 6-1 | Selection of Chemicals of Concern from List of Detected Analytes in Total Soils (Surface to depth of 10 feet) |
| 6-2 | Selection of Chemicals of Concern from List of Detected Analytes in Surface Soil |
| 6-3 | Selection of Chemicals of Concern from List of Detected Analytes in Sediments |
| 6-4 | Selection of Chemicals of Concern from List of Detected Analytes in Shallow Ground Water |
| 6-5a | Selection of Chemicals of Concern from List of Detected Analytes in Deep |

Ground Water

6-5b Selection of Chemicals of Concern from List of Detected Analytes in Bedrock Ground Water

6-6 Selection of Chemicals of Concern from List of Detected Analytes in Shellfish

6-7 Selection of Chemicals of Concern in Soil for Air Exposures Based on Transfers to Air from List of Detected Analytes in Soil

**LIST OF TABLES** (continued)

| Number | Title |
|---|---|
| 6-7 | Selection of Chemicals of Concern in Soil for Air Exposures Based on Transfers to Air from List of Detected Analytes in Soil |
| 6-8 | Summary of Background Data for Inorganics in Surface Soil |
| 6-9 | Summary of Chemicals of Concern in all Environmental Media |
| 6-10 | Summary Statistics for Chemicals of Concern in Total Soils |
| 6-11 | Summary Statistics for Chemicals of Concern in Surface Soil |
| 6-12 | Summary Statistics for Chemicals of Concern in Sediment |
| 6-13 | Summary Statistics for Chemicals of Concern in Shallow Ground Water |
| 6-14a | Summary Statistics for Chemicals of Concern in Deep Ground Water |
| 6-14b | Summary Statistics for Chemicals of Concern in Bedrock Ground Water |
| 6-15 | Summary Statistics for Chemicals of Concern in Shellfish |
| 6-16 | Chemical and Environmental Fate Parameters for Chemicals of Concern |
| 6-17 | Summary of Toxicity Values for Chemicals of Concern |
| 6-18 | Summary of Exposure Parameter Values Used in Estimating Exposures under all Exposure Scenarios |
| 6-19 | Exposure Point Concentrations for Chemicals of Concern in Total Soils |

6-20 Exposure Point Concentrations for Chemicals of Concern in Surface Soils

6-21 Exposure Point Concentrations for Chemicals of Concern in Sediment

6-22 Exposure Point Concentrations for Chemicals of Concern in Shallow Ground Water

6-23a Exposure Point Concentrations for Chemicals of Concern in Deep Ground Water

**LIST OF TABLES** (continued)

| Number | Title |
|---|---|
| 6-23b | Exposure Point Concentrations for Chemicals of Concern in Bedrock Ground Water |
| 6-24 | Exposure Point Concentrations for Chemicals of Concern in Shellfish |
| 6-25 | Input Parameters Used to Calculate Exposures in Each Environmental Medium |
| 6-26 | Summary of Subchronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario |
| 6-27 | Summary of Subchronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario |
| 6-28 | Summary of Intakes of Carcinogens via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario |
| 6-29 | Summary of Intakes of Carcinogens via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario |
| 6-30 | Summary of Chronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Average Exposure Scenario |
| 6-31 | Summary of Chronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario |

6-32 Summary of Chronic Intakes of Carcinogens via All Exposure Pathways for Recreational Users — Average Exposure Scenario

6-33 Summary of Chronic Intakes of Carcinogens via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario

6-34 Summary of Intakes of COCs with Health Effects Other than Cancer for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios

## LIST OF TABLES (continued)

| Number | Title |
|---|---|
| 6-35 | Summary of Intakes of Carcinogens for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios |
| 6-36 | Summary of Chronic Intakes of COCs with Health Effects Other than Cancer for Hypothetical Adult Residents Consuming Ground Water — Average and Reasonable Maximum Exposure Scenarios |
| 6-37 | Summary of Chronic Intakes of Carcinogens for Hypothetical Adult Residents Consuming Ground Water — Average and Reasonable Maximum Exposure Scenarios |
| 6-38 | Summary of Subchronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario |
| 6-39 | Summary of Subchronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario |
| 6-40 | Summary of Cancer Risks via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario |
| 6-41 | Summary of Cancer Risks via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario |
| 6-42 | Summary of Chronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Average Exposure Scenario |
| 6-43 | Summary of Chronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario |
| 6-44 | Summary of Cancer Risks via All Exposure Pathways for Recreational Users — Average Exposure Scenario |
| 6-45 | Summary of Cancer Risks via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario |

## LIST OF TABLES (continued)

| Number | Title |
|---|---|
| 6-46 | Summary of Chronic Hazard Quotients for Health Effects Other than Cancer for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios |
| 6-47 | Summary of Cancer Risks for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios |
| 6-48 | Summary of Chronic Hazard Quotients for Health Effects Other than Cancer for Hypothetical Adult Residents consuming Deep and Bedrock Ground Water — Average and Reasonable Maximum Exposures |
| 6-49 | Summary of Cancer Risks for Hypothetical Adult Residents Consuming Deep and Bedrock Ground Water - Average and Reasonable Maximum Exposures |
| 6-50 | Summary of Cancer Risks for All Exposure Pathways |
| 6-51 | Summary of Noncancer Hazard Indices for All Exposure Pathways |

# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| 95 UCLM | 95th percentile upper confidence limit on the mean |
| ADD | Average daily dose |
| AE | Average exposure |
| ARAR | Applicable or Relevant and Appropriate Requirements |
| AT | Averaging time |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| AWQC | Ambient Water Quality Criteria |
| BCT | BRAC Closure Team |
| BGS | Below Ground Surface |
| BRAC | Base Realignment and Closure Act |
| CED | Construction Equipment Department |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act, as amended |
| COC | Chemical of Concern or Constituent of Concern |
| CPPMB | Calf Pasture Point Munitions Bunkers |
| CS | Confirmation Study |
| CVOC | Chlorinated Volatile Organic Compounds |
| DANC | Decontaminating Agent Non-Corrosive |
| DNAPL | Dense Non-Aqueous Phase Liquid |
| DO | Dissolved Oxygen |
| DOD | Department of Defense |
| DPDO | Defense Property Disposal Office |
| DV | Data Validation |
| EM | Electro-Magnetic |
| EPA | U.S. Environmental Protection Agency |
| ERA | Ecological Risk Assessment |
| EPC | Exposure point concentration |
| FFCA | Federal Facilities Compliance Act |
| FJ | Flush Joint |
| FS | Feasibility Study |
| FUDS | Formerly Used Defense Site |
| H | Henry's Law Constant |
| HEAST | *Health Effects Assessment Summary Tables* |

| | |
|---|---|
| HHRA | Human Health Risk Assessment |
| HI | Hazard index |
| HP | Hydroprobe |
| HQ | Hazard quotient |
| HRS | Hazard Ranking System |
| HSA | Hollow Stem Auger |
| IAS | Initial Assessment Study |
| ID | Inner Diameter |
| IDW | Investigative Derived Waste |
| IRIS | *Integrated Risk Information System* |
| IRP | Department of Defense Installation Restoration Program |
| K | Hydraulic conductivity |
| $K_{ow}$ | Octanol-Water Partition Coefficient |
| $K_{oc}$ | Organic Carbon-Water Partition Coefficient |
| LADD | Lifetime average daily dose |
| LNAPL | Light Non-Aqueous Phase Liquid |
| LOAEL | Low Observed Adverse Effect Level |
| MCL | Maximum Contaminant Levels |
| MERA | Marine Ecological Risk Assessment |
| Metals | TAL metals, plus arsenic and selenium |
| mg/kg | Milligrams per kilogram |
| mg/kg-day | Milligrams per kilogram body weight per day |
| $\mu$g/L | Micrograms per liter |
| MSL | Mean sea level |
| NACIP | Navy Assessment and Control of Installation Pollutants Program |
| NAPL | Non-Aqueous Phase Liquid |
| NARF | Naval Air Rework Facility |
| NAS | Naval Air Station |
| NCBC | Naval Construction Battalion Center |
| ND | Not Detected |
| NEESA | Naval Energy and Environmental Support Activity |
| NCI | National Cancer Institute |
| NCTC | Naval Construction Training Center |
| NOAEL | No Observed Adverse Effect Level |
| NPL | National Priorities List |
| NRC | National Research Council |
| NTP | National Toxicology Program |
| NTU | Nephelometric Turbidity Units |

| | |
|---|---|
| OD | Outer Diameter |
| PA | Preliminary Assessment |
| PA/SI | Preliminary Assessment/Site Investigation |
| PAH | Polycyclic aromatic hydrocarbons |
| PCA | 1,1,2,2-Tetrachloroethane (a.k.a. Perchloroethane) |
| PCB | Polychlorinated biphenyls |
| PCE | Perchloroethene (a.k.a. Tetrachloroethene) |
| PID | Photo-Ionization Detector |
| ppb | Parts per billion |
| PPE | Personal protective equipment |
| ppm | Parts per million |
| PPT | Parts per thousand |
| PVC | Polyvinyl Chloride |
| QA/QC | Quality Assurance/Quality Control |
| RAGS | Risk Assessment Guidance for Superfund |
| RB | Rollerbit |
| RBC | Risk-based concentration |
| RCRA | Resource Conservation and Recovery Act, as amended |
| RfC | Reference concentration |
| RfD | Reference dose |
| RI | Remedial Investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| RIDEM | Rhode Island Department of Environmental Management |
| RIEDC | Rhode Island Economic Development Corporation |
| RIPA | Rhode Island Port Authority |
| RME | Reasonable maximum exposure |
| S | Storage |
| SAIC | Science Applications International Corporation |
| SARA | Superfund Amendment and Reauthorization Act |
| SDWA | Safe Drinking Water Act |
| SF | Slope factor |
| SHERP | Safety, Health, and Emergency Response Plan |
| SI | Site Inspection |
| SMCL | Secondary Maximum Contaminant Levels |
| SQL | Sample quantitation limit |
| SSL | Soil screening level |
| SVOC | Semi-volatile organic chemical |
| Sy | Specific yield |
| TAL | Target Analyte List |

| | |
|---|---|
| TCE | Trichloroethene |
| TCL | Target Compound List |
| TCLP | Toxicity Characteristic Leachate Procedure |
| TDS | Total Dissolved Solids |
| TE | Tidal Efficiency |
| TERA | Terrestrial Ecological Risk Assessment |
| TOC | Total organic carbon |
| TRC | TRC Environmental Corporation |
| TWA | Time-weighted average |
| USDA | U.S. Department Of Agriculture |
| USGS | U.S. Geological Survey |
| VOA | Volatile Organic Analysis |
| VOC | Volatile Organic Compounds |
| WLI | Water Level Indicator |
| c-1,2-DCE | cis-1,2-Dichloroethene |
| t-1,2-DCE | trans-1,2-Dichloroethene |
| 1,2-DCE | 1,2-Dichloroethene (total) |
| 1,1,2-TCA | 1,1,2-trichloroethane |
| 1,1,2,2-PCA | 1,1,2,2-Tetrachloroethane (Perchloroethane) |

# 1. INTRODUCTION

## 1.1 BACKGROUND, OBJECTIVE, AND SCOPE

This report presents the findings and results of the Phase III Remedial Investigation (RI) of ground water at Installation Restoration (IR) Program Site 07 (Site 07), located on Calf Pasture Point at the Naval Construction Battalion Center, Davisville, Rhode Island (NCBC). This report has been prepared in accordance with the Scope of Work for Contract Task Order (CTO) 0032, Contract N62472-92-D-1296. Additionally, this report includes the results of the evaluation and removal action / close-out of the Calf Pasture Point Munition Bunkers (CPPMB) by Halliburton NUS (1994) and Foster Wheeler (1997), respectively. The RI work was coordinated with the Base Realignment and Closure (BRAC) Cleanup Team (BCT), which is composed of the Navy's BRAC Environmental Coordinator and representatives of the United States Environmental Protection Agency Region 1 (EPA), and the Rhode Island Department of Environmental Management (RIDEM).

The Phase II RI did not provide sufficient data regarding the nature and extent of volatile organic compounds (VOC) and metals[1] in ground water, nor the behavior/migration of VOC and metals in ground water from Site 07 to Allen Harbor and Narragansett Bay. Therefore, the overall objective of the Phase III RI was the collection and evaluation of data related to further assessment of the nature and extent of Target Compound List (TCL) VOC and Target Analyte List (TAL) metals in ground water and the behavior/migration of VOC and metals from beneath Site 07 to Allen Harbor and Narragansett Bay. Table 1-1 provides the list of the TCL VOC and Table 1-2 provides the list of TAL metals. The specific objectives of the Phase III RI at Site 07 were to: 1) evaluate the south and west horizontal extent of the shallow ground-water VOC plume identified by the Phase II RI; 2) evaluate the potential presence and character of residual and/or free-flowing dense non-aqueous phase liquid (DNAPL) in the deep soil beneath the area of Phase II RI micro wells MW-GH2 and MW-GH7; 3) further evaluate the horizontal extent of the deep chlorinated VOC plume and metals (above bedrock in the till unit and in the upper portion of the competent bedrock; and 4) further evaluate the hydrogeology of Site 07. Further, offshore investigation beneath the harbor and the entrance channel was requested by the EPA and RIDEM in July and August 1997 to complete the RI by assessing the nature and extent of VOC from the Site potentially beneath the harbor and channel.

The potential ecological risk in Allen Harbor adjacent to Site 07 and the potential impact of Site 07 on the terrestrial ecology have also been addressed by the "Allen Harbor Landfill and Calf Pasture Point Marine Ecological Risk Assessment" (Marine ERA) (EA 1996a) and the "Facility-Wide Freshwater/Terrestrial ERA" (EA 1996b).

[1] Throughout this report, the use of the term 'metals' includes the Target Analyte List metals, plus arsenic and selenium.

The human health risk assessment (HHRA) for the Calf Pasture Point (including onsite and offshore media) is included as Chapter 6 of the Phase III RI report. It has been revised and re-issued to: (1) address EPA comments on the risk assessment methodologies used for the HHRA of the Phase II RI, (2) include the 1995 and 1996 remedial investigation sample data, and (3) include the following three additional scenarios as requested by EPA: residential drinking water (onsite media), ingestion of shellfish (offshore media), and bather/swimmer in surface water adjacent to Site 07 (offshore media). This HHRA was not prepared to specifically address only the ground water beneath Site 07 (the focus of the Phase III RI). Thus, the constituents of concern presented in this HHRA were generated from the Phase III RI, those reported in the HHRA of the Phase II RI, and those reported in the Marine ERA (EA 1996a) for offshore media (shellfish and sediment in the intertidal zone located adjacent to the site).

The Site 07 Feasibility Study (FS) will focus on a whole Site remedy, and as such, will incorporate and assess the data from both the Phase II and Phase III RI reports and the Marine and Facility-Wide Freshwater/Terrestrial ERA reports (EA 1996a and EA 1995b).

## 1.2 BACKGROUND

### 1.2.1 NCBC Description

NCBC is located in the Town of North Kingstown, Rhode Island, approximately 18 miles south of the state capital, Providence. A significant portion of the NCBC Main Center is situated adjacent to Narragansett Bay. NCBC is composed of three areas: the Main Center; the West Davisville storage area; and Camp Fogarty, a training facility located approximately 4 miles west of the Main Center (Figure 1-1). Adjoining the NCBC Main Center's southern boundary is the decommissioned Naval Air Station (NAS) Quonset Point, which was transferred by the Navy to the Rhode Island Port Authority (RIPA, now know as the Rhode Island Economic Development Corporation [RIEDC]) and others between 1974 and 1980.

NCBC was primarily used for training naval seamen in construction operations, and as storage and freight yards for construction materials. As a result, NCBC is comprised primarily of warehouse space and freight yards, most of which are currently empty. NCBC closed on 1 April 1994. Most of the staff and materials have been moved offsite. Currently, facilities management and security staff engaged with base closure remain on base.

### 1.2.2 NCBC Davisville History

The Davisville/Quonset Point area was originally settled by Europeans in the late seventeenth century. Quonset Point was the location of the first annual encampment of the Brigade Rhode Island Militia in 1893. During World War I, it was a campground for the mobilization and training of troops, and was later the home of the Rhode Island National Guard. In the 1920s and 1930s, it was used as a summer resort for local residents and for agriculture.

In 1939, Quonset Point was acquired by the Navy and construction of the air station and pier began in 1940. During construction, millions of cubic yards of sediment were dredged to create the ship basin and channel. The dredged material was used to create a 1.5 square mile section in Quonset's northeast corner, as well as what is now Calf Pasture Point. A 1939 aerial photograph shows Allen harbor in its natural configuration. The harbor was formed by two spits one trending north south and one trending northeast. In the center of the harbor was a large island which occasionally was connected to the northeast trending spit (archaeological report, 10/94). A 1958 aerial photograph of Calf Pasture Point shows the entire surface stripped of vegetation (except for sparse vegetation on the bedrock outcrop) and covered with tire tracks. Wartime activities at NAS Quonset Point included training aircraft carrier pilots and crews, overhauling aircraft, supplying military equipment and planes, and providing coastal defense.

By 1942, the operations at NAS Quonset Point had outgrown the station. Adjacent land at Davisville was designated as the Advanced Base Depot and a pier was constructed. Later that year, the Naval Construction Training Center (NCTC), known as Camp Endicott, was established at Davisville to train newly established construction battalions. By November 1942, the camp was at capacity, housing 15,000 enlisted personnel and 350 officers. More than 100,000 personnel were trained at Camp Endicott by the end of World War II.

After the war, NAS Quonset Point continued as an operating base for aircraft and ships and was the homeport of carrier-based squadrons. The NCBC Davisville area experienced reduced activity between World War II and the Korean Conflict. In 1951, it became the Headquarters of the Construction Battalion Center. The Construction Battalion Center loaded ships and trained personnel for both the Korean and Vietnam conflicts. In 1952, the Naval Construction Training Unit was established at Davisville.

The Antarctic Development Squadron Six was moved to NAS Quonset Point in 1956. A Naval Air Rework Facility (NARF) was created there in 1967. The NARF performed overhaul and repair work previously handled by NAS Quonset Point.

In 1974, the NAS and the NARF at Quonset Point were decommissioned, and operations at NCBC were greatly reduced pursuant to the Shore Establishment Realignment Act of 1973. NCBC's mission was to provide mobilization support to the active Naval Construction Force; to act as a mobilization base for the rapid assembly, outfitting, and readying of Reserve Construction Battalions; to store, preserve, and ship advanced base and mobilization stocks; and to procure, receive, pack, and ship collateral equipment for Atlantic, European, and Caribbean military construction projects. NAS Quonset Point was transferred from the Navy to RIPA and others from 1974 to 1980. In 1989, NCBC Davisville was added to the National Priorities List (54 Federal Register 48184, 1989) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1991, the closure of NCBC was announced, and operations were phased down to minimum staffing levels for public works, maintenance, security, and personnel.

NCBC was decommissioned on 25 March 1994 and closed on 1 April 1994. The facility has been transferred to Northern Division, Naval Facilities Engineering Command, which has caretaker status pending disposal of the property.

### 1.2.3 Site 07 Description and History

The Site is located on Calf Pasture Point, a peninsula in the northeastern portion of NCBC Davisville (Figure 1-1). As shown on Figure 5-8 (copy provided in Appendix A-1), prior to 1940, the central portion of the Calf Pasture Point peninsula was a portion of Allen Harbor (Ecology and Environment 1994). During the 1942-43 dredging activity by the Navy for the pier area along the Narragansett Bay Shoreline south of Site 07, the dredged material was disposed at Calf Pasture Point, filling in the shallow lagoon (Figures 5-1 and 5-8, Appendix A-1). The Phase III RI study area covers approximately 40 acres of Calf Pasture Point. Calf Pasture Point is bounded to the southwest and south by Allen Harbor and its entrance channel, respectively; to the east by Narragansett Bay, and to the west by Sanford Road. Vehicular access to Calf Pasture Point is controlled by a fence with locked gate at the Sanford Road entrance. Calf Pasture Point contained 3 former munitions bunkers, Buildings 59, 60, 339, located along Magazine Road. The bunkers were earthen covered and located in the middle of Calf Pasture Point just north, east and south of the bedrock outcrop (a prominent hill with a maximum elevation of approximately 55 ft above mean sea level (MSL) the highest location at Calf Pasture Point). CPPMB 339 was demolished in February 1997, and the doors to CPPMB 59 and 60 were welded shut in March 1997 at Navy request. The Site comprises the area of Calf Pasture Point south of the bunkers, i.e., south from monitoring well MW07-07S and generally east of the dirt access road that extends south to the entrance channel shoreline (Figure 1-2). Calf Pasture Point is currently overgrown by shrubs, small trees, grasses and reeds. South from well cluster MW07-05, the Site surface topography (Figure 1-3) slopes gently from approximately 10 ft above MSL to sea level at the shoreline. North from MW07-05, the ground surface rises to an elevation of approximately 19 ft above MSL at MW07-07S. North of MW07-07S is the previously noted prominent hill where bedrock is exposed.

Review of the Phase I, II, and III RI soil boring logs indicates that Site 07 is underlain by five main stratigraphic units (from the ground surface to bedrock): (1) brown to gray sand with varying amounts of silt and occasional shell fragments (some is native material and some is dredge spoil from Allen Harbor) (upper sand unit), (2) silt unit, (3) very fine to medium sand with varying amounts of silt (lower sand unit; only present beneath the eastern part of Site 07), (4) till unit, and (5) meta-quartzite, phyllite and gneissic bedrock.

Calf Pasture Point was reportedly the site of three distinct disposal incidents. The following summary of these incidents is from Hart (1984). These incidents reportedly involved disposal of twenty 5-gal cans of calcium hypochlorite, thirty to forty 35-gal containers of an unidentified chloride compound and approximately 2,500 three-gal cans containing Decontaminating Agent Non-Corrosive (DANC) solution. DANC is a reactive, chlorinated compound. The following is a summary of the historic disposal events:

- Between 1960 and 1974, approximately 20 five-gal cans (100 gal) of calcium hypochlorite (bleach) were disposed in a drainage ditch alongside Bunker 60 at Calf Pasture Point. Between 1978 and 1982, metal cans containing calcium hypochlorite were removed from this site for offsite disposal. This is the only documented remedial activity known to have occurred at the site. Calcium hypochlorite $Ca(OCl)_2$ is a water-soluble solid which degrades rapidly in water. The commercial product usually contains 50 percent or more of $Ca(OCl)_2$. It could not be determined if all of the calcium hypochlorite disposed in this area was removed, and the ultimate location of offsite disposal was not identified.

- In 1973, thirty to forty 35-gal cardboard containers of an unidentified chloride compound were stored at Calf Pasture Point. This material reportedly originated from the utilities school, where it was used for water treatment purposes. These containers became very deteriorated over time and were reportedly buried at the site. Although the chloride compound was not identified, it may have been ferric chloride, a black-brown, corrosive solid which is readily soluble in water. It is expected that most chlorides would leach from the cardboard containers during the period of their burial at the site.

- At some time between 1968 and 1974, a trench measuring approximately $10 \times 20 \times 15$ ft was filled with 3-gal cans which contained DANC solution. This would be approximately 2,500 cans (Hart 1984). The cans were reportedly buried at an undetermined location at Calf Pasture Point. However, through the various phases of investigation of this site, the approximate location of the disposal area has been inferred as presented in Section 1.2.4.3, Supplemental Phase II RI, and Section 4.7 and is shown on Figure 1-2. DANC consisted of two separate chemicals that were mixed to form the decontaminating solution: 1,3-dichloro-5,5-dimethyl-hydantoin, a crystal; and acetylene tetrachloride (1,1,2,2-perchloroethane) (1,1,2,2-PCA), a heavy colorless liquid. 1,3-dichloro-5,5-dimethyl-hydantoin and hydantoin products are oxidizing agents and readily break down to release chlorine when contacted by water. The DANC was apparently used during Defense Disaster Preparedness Training activities during which biological and nuclear warfare attacks were simulated. 1,3-Dichloro-5,5-dimethyl-hydantoin on contact with water will liberate hypochlorous acid (ClHO), a very weak acid and strong oxidizing agent. In general, it can be used as a chlorinating agent, disinfectant, or industrial deodorant. In water treatment, it has been used as the active ingredient in powdered laundry bleach such as Sage's Dry Bleach and Colgate's Pruf. Hyprochlorous acid can be used as a disinfectant (Budavari 1989).

### 1.2.4 Previous Investigations and Parallel Close-out Activity

Several previous investigations and a parallel close-out activity have been performed at NCBC in conjunction with Navy, RIDEM, and EPA. The primary Navy investigation reports that pertain to characterization of Site 07, in chronological order, include the following:

- Initial Assessment Study (IAS) (Hart 1984)
- Confirmation Study (CS) - Verification Step Report (TRC 1987)
- CS - Characterization Step Report (TRC 1988)
- Phase I RI Report (TRC 1991)
- Phase II RI Report (TRC 1994)
- Study Area Screening Evaluation (Halliburton NUS 1994)
- Removal Action and Close-Out, Calf Pasture Point Munitions Bunkers (Foster Wheeler 1997)

#### 1.2.4.1 Pre-CERCLA Investigations—U.S. Navy

**Initial Assessment Study (IAS)**

In 1983, the Navy Assessment and Control of Installation Pollutants (NACIP) Office awarded Fred C. Hart Associates, Inc. (Hart), Navy Contract No. N62474-83-C-6974 to conduct an IAS of potentially contaminated sites at NCBC. The IAS identified a total of 14 potentially contaminated sites at NCBC (Hart 1984). The EPA identified ten additional sites (Sites 15 through 24), for a total of 24 potentially contaminated sites at NCBC). The IAS concluded that three of the 14 sites identified at NCBC Davisville posed a sufficient threat to human health or the environment to warrant additional investigation. The IAS report recommended that the Navy conduct a Confirmation Study (CS), as defined under the NACIP Program, on the following three sites: Site 05 - Transformer Oil Disposal Area; Site 07 - Calf Pasture Point; and Site 09 - Allen Harbor Landfill. Based on the potential for the discharge and migration of PCA into Allen Harbor and Narragansett Bay, and the potential impact on the marine life and wetlands, the IAS recommended the Calf Pasture Point site for a CS.

A copy of the IAS was sent by the Navy to the RIDEM for review and comment. In a letter dated 9 October 1984, RIDEM presented its review findings and requested that the Navy add seven of the 14 sites originally identified in the IAS to the list of sites to be examined further in the upcoming CS. The Navy agreed to the RIDEM request and added the seven sites.

**Confirmation Study - Verification Step**

In 1985, the Navy awarded TRC the CS (Contract No. N62472-85-C-1026). Thirteen sites were investigated as part of the Verification Step of the CS. The scope of work for the Verification Step included investigation of the three sites identified in the IAS as needing additional study, the seven sites requested by RIDEM, and three sites identified by the Navy

that warranted further investigation. The following are the 13 sites investigated during the Verification Step program:

- Site 02 - CED Battery Acid Disposal Area
- Site 03 - CED Solvent Disposal Area
- Site 04 - CED Asphalt Disposal Area
- Site 05 - Transformer Oil Disposal Area
- Site 06 - Solvent Disposal Area
- Site 07 - Calf Pasture Point
- Site 08 - DPDO Film Processing Disposal Area
- Site 09 - Allen Harbor Landfill
- Site 10 - Camp Fogarty Disposal Area
- Site 11 - Fire Fighting Training Area
- Site 12 - DPDO Transformer Oil Spill Area
- Site 13 - Disposal Area Northwest of Buildings W-3, W-4, and T-1
- Site 14 - Building 38 Transformer Oil Leaks

A draft report of the Verification Step of the NCBC CS was completed by TRC in May 1985. This report was sent by the Navy to RIDEM for review and comment. The Navy received review comments from RIDEM in June 1985. The comments suggested that additional sampling should be conducted, which TRC subsequently performed.

The final report on the Verification Step of the CS was completed by TRC in February 1987. This report was sent by the Navy to RIDEM and RIDEM's review comments recommended additional investigation.

**Confirmation Study - Characterization Step**

In March 1988, TRC was tasked by the Navy to implement the recommendations of the CS - Verification Step by developing a plan of action to conduct more extensive sampling under a NACIP CS - Characterization Step. The CS - Characterization Step performed by TRC included a magnetometer survey and the installation of two monitoring wells, MW 7-1, MW 7-2 (Figure 2-3, Appendix A-2). (Note: in this historical section of Chapter 1, wells will be denoted with their original designation.) The purpose of the magnetometer survey was to locate buried drums on the site. Of the eight magnetic anomalies identified, four could be attributed to possible buried drums. Upon auguring and shoveling in the area of the strongest anomaly several 3-gal rusty cans, some containing a solid white substance comprised mostly of calcium, were unearthed. The monitoring wells were placed downgradient of the buried containers and sampled eight days after installation. In ground water, 1,1,2,2-PCA was not detected but an unidentified VOC was reported at concentrations below 0.2 milligrams per liter (mg/L). See Figure 2-3 for locations and Table 5-5 for chemical analysis results (Appendix A-2). The CS recommended the removal of contaminated soil and containers, backfilling and revegetation of the area or a no action alternative that involved only ground-water quality monitoring. (TRC 1988)

### 1.2.4.2 Previous Investigations—EPA

EPA proposed NCBC for inclusion on the NPL in July 1989. NCBC was added to the NPL on 21 November 1989. A Hazard Ranking System (HRS) scoring was undertaken by EPA to support the proposed final listings (EPA 1989a). The HRS was based on existing information; a Preliminary Assessment/Site Inspection (PA/SI) was not performed for the sites.

The HRS package was based on the 24 potential sites; the areas designated 1 through 14 coincide with the 14 areas identified in the Navy's IAS, described above. The remaining potential areas, 15 through 24, were identified by the EPA from an "Off-Site Activity Investigation" report (Hart 1984b). The HRS notes that areas 15 through 24 are on property not currently owned or operated by the U.S. Navy. Several of these areas are being investigated by the U.S. Army Corps of Engineers' Formally Used Defense Site (FUDS) program. The HRS used an aggregate of the two most seriously impacted sites to form the basis of the ranking package. The two sites used in the HRS package were: Site 09 - Allen Harbor Landfill and Site 07 - Calf Pasture Point.

### 1.2.4.3 Remedial Investigations

In March 1988, the Navy's three-phase NACIP Program was restructured to conform with EPA's four-phase program. This change was predicated by the Superfund Amendments and Reauthorization Act (SARA) of 1986. Thus, the U.S. Navy changed its NACIP Program to closely parallel the EPA requirements for remedial actions at Superfund sites. The Navy's program is now referred to as the IR Program. Under the IR Program, current investigations at NCBC Davisville are in the Remedial Investigation/Feasibility Study (RI/FS) phase.

#### Phase I RI

Shortly after initiating the CS - Characterization Step, the Navy requested that TRC develop an RI Work Plan. The Phase I RI field investigations were conducted by TRC from September 1989 to March 1990 and the Phase I Draft Final RI Report was submitted to the Navy in May 1991 (TRC 1991). The Phase I RI was performed during 1989-90 and included: two soil borings/monitoring wells MW7-3 and MW7-4 located downgradient of a magnetic anomaly identified during the CS, and the collection and analysis of soil samples from the two borings and ground-water samples from three wells (MW7-1, -3 and -4) for the full TCL/TAL (Appendix A-3). The Results of the RI indicated that estimated concentrations of chloroform, 4,4'-DDT, and 4,4'-DDE were present in one of the surface soil samples (B7-1), while an estimated concentration of bis(2-ethylhexyl)phthalate was detected in the 2-4-ft below ground surface (bgs) sample from boring B7-2. 1,1,2,2-PCA was not detected in the soil or ground-water samples; however, two potential microbial degradation products of 1,1,2,2-PCA, 1,2-dichloroethene (1,2 DCE) and vinyl chloride (VC), were detected in the ground-water samples at concentrations of 30 micrograms per liter ($\mu$g/L) and an estimated concentration of 2 $\mu$g/L, respectively. Metals found to be common to each surface and subsurface soil sampling location included arsenic, chromium, lead, and zinc. No depth-specific differences were

observed in either the presence or concentration of these metals. In addition to these metals, antimony and copper were detected in the ground-water samples. Toxicity Characteristic Leaching Procedure (TCLP) results indicated that a low concentration of toluene may be leachable from the soil. TCLP extraction results also revealed that copper, lead, and zinc are leachable from the soil. The Phase I RI recommended no further remedial action with bi-annual ground-water monitoring for Site 07 (TRC 1994).

As a result of comments and concerns from the EPA and RIDEM regarding the Phase I RI, a Phase II and Supplemental Phase II RI were performed by TRC during 1993-94 to further delineate the horizontal and vertical extent of VOC associated with previous disposal activity at the site.

**Phase II RI**

Geophysical investigations comprised of a seismic refraction survey, and electromagnetic conductivity (EM) survey, and a magnetometer survey, were performed to gain a better understanding of the subsurface at the Calf Pasture Point prior to drilling the site for the Phase II RI. The seismic refraction survey was primarily used to profile the bedrock surface below portions of the site. The EM conductivity survey was used to aid in assessing the location and/or extent of buried metallic objects (e.g., drums, tanks, metal structures), or conductive ground water. The magnetometer survey aided in distinguishing anomalies due to ferrous metal from electrically conductive, EM-identified non-ferrous objects. The Phase II RI included: [Note: copies of the referenced Phase II RI report figures and tables (TRC 1994) are provided in Appendix A-4.]

- A soil gas survey was performed on 22 December 1992 and 12 January 1993 at 30 points in an area located just east of Bunker No. 339, and between Bunker No. 60 and wells MW-1S, -2S and -3S (Figure 5-5, Appendix A-4). VOC were detected at one sample location east of Bunker 339 at a total concentration of 12 $\mu$g/L. Results of the soil gas survey (Figure 6, Appendix A-4) provided the rational for moving a planned surface soil sampling location 07SS-8 to investigate an elevated VOC soil gas sample location.

- During January 1993, a seismic refraction survey was conducted at Site 07. Four seismic refraction geophysical survey lines were performed in the vicinity of the three bunkers and south to the vicinity of wells MW-3S, -4S, and -5S (plus a line to about 400 ft east of MW-5S and one line south) (Figure 4, Hager-Richter 1993). The interpreted depth to the competent bedrock surface was estimated to range between 14 to 26 ft below ground surface (bgs) and to be sloping downward from the north to the south. An assessment of the extent and thickness of highly fractured or highly weathered bedrock was unsuccessful because the refraction velocities

through this zone could not be distinguished from that of the saturated soil. Therefore, only the top of competent bedrock could be identified.

- On 11 January 1993, an EM survey was performed on approximately 9.2 acres extending as far north as the bedrock outcrop and as far south as the marshlands, on a 50-ft grid using a Geonics EM-31 instrument. A small electrically conductive area was recorded near monitoring well MW-2, corresponding to the area of buried drums discovered during the CS (Figure 29, Appendix A-4). Data from the EM survey were used to generate a conductivity contour map of the site (Figure 29, Appendix A-4). The EM values ranged from 3.0 micromhos per meter (mmhos/meter) in the northwest portion of the site to 68 mmhos/meter in the southeast. This gradual change in EM values was attributed to salt water intrusion into the ground water.

- A magnetometer survey was performed on 12 January 1993 along the same field location grid used for the EM survey. One of the anomalies identified during the CS was located, the same anomaly also identified by the EM survey (Figure 32, Appendix A-4). A test pit was planned at this location between MW-2 and MW-1 (Figure 37, Appendix A-4). Magnetometer values recorded during the survey were used to produce a magnetic contour map of the site (Figure 32, TRC 1994). The magnetometer contour map indicated areas of elevated or depressed magnetometer values (with respect to background) across the site. Based on the EM and magnetometer surveys, one of the planned test pits (TR-04) was relocated to investigate the magnetic anomaly located adjacent to MW-2.

- From 11-13 May 1993, four test pit investigations were conducted, including soil sampling, to visually inspect three areas where geophysical anomalies were mapped (Figure 5-3, Appendix A-4). At three test pit locations, no evidence of soil contamination was detected. At the fourth location (TP02), no evidence of soil contamination could be identified but the source of the geophysical anomaly could be attributed to a short length of buried metal pipe about 0.5 ft bgs (below ground surface), also believed to be the source of the Confirmation Study anomaly. A summary of the soil sample analytical results is provided in Appendix A-4.

- In June 1993, four shallow borings/wells (MW-5S, -6S, -7S, and -8S) and 2 deep borings/wells (MW-3D and -5D) were drilled and installed. During drilling of the boreholes, surface and subsurface soil samples were collected for analysis. The analytical summary tables are provided in Appendix A-4. NX- rock cores were obtained from MW-3D, -5D and -7S (Figure 5-3, Appendix A-4). (The shallow [S] wells approximately screen the water table interval to assess what was designated as "shallow" ground water. In

general, the deep [D] wells screen the interval above the top of competent rock which included the lower portion of a silt unit and/or the till unit [refer to Section 3.6.2 of the Phase III RI report] and were designated as "deep" ground water.)

- In July 1993, evaluation of the analytical results of ground-water samples from Phase II monitoring wells indicated that VOC were detected in samples of both shallow and deep ground water at Site 07. The analytical summary table is provided in Appendix A-4. The highest total VOC concentration detected in the ground water was in the sample from MW-5D at 57,400 $\mu$g/L for deep (D) wells and in the sample from MW-2S at 37 $\mu$g/L for shallow (S) wells. These results indicated that more information was needed; and therefore, a Supplemental Phase II investigation was considered necessary.

**Supplemental Phase II RI**

The objectives of the Supplemental Phase II RI at Site 07 were to locate the original source area of the chlorinated VOC detected in the Phase II RI ground-water samples as well as the horizontal extent of VOC in the deep ground water downgradient (south and east). The Supplemental Phase II RI included:

- Installation of 21 micro-wells in the general area between monitoring wells MW-7S, -1S, and -2S to assess the source area for the chlorinated solvent (DANC) disposal/release (Figure 5-9, Appendix A-4). The micro-wells were sampled in March 1994. Results of the micro-well ground-water samples were used to delineate the extent of the VOC in shallow ground water in the suspected disposal/release area (Figure 3-4, Appendix A-4). The highest VOC concentrations were detected in micro-wells GH-2 and GH-7 at total VOC concentrations of 776 $\mu$g/L and 318 $\mu$g/L respectively. These two micro-wells are located north of well MW-2S and just south and north of the dirt road, respectively. A summary table of the analytical results is provided in Appendix A-4.

- Installation of five deep (D) monitoring wells (MW-9D through -13D) in the area south of wells MW-4S and -3S toward the shoreline (Figure 5-4, Appendix A-4). These wells were drilled to refusal, i.e., bedrock was not confirmed by coring.

- Based upon the results of the micro-wells, the source area for the chlorinated VOC detected in ground-water samples appeared to be approximately 30-80 ft north of well MW-2S. A relatively small plume of dissolved chlorinated VOC was detected in samples from wells MW-2S and -4S. Dissolved chlorinated VOC were detected in ground-water samples collected from all

of the deep (D) wells with the highest concentration detected in the sample collected from well MW-5D at 57,400 $\mu$g/L. A summary table of the analytical results is provided in Appendix A-4.

The Phase II and Supplemental Phase II RI report concluded that additional information was required to define the extent of chlorinated VOC particularly in the bedrock.

### 1.2.4.4 Study Area Screening Evaluation - Calf Pasture Point Munitions Bunkers

In June 1993, Halliburton NUS Corporation (Halliburton NUS 1994) conducted a Study Area Screening Evaluation (SASE) (Figure 2-3, Appendix A-5) . The purpose of the SASE was to investigate the CPPMB and assess whether releases of previously stored materials may have affected the interiors of the bunkers, determine if the concrete bunker floors were cracked providing possible pathways for any related releases, and determine the presence of wastes reportedly buried next to one of the bunkers.

The CPPMB included three bunkers (designated as numbers 59, 60, and 339 [339 demolished in 1997]) located north of Site 07 (Figure 2-3 of Appendix A-5 and Figure 1-2 of the Site 07 RI report).

Assessment of the interior of the bunkers found no cracks in the floors. Some staining was observed and wipe samples were obtained from the inside surfaces of the bunkers. Four wipe samples were collected from each bunker and analyzed for TCL semi-VOC (SVOC), pesticides/polychlorinated biphenyls (PCB), and TAL inorganic analytes. Six organic compounds and 12 inorganic analytes were detected in wipe samples of which the highest detected concentrations exceeded the proposed New Jersey clean up standards and Rhode Island lead standards (Tables 6-2 and 6-3, Appendix A-5). (New Jersey clean-up standards were used as reference, because at the time of the SASE, Rhode Island had no standards for the parameters listed on Tables 6-2 and 6-3, except for lead.) Because no release pathway was identified, there is no apparent impact on Site 07.

Magnetic and electrical conductivity geophysical investigations were conducted at each bunker and test pits were excavated near Bunker 60 (Figure 2-3, Appendix A-5). Anomalies were detected near each of the bunkers. However, these anomalies were attributed to steel on the roof of each bunker. No buried containers were found.

Seven test pits were excavated. No buried wastes, discolored soil, or other visual signs of contamination were found. Methylene Chloride (a common laboratory contaminant) was detected in 10 of 12 subsurface soil samples.

### 1.2.4.5 Removal Action and Close-Out - Calf Pasture Point Munitions Bunkers

Foster Wheeler Environmental Corporation (Foster Wheeler) performed the removal action during the period of 3 October 1996 through 13 March 1997. The removal activities at

CPPMB Nos. 59 and 60 included the collection of paint chip samples prior to lead decontamination efforts, the performance of a test wash to determine the potential effectiveness of decontamination efforts, the eventual removal of lead dust using a high pressure washer with a solution of water and lead dissolving detergent, and the collection of confirmatory wipe samples from the floors and walls of each bunker. On 13 March 1997, the doors of CPPMB Nos. 59 and 60 were welded shut, as requested by the Navy. It was decided that Bunker No. 339 would be slated for demolition, and lead dust removal would not be performed. The Rhode Island Department of Health lead-free standard of less than 20 $\mu g/ft^2$ total lead in interior dust was eventually achieved at Bunker Nos. 59 and 60. All decontamination water and sediment were drummed and disposed off site. Bunker 339 was demolished on 19 February 1997. Details of the removal action are provided in the October 1997 Contractor's Revised Close-out Report for the Removal Action at CPPMB (Foster Wheeler, 1997).

## 1.3 REPORT ORGANIZATION

This report is organized as follows: Chapter 1 presents the objectives and scope of the RI, the site background, and organization of this report. Chapter 2 presents a description of the site investigations performed. Chapter 3 presents the physical characteristics of the site and includes the ground-water modeling work. Chapter 4 presents the nature and extent of VOC detected in the soil and ground water and the Site conceptual model. Chapter 5 presents the contaminant fate and transport findings and includes the ground-water solute transport modeling and surface water modeling work. Chapter 6 presents the HHRA findings. Chapter 7 presents the Phase III RI conclusions. Supporting documentation is contained in the appendices. The Phase III RI report is provided as three volumes, as follows:

Volume 1: Technical Report (text, tables, and figures)
Volume 2: Appendices A through J and L through N
Volume 3: Appendix K (Data Validation Reports for 1995-96 Samples)
Volumes 4-6: Appendix K (Data Validation Reports for 1997-98 Samples)

# 2. PHASE III RI FIELD INVESTIGATION

## 2.1 INTRODUCTION

This chapter describes the Phase III RI onsite and offshore field programs conducted to further characterize subsurface and ground-water conditions at Site 07. The Phase III RI Work Plan describes the procedures that were used to conduct the onsite field sampling activities and laboratory analysis. Offshore investigation beneath the harbor and the entrance channel was requested by EPA and RIDEM in July and August 1997 to complete the RI by assessing the nature and extent of VOC from the Site potentially beneath the harbor and channel. The offshore sampling and analytical procedures are presented in the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997.

Section 2.2 briefly summarizes previous investigations (refer to Section 1.2.4 for a detailed presentation). Section 2.3 details the sampling program. Procedures for field activities are presented in Section 2.4. Section 2.5 addresses investigation-derived waste (IDW) handling procedures. Section 2.6 details the site-specific health and safety requirements, Section 2.7 reviews analytical procedures, and Sections 2.8 and 2.9 present quality assurance/quality control (QA/QC) and data validation procedures, respectively.

## 2.2 PREVIOUS INVESTIGATIONS

Previous investigations and studies at Site 07 have focused on locating and evaluating the vertical and horizontal extent of releases associated with former disposal activities at Site 07. In 1984, an IAS was conducted by Fred C. Hart Associates, Inc. (Hart 1984), which due to past waste disposal approaches identified Site 07 as a possible hazardous waste site and was recommended for a Confirmation Study (CS). RIDEM requested that the Site be included in the CS-Verification Step (TRC 1994). The CS concluded that additional information was needed on the extent of VOC at Site 07. For this reason, a Phase I RI was conducted by TRC in 1991 (TRC 1991). The Phase I RI recommended no further action combined with bi-annual ground-water monitoring. As a result of comments and concerns from the EPA and RIDEM regarding the Phase I RI, a Phase II RI and Supplemental Phase II RI was performed by TRC during 1993-94 to further delineate the horizontal and vertical extent of VOC at Site 07. These investigations reported that chlorinated VOC were detected in all ground-water samples collected from deep wells in the unconsolidated material just above the top of competent bedrock. These previous investigations were unable to identify the source area(s), adequately characterize the extent of VOC in ground water, or provide information regarding the presence/extent of VOC in bedrock. (Refer to Section 1.2.4 for a more detailed summary of the previous investigations of Site 07.)

The following data gaps were identified and are addressed in this Phase III RI report:

- Further evaluation of the southern and western horizontal extent of the chlorinated VOC (CVOC) plume in shallow ground water.

- Evaluation of the potential presence and character of residual and/or free-flowing dense non-aqueous phase liquid (DNAPL) in the deep soil beneath the area of micro-wells MW-GH2 and MW-GH7.

- Further evaluation of the horizontal extent of the CVOC plume detected in deep ground water above bedrock and also in the upper portion of the competent bedrock.

- Further evaluation of the bedrock topography beneath the Site along which the CVOC plume detected during the Phase II RI in deep ground water appears to have migrated.

- Additional characterization of the Site geology and hydrogeology.

- Assessment of the geology and soil and ground-water quality offshore beneath the harbor, entrance channel, and Spink Neck.

## 2.3 PHASE III RI FIELD SAMPLING PROGRAM

### 2.3.1 Historical Data Evaluation for the Phase III RI Strategy/Planning

The hydrogeological data and detected CVOC in ground water upon which the design of the Phase III RI is based are provided as Figures 1 through 6 of Appendix A-6. Figures 1 and 2 show the estimated horizontal extent of the shallow and deep ground-water plumes based upon the results of the Phase II and Supplemental Phase II RI. This figure shows the composite plume for 1,1,2,2 PCA, trichloroethene (TCE), and 1,2-DCE detected in ground-water samples collected from monitoring wells and micro-wells. The northern extent of the shallow ground-water plume was defined by several micro-wells which are not located on Figure 2. Figure 3 shows the location of three hydrogeological cross-sections which are presented in Figures 4, 5, and 6 (Appendix A-6).

Figures 1 and 2 (Appendix A-6) show that for the shallow ground water, CVOC were detected only in the apparent source (DANC burial/release) area (MW-GH2 and MW-GH7 samples from March 1994) and downgradient in wells MW-2 and MW-4 (July 1993 samples). With regard to the deep ground water, the highest detected concentration of total CVOC was from a July 1993 sample from MW-5D (57,400$\mu$g/L), followed by the samples from downgradient MW-9D (5,860 $\mu$g/L on April 1994) and MW-10D (2,044 $\mu$g/L on April 1994). The detected concentrations in samples from the remaining deep wells are each less than 65 $\mu$g/L. Based upon the Phase II RI (July 1994), it appears that the CVOC release occurred in the vicinity of micro-wells MW-GH2 and MW-GH7 (Figure 1, Appendix A-6). Although geologic logs which include rock coring are available for nearby wells MW-5D and MW-7S, no logs were

available for MW-2 or the two micro-wells (no soil samples were collected). Based upon surface observation and the geologic logs for MW-5D and MW-7S, the bedrock surface slopes steeply downward from north of Bunker 60 (about 50 ft MSL) to MW-7S (about 3.5 ft MSL) to MW-5D (about -38 ft MSL). The silt unit may be absent or thin beneath the apparent source (DANC burial/release) area which could allow DNAPL to migrate downward closer to the bedrock surface, and then to move downslope through the soil above bedrock to the vicinity of MW-5D. Along this possible flow route, there may still be residual and/or free-flowing DNAPL that would be a continuing source for the dissolved CVOC plume in the deep ground water.

During the Phase II RI, VOC and metals were detected in ground-water samples collected from the shallow (S) and deep (D) monitoring wells at the site, including:

| Constituent | Maximum Reported Concentration ($\mu$g/L) | |
|---|---|---|
| | Shallow | Deep |
| 1,1,2-Trichloroethane (1,1,2-TCA) | ND | 270 |
| 1,1,2,2-PCA (PCA) | 18 | 33,000 |
| 1,2-DCE (total) | 12 | 2,800 |
| TCE | 7 | 22,000 |
| Arsenic | 2.8 | 63.5 |
| Benzene | ND | 40 |
| Chromium | 4.2 | 292 |
| Lead | 21.4 | 125 |
| Manganese | 179 | 4,100 |
| Nickel | 11.2 | 320 |
| Selenium | 1.5 | 1.7 |

NOTE: ND = Not detected.

### 2.3.2 Onsite Field Program

The Site 07 Phase III RI onsite field sampling program included a three-staged approach (Stages 1, 2, and 3) to further investigate the Site hydrogeology in general, and specifically the Phase II RI designated "shallow" and "deep" ground-water zones:

(1) The water table and saturated portion of the upper sand unit designated as "shallow" ground water during the Phase I or II RIs;

(2) The lower portion of the silt unit, the lower sand unit, and the till unit designated as "deep" ground water during the Phase II RI; and

(3) The upper portion of the competent bedrock (approximately 25 ft into the unit) which was not investigated (i.e., screened by monitoring wells) during the Phase I or II RIs.

The field work was performed in three stages, such that the scope of each stage would be dependent upon the results of the previous stage. Stage 1 was a seismic refraction (geophysical) survey of the Site, Stage 2 was a hydroprobe (ground-water sampling screening) survey of the Site, and Stage 3 included soil borings and monitoring well installation. The field work (e.g. seismic refraction survey, hydroprobe investigation, drilling, well installation, sampling, and hydrogeologic testing) was performed in accordance with the field procedures in the Phase III RI Work Plan for Sites 03, 07, and 09 at NCBC Davisville (EA 1994).

#### 2.3.2.1 Stage 1 (Seismic Refraction Survey)

The surface between the top of competent bedrock and the overlying till unit appears to have been a feature along which the CVOC plume detected during the Phase II RI in deep ground water migrated (Section 2.3.1). Therefore, the purpose of Stage 1 was to prepare a map of the top of competent bedrock beneath the Site by performing a seismic refraction survey.

During 31 March through 26 May 1995, a seismic refraction survey, totaling over 8,100 ft in length, was performed by Geophysical Applications, Inc., under contract to EA. The methodologies and results of the seismic refraction survey are presented in Appendix B. Additionally, Figure 2-1 shows the approximate locations of the nine seismic refraction survey lines (AA′ through II′). The interpretive geophysical data along each of the survey lines along with the elevation that the bedrock surface encountered at various borings/wells are the basis for the contouring of the bedrock surface also shown on Figure 2-1. Figure 2-1 was used along with the Phase II RI geological and ground-water quality data to select locations for the hydroprobe survey to be performed during Stage 2, as well as locations for Stage 3 soil borings and monitoring wells. The geophysical survey results and the selected locations for hydroprobe sampling were presented to and discussed with the BCT. The agreed upon hydroprobe locations were then sampled during Stage 2.

#### 2.3.2.2 Stage 2 (Hydroprobe Survey)

After review of the seismic refraction survey results, Stage 2 was started. The objectives of the hydroprobe survey were to:

- Provide screening-level CVOC data for ground-water in the upper sand unit and the till unit beneath Site 07 to aid in selection of Stage 3 soil boring and monitoring well locations; and

- Aid in the location of potential CVOC source areas and estimation of the extent of the CVOC previously detected in the Phase II RI ground-water samples (particularly the plume in shallow ground water and the plume in the deep ground water) and in areas not previously studied.

During this stage, a screening level ground-water sampling and analysis survey was conducted across Site 07 by Target Environmental Services, Inc., under contract to EA using a truck-mounted hydraulic probe to obtain ground-water samples from various intervals in the saturated overburden. Twenty five hydroprobe locations were selected (Figures 2-2 and 2-3). The ground-water samples were field screened for selected CVOC (t-1,2-DCE, c-1,2-DCE, PCE, TCE, PCA, 1,1,2-TCA) and acetone using a portable gas chromatograph in a mobile laboratory located at NCBC. The hydroprobe survey was performed during June and July 1995. At all but two of the hydroprobe locations, ground-water samples were collected from three different depths to better characterize the CVOC concentrations in three-dimensions. Depth to the water table and thicknesses of the geological units at the hydroprobe locations were estimated from boring logs and well data from previous investigations and the Stage 1 seismic refraction survey results. Based on these estimates, the first sample at each location was collected from approximately 5 to 10 ft below the anticipated water table, the second sample was planned to be collected approximately from the bottom one third of the silt unit, and the third sample was collected at refusal in an attempt to sample the bottom of the till unit or just above bedrock to evaluate deep ground water. However, at HP-2 and HP-9, the depth to refusal was shallower than expected and only two samples could be collected at these locations.

The following summarizes the rational for the various hydroprobe ground-water sampling locations:

- HP-01 evaluates the downgradient of Bunker 339, a potential source area, as requested by EPA.

- HP-02 evaluates the vicinity of the potential DANC disposal area.

- HP-03 and HP 04 evaluate the west and southwest extent of the CVOC plume detected in shallow ground water during the Phase II RI.

- HP-05, -06, -07, -10, -12, -14, -15, -16, -17, -18, -20, -21, and -24 evaluate the CVOC plume in deep ground water along a potential migration pathway, i.e., the interpreted valley in the bedrock surface which extends approximately southeast from MW07-05, then trends approximately east under the shoreline (Figure 2-1)

- HP-08, -09, -23, and -25 evaluate the western portion of the CVOC plume in deep ground water detected at MW07-10D during the Phase II RI.

- HP-12 and -13 evaluate the southern extent of the CVOC plume in deep ground water.

- HP-19 and -22 evaluate the northeastern extent of the CVOC plume in deep ground water.

The results of Stage 2 are summarized on Table 2-1 and Figures 2-2 and 2-3 (shallow and deep samples, respectively). Generally, the shallow samples are from a few feet below the water table and the deep samples are from the till unit as planned. However, based upon the Phase III RI boring logs, the intermediate depth hydroprobe samples were actually from a variety of geological units, i.e., not one common horizon (depth) within the silt unit as was planned. (This became apparent after completion of the Phase III RI borings/wells which provided a better understanding of the extent of the various geological units). Therefore, a figure was not prepared for the intermediate depth sample results because they are sometimes from the base of the silt unit close to the contact with the till unit or below the silt unit where the VOC concentrations are higher in the plume area; i.e., this intermediate depth sample zone does not represent a common horizon that can be evaluated as a hydrogeologic unit. Separate-phase DNAPL was not observed in the hydroprobe-collected ground-water samples. Seven of the hydroprobe-collected ground-water samples were also sent to CEIMIC Labs for confirmation analyses (Table 2-1). Although the CEIMIC Lab results were higher than the field GC results, the CEIMIC Lab results generally confirmed the parameters and relative concentrations detected by the field GC (Table 2-1). The reason for the lower detected concentrations by the field GC is that when the field GC-detected concentrations were above the GC calibration range, the results were biased low. For each sample that exceeded the calibration range, the sample was diluted and reanalyzed. Further dilution and analysis of an individual sample was not performed by the field lab GC because this was a screening activity to aid in locating the VOC plume and source area(s) and aid in selecting locations for additional monitoring wells which it did well.

#### 2.3.2.3 Stage 3 (Soil Boring and Monitoring Well Installation)

After the hydroprobe survey was completed, Stage 3 began. Utilizing Phase I and II RI analytical data, the seismic refraction survey data, and hydroprobe survey data, locations were selected for two soil borings and 28 ground-water monitoring wells. The results of the hydroprobe survey and the selected locations for the borings and wells were presented to and discussed with the BCT. The agreed upon boring and well locations were then used during Stage 3. One soil boring and four monitoring well locations were added after information from the initial Stage 3 work became available.

**Subsurface Soil**

The objectives of the Phase III RI relative to subsurface soil were to:

- Assess the potential presence and extent of residual and/or pooled (free-flowing) DNAPL and/or high concentrations of VOC in the area of monitoring well MW07-05D, via field observations (e.g., solvent rather than ground water draining from a soil sample with a strong solvent odor similar to that from a dry cleaner and/or presence of anomalously high soil sample headspace measurements, the presence of observable separate-phase liquid in water samples collected during the hydroprobe survey or in water collected from wells obtained during well development or purging/sampling along with a strong solvent (dry cleaner) odor).

- Further characterize the site geology.

- Field screen the head space of soil samples for worker health and safety reasons and to aid in the selection of samples to be sent for laboratory analysis.

- Qualitatively assess the physical characteristics and properties of the soil (soil types, e.g., sand vs. silt, and hydraulic conductivity).

A summary of the geology and the VOC analytical results for the subsurface soil samples is presented in Chapters 3 and 4, respectively. Phase III RI boring logs are provided in Appendix D.

**Ground Water (Wells)**

The objectives of the Phase III RI relative to ground water were to:

- Assess the depth and slope of the water table and the potentiometric surface of the deeper confined/semi-confined units.

- Assess the concentration and distribution of VOC detected in the ground water.

- Provide data to support development of a HHRA to characterize potential risk to human health from potential exposure to ground water from beneath Site 07.

Information collected from the monitoring wells included water-level data and ground-water quality data. Static water levels were plotted on site maps to make ground-water contour maps from which ground-water flow direction and gradients were estimated. Slug tests were conducted and the results were used to estimate hydraulic conductivity. These

data and maps are presented in Chapter 3. The ground-water sample results are presented in Chapter 4 and the HHRA is presented in Chapter 6. Phase III RI monitoring well construction diagrams are in Appendix E.

A total of 32 wells were installed throughout the area of Site 07 during the Phase III RI. Ten wells were screened in the shallow zone, straddling the water table. Seventeen wells were screened in the deep zone, with the bottom of the screen approximately one half foot to one foot above competent bedrock. Five wells were installed in the upper 15 to 25 ft of competent bedrock. The locations of all wells are shown on the site map (Figure 1-2). Soil borings SB07-01 and SB07-02 were drilled to refusal. Bedrock was confirmed by rollerbitting two to three feet into competent rock. The third soil boring (SB07-03) was drilled to auger refusal. Well installation occurred between 18 July and 27 November 1995. The locations of the monitoring wells are shown on Figure 1-2. Rock coring was performed at each deep (D) well to confirm the top of competent bedrock and at all bedrock (R) wells to assess the amount of fracturing at those locations.

Existing (Phase I and II) wells are referred to by their new designations in this document (Except where noted in the historical section of Chapter 1.) The new well identification consists of the prefix MW07 for the Site 07 monitoring wells, followed by the two digit identification of the well number originally assigned. This number is then followed by a single letter designation indicating the ground-water zone in which the well screen is set (e.g., MW07-05D for the deep well in the 05 well cluster located at Site 07).

**Selected Boring/Well Locations**

The following paragraphs summarize the planned purpose of the various borings and wells.

Two monitoring wells (MW07-14D and MW07-31I) and one soil boring (SB07-03) were installed to evaluate subsurface conditions in the anticipated vicinity of the DANC disposal area.

Four monitoring wells (MW07-04D, MW07-05R, MW07-15D, and MW07-17D) were installed to evaluate subsurface conditions and the extent of elevated concentrations of total CVOC detected in a sample from MW07-05D during the Phase II RI and in deep hydroprobe samples from HP-04, HP-05, HP-06, and HP-07 collected during Stage 2. Additionally, two soil borings (SB07-01 and SB07-02) were drilled to confirm the geophysically interpreted valley in the bedrock surface at MW07-05D which could act as a pathway for migration of potential DNAPL.

Two wells (MW07-19S/D) were installed to evaluate subsurface conditions at HP-11 where unexpected elevated concentrations of CVOC were detected.

Five monitoring wells (MW07-09R, MW07-10S, MW07-13S, MW07-26S, and MW07-27D) were installed to evaluate subsurface conditions between the VOC plume detected in ground water during the Phase II RI and the study area perimeter.

The remaining nineteen monitoring wells were installed at eleven locations to evaluate VOC in ground water and the hydrogeology along the perimeter of the study area. Beginning in the northern portion of the study area:

- MW07-22S/D were installed to evaluate subsurface conditions upgradient of the anticipated area of DANC disposal;
- MW07-25D/R and MW07-23 S/D were installed to evaluate the western and southwestern perimeter;
- MW07-21S/D/R and MW07-24S/D were installed to evaluate the southern perimeter; MW07-21S/D/R was also located to evaluate the area downgradient of HP-09 where unexpected elevated concentrations of CVOC were detected during Stage 2.
- MW07-20S/D, MW07-18D, and MW07-16D/R were installed to evaluate the eastern perimeter, particularly within interpreted low areas in the bedrock surface where potentially migrating CVOC may flow;
- MW07-28D, MW07-29D, and MW07-30D were installed to evaluate the northeastern perimeter, assumed to be beyond the CVOC plume.

#### 2.3.2.4 Hydrological Testing

The objective of the Phase III RI relative to hydrological testing was to:

- Provide data for assessment of hydraulic conductivity.

Hydrological tests were conducted in all Phase III monitoring wells and in two previously existing Phase II wells (MW07-10D and MW07-13D) to estimate the in situ hydraulic conductivity of the geological material adjacent to the screened intervals. The tests included packer (pressure) testing of the borehole prior to installation of each of the five bedrock wells and slug testing wells (screened in various units). Slug test data and calculations are provided in Appendix F. The packer test data is provided in Appendix G. "AQTESOLV®" software was used to calculate hydraulic conductivities from the slug test data. The results are presented in Chapter 3.

### 2.3.3 Offshore Field Program

Two soil borings (SB09-16 and SB09-17 located mid-harbor, west to southwest of the Site) and two monitoring wells (MW07-32D/R on Spink Neck; south of the Site) were drilled and sampled as part of the Offshore Geotechnical Sampling and Confirmation Study at Site 09 (Fall 1997). The location of these borings and wells is shown on Figure 1-2. These borings and wells were installed to assess the potential offshore extent of VOC from the Site from areas where VOC had been detected previously in ground-water samples from wells near the perimeter of the Site. The drilling, sampling, and analyses were performed in accordance with the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997. The soil and ground-water sample results have been incorporated in Chapter 4.

### 2.3.4 EPA SITE ACTIVITIES

EA was authorized by the Navy to provide oversight for the following EPA Site 07 field activities: borehole geophysical logging of monitoring wells by the USGS in December 1996 and July 1997 (see Chapter 4, Section 4.6.1.4) and interior wetlands sediment sampling on 4 December 1997 (see Section 2.4.8) .

## 2.4 FIELD INVESTIGATION PROCEDURES

### 2.4.1 Hydroprobe Sample Collection and Analysis

#### 2.4.1.1 Sample Collection

The hydroprobe survey was performed by Target Environmental, Services, Inc. To collect the ground-water samples, a truck-mounted hydraulic probe was used to hydraulically drive connected 3 ft sections of 1" to 1.5" OD threaded steel casing equipped with a retractable screened water sampler down to the sampling depth. The steel casing was then retracted approximately 18-in. to expose the sampler screen to the ground water. Once a sufficient amount of ground water had entered the pipe through the screen, a 21-in. long by 7/16-in. OD stainless steel bailer was used to collect the ground-water sample. Samples were placed in 40 ml glass VOA vials, sealed, labeled and relinquished to TARGET's onsite mobile laboratory for headspace analysis. All samples were stored at less than or equal to 4°C pending analysis. Seven duplicate ground-water samples were collected at selected locations at the same time and with the same bailer as used for the related sample collected for analysis by the mobile laboratory at NCBC, placed in 40 ml glass VOA vials, preserved, sealed, and submitted for TCL VOC analysis to CEIMIC Laboratories. Samples were designated as HP-XX-YY where HP is for hydroprobe sample, XX is the location designation, and YY is the depth below ground surface at which the sample was collected.

#### 2.4.1.2 Sample Analysis

The ground-water samples collected during the field phase of the survey were prepared for headspace analysis in accordance with the Work Plan Addendum. The specific analytes standardized for this analysis were:

- trans-1,2-dichloroethene (t-1,2 -DCE)
- cis-1,2-dichloroethene (c-1,2-DCE)
- TCE
- 1,1,2-TCA
- PCE
- PCA.

The chlorinated hydrocarbons in this suite were chosen because they were previously detected in ground-water samples from the site. A summary of the field and laboratory results for hydroprobe samples are summarized on Table 2-1.

### 2.4.2 Soil Sample Collection

During drilling, soil samples were collected with using 2-ft long, 2-in. outside diameter (OD) split-barrel samplers. For the three soil borings, soil samples were collected every 2 ft (continuously) until refusal. For monitoring wells, soil samples were collected continuously to a depth of 20 ft or until encountering the silt unit, whichever was deeper, then every 5 ft thereafter to the top of bedrock (or refusal). Soil samples were screened with a HNu model PI-101 or DL-101 photo-ionization detector (PID) with an 11.7 electron volt (eV) probe after the sampler was opened. Then, analytical and jar headspace samples were collected directly from the split-barrel sampler using stainless steel spoons or spatulas. The soil was then logged by the EA geologist. In general, the two samples with the highest headspace readings and/or samples that represent the geological units encountered (especially when the two highest headspace reading intervals were close together) were sent to CEIMIC Labs in Narragansett, RI, for TCL VOC analysis. Results of soil sample analyses are presented in Chapter 4. Soil samples were collected in accordance with the Phase III RI Work Plan. Split-barrel samplers were disassembled and decontaminated between sampling intervals in accordance with the Phase III RI Work Plan.

Field procedures, including soil sampling, conducted as part of the Offshore Geotechnical Study (including SB09-16, SB09-17, MW07-32D/R), were performed in accordance with the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations. resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997.

### 2.4.3 Drilling

Drilling was performed during 7 July through 27 November 1995. Drilling for all wells was conducted with a Mobile B-61 drill rig using 4-in. to 6-in. ID flush-joint (FJ) casing with a 3 7/8-in. to 5 7/8-in. diameter rollerbit (RB), or 4-1/4-in. ID hollow-stem augers (HSA). For deep (D) wells, after HSA refusal, a rollerbit was inserted to advance the borehole a few feet (generally 1-3 ft) to verify the top of bedrock prior to beginning coring. Bedrock was cored five feet using a diamond bit, HX- or NX- core barrel. For bedrock (R) wells, drilling continued 15 ft into the top of competent bedrock along with temporary 6-in. diameter FJ casing and flushed clean with a 5 7/8-in. diameter roller bit. A length of permanent 4-in. diameter FJ casing was then grouted in place. The temporary 6-in. diameter casing was removed. After the grout had set (no sooner than 24 hours after installation), the inside of the permanent casing was flushed clean with a 3 7/8-in. diameter roller bit. Fourteen feet of bedrock was then cored with a HX-core barrel.

The Phase III RI, offshore, and Spink Neck boring logs and monitoring well construction diagrams are presented in Appendices D and E, respectively. For convenience and direct reference, the Phase I and Phase II RI boring logs and monitoring well diagrams are provided in Appendix A-7.

Typically, at a well cluster location, soil sampling during drilling of deeper wells in the cluster began at a depth which would overlap the last two samples of the shallower well. In some cases, the deep (D) well was installed prior to the shallow (S) well. Headspace vapor of the soil samples obtained from the well borings were screened with a PID. Both headspace samples and samples for chemical analysis were collected in accordance to the Phase III RI Work Plan. After drilling was complete, downhole drilling and sampling equipment were steam cleaned in accordance with the Phase III Work Plan prior to drilling at the next well location.

Drill cuttings (Investigation Derived Waste, IDW) from soil boring and well installation activities were collected and placed in 55-gal drums and staged adjacent to the related boring/well in accordance with the Phase III RI Work Plan. The handling of IDW is presented in Section 2.5.

Drilling activities were recorded by the EA geologist in a bound field notebook. Information in the field notebook included location, time on-site, personnel and equipment present, down time, materials used, and other pertinent information necessary to reconstruct field activities at a later date. Geological data was entered into the field notebook and later placed on boring logs (Appendix D).

Drilling activities were conducted in Level D Personal Protective Equipment (PPE). Drilling activity was completed as defined in the Site-Specific Safety, Health, and Emergency Response Plan (SHERP). In addition, while drilling was in progress, periodic readings of borehole vapor and the breathing zone were obtained using a PID.

Additionally, an Industrial Scientific combustible gas and oxygen indicator (CGI/$O_2$) was used to monitor the level of potential explosive gases at the top of the borehole. Readings from these instruments were recorded on environmental monitoring logs. The PID and CGI/$O_2$ instruments were calibrated in accordance with the Work Plan.

Field procedures, including drilling, conducted as part of the Offshore Geotechnical Study (including SB09-16, SB09-17, MW07-32D/R), were performed in accordance with the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations. resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997.

### 2.4.4 Well Installation

The Phase III RI onsite monitoring wells were constructed in accordance with the Phase III Work Plan. Field procedures, including well installation, conducted as part of the Offshore Geotechnical Study (including SB09-16, SB09-17, MW07-32D/R), were performed in accordance with the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations. resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997. Well completion details for Site 07 are summarized on Table 2-2. Well completion diagrams for the Phase III RI and the Spink Neck monitoring wells are included in Appendix E.

#### 2.4.4.1 Riser and Screen Installation

New machine-slotted polyvinyl chloride (PVC) or continuous wrap, stainless steel well screen and riser were used in well construction. Materials were delivered directly to the field in packaging from the manufacturer. Details of well completion were recorded on well completion diagrams (Appendix E). After the borehole was drilled to the depth determined by the EA field supervisor, 2-in. ID, threaded, flush-jointed PVC or stainless steel screen and riser were set through the HSA or steel casing into the borehole. The screen interval was placed at the bottom of the well at the appropriate depth, i.e., across the water table (shallow well), on top of competent bedrock (deep well), or 15 to 25 ft into the top of competent bedrock (bedrock well). The use of PVC versus stainless steel well materials was based upon the results of the hydroprobe (Stage 1) survey. PVC well material were used, except in areas where the total CVOC was detected in Stage 1 samples at concentrations greater than 1,000 $\mu$g/L, then stainless steel was used (MW07-04D, MW07-05R, MW07-09R, MW07-14D, MW07-15D, MW07-17D, MW07-25D, MW07-25R, and MW07-31S).

Screen slot size was 0.010 in.(10-slot), 0.006 in. (6-slot) or 0.007 in.(7-slot) depending upon the amount of fine sediment (silt and clay) observed in the samples taken at the screened interval (see Appendix E for specific wells). Borings with more fine sediment in

the screened interval received the smaller slotted screen (6-or 7-slot). The well riser pipe extended approximately 1.5-2.5 ft above the ground surface. A small vent hole was cut into the top of each well riser pipe. A protective steel casing with lockable cover and expanding well cap were grouted in over each well riser.

#### 2.4.4.2 Filter Pack

Inert silica sand was used as filter pack. Nominal grain size was grade 0 silica sand for 10-slot screens and grade 00 silica sand for 6-slot and 7-slot screens. The well screen and riser were installed through the HSA or FJ steel casing and the filter pack was added. HSA sections or steel casing were progressively removed from the borehole allowing the filter sand to be poured through the augers/casing and into the space created by this action. Sand was added to a height ranging from 0.5 to 3.0 ft, with an average of 1.0 ft, above the top of the well screen. That portion of the filter pack that is placed above the top of the screen allows for some settlement of the filter pack and acts as a buffer between the top of the well screen and the annular bentonite seal. The depth to the top of the filter pack was sounded with a weighted measuring tape and recorded on a monitoring well construction diagram (Appendix E).

#### 2.4.4.3 Bentonite Seal

Commercially available bentonite pellets (Pelplug®) were used as bentonite seal. Bentonite seals were an average of 2.35 ft thick with a range of 0.5 - 4.5 ft for the Phase III wells (Appendix E) as measured immediately after placement, without allowance for swelling. Where placement of the pellets occurred above the water table, clean, potable water (from tested and approved water supply source, i.e., the Base water supply system) was poured down the annular space to hydrate the pellets. Pellets were allowed to hydrate for a minimum of 1 hour prior to grouting. A sample of the Base water supply system was collected and analyzed for TCL VOC. The results are presented in Section 4.6.1.

#### 2.4.4.4 Grout Seal

The grout seal consisted of cement-bentonite grout, composed by weight of approximately 10 parts Portland cement to ½ part bentonite with a maximum of 7 gal of approved water per 94-lb bag of cement. Water from the Base water supply system was used. Bentonite was added after the required amount of cement was mixed with water. The grout materials were combined in an above-ground rigid container and mixed onsite to produce a thick, lump-free mixture.

The grout seal was placed utilizing a tremie pipe, initially located within 3 ft above the top of the bentonite seal in the annulus between the HSA (or steel casing) and the monitoring well riser pipe. The grout was pumped through this pipe to the bottom of the open annulus until a column of grout extended from the bentonite seal to grade. The HSA (or steel casing) was removed from the borehole as the grout seal filled the borehole.

#### 2.4.4.5 Surface Completion

The 32 Phase III wells installed at Site 07 and the two wells installed on Spink Neck were completed with above-grade steel protective casings that extend to a depth of approximately 3.0 ft bgs. The annular space between the borehole and steel protective casing was filled with concrete and the annular space between the steel protective casing and the riser was filled with silica sand. This type of construction was designed to allow for the steel protective casing to move independently of the riser section should frost heaving affect the protective casing.

The surficial protective casings were constructed with a 5-ft-long by 4- or 6-in. ID steel casing with a hinged locking steel cover. Each stick-up was constructed with approximately 2 ft of protective casing extending above grade and 3 ft extending below grade (Appendix E). Each well at Site 07 was completed with an approximately 2- x 2-ft concrete pad that extends a minimum of 4 in. below grade. The upper surface of the pad consists of an outward-sloping surface. A keyed-alike padlock was placed on the locking steel cover to secure each well.

#### 2.4.4.6 Well Identification

All Phase III and the Spink Neck monitoring wells are identified by their respective number on the exterior of the protective casing with oil-based paint. Each well was surveyed to establish the vertical elevation of the top of the well riser and ground surface (mean sea level datum) and the horizontal location (Rhode Island grid coordinates). These data are summarized as part of Table 2-2.

### 2.4.5 Well Development

The Phase III RI and the Spink Neck monitoring wells were developed generally within 1-8 weeks after the well was constructed, but no sooner than 24 hours after grouting was completed. The wells were developed from 5 October through 12 December 1995, and December 1997.

The wells were developed using a Grundfos Redi-flo 1.7-in. OD submersible pump or 1.7 in. OD PVC Bailer. The pump was connected to an appropriate length of disposable, polyethylene (PE) tubing and was placed at or near the bottom of the screened interval. As the turbidity decreased during pumping, the pump was raised and lowered in the well through the screened interval to produce a surging action that stirred up fine sediment (if present) in the well and forced water back and forth through the screen to remove very fine sediment (silt). If the well recharge was to slow to pump, a PVC bailer was used. The goals of the well development were to stabilize the field measured parameters and remove as much fine sediment from the well and the filter sand as possible. During well development, water quality parameters were measured at the beginning of development and after approximately each well volume. The parameters measured where pH, specific

conductance (conductivity), salinity, temperature (in °C), dissolved oxygen (DO), redox potential (Eh), and turbidity. Development continued until the turbidity was less than 100 Nephelometric Turbidity Units (NTU) units and other parameters had stabilized to within 10 percent for three consecutive readings, as possible, except for very low yield wells. [Some wells seemed to reach a point at which further reduction in turbidity (below 100 NTU) did not seem feasible. The development process resulted in the removal of 10 or more volumes of water from each of the developed wells, except for wells MW07-09R (8 volumes), MW07-16R (6 volumes), MW07-21R (9 volumes), MW07-25R (6 volumes), MW07-29D (9 volumes), MW07-30D (8 volumes) and MW07-31S (8 volumes). It was assumed that the low-flow sampling method and field filtering would further aid in the reduction of the turbidity in the future collection of a sample for chemical analysis. The low flow sampling method results in exerting less stress on a sampled zone than bailers or submersible pumps, and therefore, causes less sampling-induced turbidity.] Water produced during development was contained in properly labeled 55-gal drums. Well development forms are presented in Appendix H and selected data are summarized in Table 2-3.

### 2.4.6 Ground-Water Sampling

#### 2.4.6.1 Measurement of Water Level

The water level in the well was measured using a water level indicator probe (WLI).

#### 2.4.6.2 Purging and Sampling

Purging and sampling of the monitoring wells at Site 07 was performed no sooner than one week after well development. The ground-water sampling method was modified from the Phase III RI Work Plan to include a low-flow sampling technique

Purging of wells was conducted to remove ground water in the well casing which had been isolated for an extended period of time to ensure the subsequently sampled water was representative of the aquifer. The volume of water to be removed was calculated using the water-filled screen length and the ID of the well screen. This volume of water is referred to as one screen volume. The volumes removed were recorded on the Field Sampling Forms (Appendix I). Prior to collecting a ground-water sample, a minimum of two water-filled screen volumes was required to be purged, plus again the volume of water already purged prior to water level stabilization.

Purging and sampling was performed with a Masterflex Peristaltic Pump with Type 15 silicon tubing. The water level and total well depth were measured and one screen volume was calculated. The typical purging rate ranged from approximately 0.07-gal per minute (gpm) to 0.3 gpm. The pump was attached to an appropriate length of dedicated Teflon-lined polyethylene tubing so that the intake end of the tubing the was located at approximately the middle of the screened interval for the shallow, deep, and bedrock wells.

Whenever a low yielding well was encountered, the tubing was placed approximately one foot above the bottom of the well.

Water quality parameters including pH, Eh, salinity, conductivity, DO, turbidity, and temperature, were measured every 5 minutes until the pH was within 0.2 units and other parameters stabilized to within 10 percent for three consecutive readings, as possible. Sample collection was then initiated assuming that the minimum volume of water had also been purged. Low yielding wells dewatered before stabilization of the parameters. These wells were allowed to recover and were immediately sampled. Equipment used for field analyses of water quality parameters included Grant YSI 3800 Water Quality Meter with a flow through cell, and occasionally the Hach 2100P for turbidity when the turbidity reading on the Grant meter was questionable.

The purged water was containerized in appropriate 55-gal drums. Information related to IDW handling is presented in Section 2.5.

All non-dedicated field equipment (flow-through cells of the water quality meters) used during purging was decontaminated or disposed of in accordance with of the Phase III RI Work Plan before purging the next monitoring well. New protective gloves were worn for the sampling of each well.

Samples for VOC analysis were collected carefully by allowing the water to flow slowly along the inside wall of the container to avoid agitating the sample. In addition, no headspace was present in the sample container after it was filled. The pre-preserved sample container was filled until the meniscus was above the top of the container. A separate sample vial was also filled and the pH was checked. After the pH was checked and found to be less than two, the sample bottle was capped, and then, inverted and tapped lightly on the back of the samplers hand to determine if air bubbles were trapped within the container. Containers with trapped air were topped off and rechecked until no air bubbles were present in the sample. The sample aliquot for analyses of sodium, chloride, TDS and salinity was collected in a 500-ml poly container without preservative. Prior to collection of the aliquot for metals analysis, a 0.45 $\mu$m inline filter was attached to the tubing. A sample was then collected into a 500-ml poly bottle preserved with nitric acid. Sampling activity, observations, and field-measured water quality parameters immediately prior to sample collection (also summarized on Table 2-4) are documented on the field sampling forms, which are provided in Appendix I.

In addition to the ground-water samples collected, a sample was collected from Allen Harbor at the shoreline to the west of the MW07-12D and another surface water sample was collected from Narragansett Bay east of MW07-16 well pair. The samples were collected directly into the sample containers for analysis of VOC, metals, sodium, chloride, TDS, and salinity.

Collected samples were placed in a cooler with bagged ice to maintain a temperature of less than 4°C, and a chain-of-custody form was filled out indicating the analyses to be performed. The samples were taken to the field office where final packaging and processing of samples was completed. The samples were then shipped to CEIMIC Labs for analyses.

The validity of some of the ground-water sample results from the sampling event (December 1995) were in question as a result of the data validation (DV) process. Three VOC (DCE, PCA, and TCE) were detected in 3 of 4 rinsate blanks collected at the end of the sampling event. The rinsate blanks were collected to evaluate the effectiveness of the decontamination of the flow-through cells of the water quality meters used to field measure general water chemistry parameters. All but seven of the ground-water samples were collected beyond/after the flow-through cells. The presence of VOC in the Rinsate blanks forced some results to be considered "non-detect" (at elevated detection limits) by the validation process. A plan to resample 18 wells was agreed to by the BCT. In May 1996, the 18 wells were resampled using the low-flow sampling technique and the samples were collected prior to the flow-through cells of the water quality meters. During the December round of sampling, it was observed that ground-water level stabilization was unable to be achieved in wells that were tidally influenced. Tidal fluctuations were taken into account during the May 1996 sampling event.

Field procedures, including ground-water sampling, conducted as part of the Offshore Geotechnical Study (including SB09-16, SB09-17, MW07-32D/R), were performed in accordance with the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' and revisions, additions, and adaptations. resulting from field conditions and dated July 1997, September 1997, October 1997, and November 1997.

### 2.4.7 Hydrological Testing

#### Slug Testing

Hydrological tests were conducted to estimate *in situ* horizontal hydraulic conductivity (K). Slug tests were conducted in all Phase III monitoring wells from 2 to 25 January 1996. Packer testing was conducted in the borehole of bedrock wells prior to well installation. The slug tests and packer tests were performed in accordance with the Phase III RI Work Plan. The slug test and packer test field data are provided in Appendices F and G, respectively. The results are presented in the hydrogeology section of Chapter 3. No water could be pumped into the bedrock during performance of the packer tests in MW07-25R and MW07-05R (run 1), and therefore, there was no resultant data to be analyzed. For this reason, slug tests were performed on these wells to estimate K values.

For slug tests, the slug consisted of a 4-ft length of 1.75-in. outside diameter (OD) PVC pipe filled with sand, and capped on both ends. Using the formula $v = \pi r^2 L$, the volume of

the slug (115.2 $in^3$) was calculated. The water level in the monitoring well was measured with a WLI prior to the initial insertion of the slug or transducer. A pressure transducer was placed in the well and calibrated according to the manufacturer's instructions. In performing the rising head test, the slug was quickly removed from the well after the water level had equilibrated following insertion of the slug. Water levels were then automatically monitored by an *In-Situ* Inc. Hermit data logger until the water level had recovered to not less than 70 percent of the original static water level or 30 minutes had elapsed. All downhole equipment was decontaminated between slug tests in accordance with the Phase III RI Work Plan.

After the slug tests were completed, the data were downloaded from the data logger to a computer for further analysis using the Bower and Rice method with AQTESOLV®. The computer derived data analyses are presented in Appendix F and the results are presented in Chapter 3.

**Packer Testing**

Prior to installation of the bedrock wells, packer tests were conducted in the bedrock borehole interval to be screened. A double-packer system was used to isolate a 5-ft section of bedrock. Water was then pumped into the borehole interval at various pressures based on the methodology provided in the Phase III RI Work Plan. A modification to the work plan was made, if the calculated packer inflation pressure exceeded the maximum inflation pressure specified by the manufacturer. For these cases, the packers were inflated to the maximum allowable pressure as specified by the manufacturer. The volume of water pumped into the borehole interval was recorded based on flow-meter readings. Calculations of the packer test data were performed according to the procedure outlined in the Phase III RI Work Plan and Earth Manual (USDI 1980).

**Tidal Monitoring**

Ground-water levels were monitored using transducers in 17 wells and recorded by the aforementioned data loggers and at a point in Allen Harbor (the marina across from Site 07) using an Endeco 1029-SSM tide gauge through 48 hours from 16-17 January 1996. All wells at Site 07 were periodically measured manually during this time frame. The purpose of the water level measurements was to: (1) aid in the evaluation of the hydraulic relationship between the unconsolidated units and the upper portion of the bedrock which underlie the site, and (2) further evaluate the tidal impact on the ground-water conditions. Graphs of the field data are presented in Appendix J.

### 2.4.8 Wetlands Sediment

Site data indicate that because of the presence of a denser salt water wedge near the south perimeter of the site, deeper ground water that is in the brackish to fresh range appears to be flowing up along this interface into the shallow zone. Because of a concern that VOC in

that ground water may discharge to interior wetlands located in the southern portion of the Site, sediment samples were collected in two general locations (near MW07-13S and MW07-19S) in these wetlands on 4 December 1997 by the EPA. Four shallow wetlands samples (0-6 inches) and one deep wetlands sample (18-24 inches from grade) were collected in the vicinity of monitoring well MW07-13 (see Figure 2-1A). Four shallow samples and one deep sample were also collected near MW07-19. These samples were reportedly collected and analyzed by EPA as per the Quality Assurance Project Plan prepared by EPA. The sample results are presented in Chapter 4.

During these EPA field activities, EA collected and analyzed for VOC two split samples from sediment samples collected near MW07-19S (SD2MW19) and two spit samples from wetland sediment samples collected near MW07-13 (SD8MW13) (Figure 2-1A). The sample results are presented in Chapter 4.

## 2.5 INVESTIGATION DERIVED WASTE MANAGEMENT

IDW generated by the Phase III field activities was staged in the areas where it was generated. Three types of wastes generated during the Phase III RI field work were: (1) disposable PPE and sampling equipment that could not be decontaminated (e.g., twine, polyethylene rope and tubing), (2) soil (drill cuttings), and (3) fluids. Wastes were placed in appropriate 55-gal drums, labeled, and staged in accordance with the Phase III RI Work Plan. This IDW was then properly disposed by Inland Waters Pollution Control, Inc. of Johnston, RI.

Disposable PPE (e.g., gloves, respirator cartridges) and equipment that could not be decontaminated were collected in plastic bags at the site on a daily basis. These bags were containerized in drums.

Decontamination fluids, including drill rig wash water, were containerized in 55-gal drums. Monitoring well development and purge water was containerized in 55-gal drums.

IDW in the form of soil cuttings from drilling and monitoring well installation activities were consolidated in 55-gal drums at each well location.

## 2.6 HEALTH AND SAFETY

Field sampling activities were conducted in accordance with the provisions set forth in the Site-Specific SHERP and in the aforementioned Phase III RI and Offshore Work Plans. Field personnel and visitors entering the project site were required to read, understand, and sign the Site-Specific SHERP. Personnel entering the site were noted in the field logbooks. No reportable health or safety accidents occurred during the conduct of the field investigation.

## 2.7 ANALYTICAL PROCEDURES

Phase III RI soil and ground-water samples collected from onsite locations were analyzed using EPA methods for TCL VOC analysis (Method OLM03.1), TAL metals, and for chloride, TDS, and salinity analysis, as described in SW-846, 3rd edition, September 1986. The offshore investigation samples were also analyzed for SVOC, polycyclic aromatic hydrocarbons (PAH), PCB, and pesticides as listed in the 'Addendum to the Sites 03 and 09 Phase III Work Plan Offshore Geotechnical Sampling and Confirmation Study at Site 09 (NCBC)' revision dated September 1997. Laboratory analyses of the Phase III RI samples collected from onsite locations were performed by CEIMIC Laboratories of Narragansett, Rhode Island. The offshore investigation soil and ground-water samples were analyzed by EA Laboratories of Sparks, MD. The laboratory reports for the soil and ground-water samples are maintained in the project file at EA.

## 2.8 FIELD AND LABORATORY QA/QC

### 2.8.1 Field QA/QC

The field investigation was subject to the QC requirements of the Phase III RI Work Plan. Field QA/QC was achieved by adherence to the Phase III RI Work Plan. Equipment check-out, calibration of field instruments, and sampling techniques were documented. Several types of QA/QC samples were analyzed with the environmental samples, i.e., trip blanks, field (equipment rinsate) blanks, and duplicate samples.

### 2.8.2 Trip Blanks

Trip blanks were included with sample shipments to the laboratory which included samples for VOC analysis, and were prepared by the laboratory prior to the sampling event. The deionized water was provided by the laboratory and was free of VOC. Appropriate preservatives were added by the laboratory at the time that the blanks were prepared. The sample containers were sealed, labeled appropriately, and transported to the field in the same containers as the sample containers. These blanks were not opened in the field. They were transferred to ice chests designated for aqueous VOC sample storage/transport, and accompanied the samples to the analyzing laboratory. One trip blank was sent for analysis with each cooler of VOC water samples that were shipped. A total of 12 trip blanks were submitted to the lab for analysis with Site 07 aqueous samples. Refer to Chapter 4 for a presentation of the results.

### 2.8.3 Field Rinsate Blanks

Field rinsate blanks for VOC used the same source water as the trip blanks. Field rinsate blanks were prepared on site by filling the sample pre-preserved container(s) with deionized water that had been passed through selected field sampling equipment (after equipment decontamination had been performed), sealing the containers and completing the

appropriate documentation. The field rinsate blanks were handled in the same manner as the sample group for which it was intended (i.e., blanks were stored and transported with the sample group). A total of 4 field rinsate blanks (collected near the end of the sampling event) related to water sample collection and 1 field rinsate blank related to soil sample collection were submitted for analysis with Site 07 samples. Refer to Chapter 4 for a presentation of the results.

### 2.8.4 Duplicate Samples

To help assess the precision of the measurement system field duplicate samples were collected or prepared. These were of two types: Matrix spike/Matrix Spike Duplicate (MS/MSD) samples and blind duplicate samples. Duplicate samples were sent to CEIMIC Laboratories along with field samples. During soil sampling, 7 duplicate soil samples (a frequency of 10 percent of the total number of samples) and 16 MS/MSDs were sent for analysis. During ground water sampling, 5 duplicates (a frequency of 11 percent of the total number of samples) and 3 MS/MSDs were sent for analysis. Blind duplicate sample summaries are presented in Chapter 4.

### 2.8.5 Source Water

Samples of water used during drilling and well installation were collected. Three samples were collected during drilling operations and were submitted for TCL VOC analysis. These samples were collected from the hydrant northwest of Building 224, used as the source of water during drilling. One sample was collected during the December 1995 ground-water sampling event and was analyzed for VOC, metals, TDS, salinity, and chloride. This sample was collected from the hydrant near the (now) former RIEDC (formerly RIPA) maintenance building at Quonset Point because the hydrant near Building 224 was shut off for the winter.

## 2.9 DATA VALIDATION

Data validation (DV) of the CEIMIC Laboratory results for the Phase III Remedial Investigation phase soil and water samples was performed in accordance with EPA Region I Laboratory Data Validation, Functional Guidelines for Evaluating Organic and Inorganic Analyses (1 February 1988 and 13 June 1988, respectively). Data validation of the EA Laboratories results for the offshore investigation soil and water samples was performed in accordance with EPA Region I Laboratory Data Validation, Functional Guidelines for Evaluating Organic and Inorganic Analyses (December 1996). Use of the newer DV guidance for the offshore investigation soil and water sample results was required by EPA because these samples were collected as part of the remedial design phase of work for nearby Site 09. The data validation reports (one for each laboratory report) is provided in Appendix K.

# 3. PHYSICAL CHARACTERISTICS

## 3.1 INTRODUCTION

This section describes the physical characteristics of Site 07. Descriptions of subsurface physical features are based upon the Site 07 Phase III RI field investigation and site-related portions of the Site 09 offshore investigation, which together included drilling and installing 30 additional monitoring wells and three borings onsite, two mid-harbor borings in Allen Harbor, and a monitoring well pair on Spink Neck located south and across the harbor entrance channel from the Site. Supporting data used in the preparation of this chapter include the Site 07 Phase I and Phase II RI reports (TRC 1991, 1994) and the Site 09 Offshore Investigation Report (EA 1998). Those supporting studies have been previously summarized in Sections 1.2.4 and 2.3.3, respectively.

## 3.2 PHYSIOGRAPHY

NCBC Davisville is located on the Seaboard Lowland coastal belt of the New England physiographic province (Fenneman 1938), and within the Narragansett Basin of metamorphosed sedimentary rocks of Pennsylvanian age. The surface topography near NCBC Davisville (from Quonset Point to a point approximately 5 miles west of Quonset Point) exhibits over 150 ft of relief in a series of north-south trending valleys and ridges (Williams 1964) (Figure 1-1). These valleys were developed by river and stream erosion and deepened by the glacial activity. Surface drainage is not well developed, and swamps and marshes are extensive. Streams are small and, in most places, bordered by swamps.

Nearly all the surficial deposits are of glacial origin deposited during the Wisconsin Glacial Stage. The glacial deposits record a single invasion of the ice sheet and are only slightly modified by post-glacial weathering and erosion (Schafer 1961). The land surface at NCBC Davisville has undergone significant modification; e.g., hills were leveled and depressions filled in as part of the original construction of the Base. The elevation of the ground surface at the Site ranges from about mean sea level along the beaches to about 55 ft above MSL at the bedrock outcrop (Figure 1-3). The site is currently overgrown with a mixture of shrubs, small trees, and grasses.

## 3.3 METEOROLOGY

Meteorological data were obtained from the National Weather Service Station, located at T.F. Green Airport, Warwick, Rhode Island, and the National Climatic Center, Asheville, North Carolina. The airport is approximately 6.5 miles north of NCBC Davisville.

In Rhode Island, the winters are cold and summers are warm. Both seasons are influenced by the moderating effect of the Atlantic Ocean. The ocean effect is shown by the higher winter temperatures and the lower summer temperatures, as compared to inland areas. In the winter,

the average temperature is 30°F and the average daily minimum temperature is 20°F. In the summer, the average temperature is 70°F and the average daily maximum is 80°F.

The average annual precipitation for the area is 45.32 in., as measured for the period of 1951 through 1980. In 1989, total precipitation was 56.06 in. June has been the driest month historically with an average of 2.79 in. of precipitation, whereas December, averaging 4.47 in., has been the wettest. In 1989, the driest month on record was January with 1.17 in. of total precipitation; the wettest month was October with 8.37 in.

Given the coastal proximity of NCBC Davisville, weather patterns are continuously modified by the dynamic effects of the Narragansett Bay and the Atlantic Ocean. The average annual wind speed over the area is 10.6 miles per hour (mph) with a prevailing southwesterly direction.

## 3.4 SURFACE WATER HYDROLOGY

NCBC Davisville lies within the Hunt River and Coastal drainage basins. Camp Fogarty and West Davisville lie within the eastern portion of the Hunt River drainage basin, and NCBC Davisville's Main Center, which includes Site 07, lies within the Coastal drainage basin. All stream and river flow eventually discharges into Narragansett Bay. During most of the year, a part of the stream flow consists of water discharged from retention storage in natural and man-made impoundments. The remaining flow is from direct runoff of precipitation and from base flow runoff consisting largely of ground-water discharge. During 1962 and 1963, the ground water contributed approximately 50 percent of the average annual stream flow (Rosenshein et al. 1968).

## 3.5 SOIL

Soil development at NCBC Davisville generally refers to the first 5 ft of material underlying the ground surface. The majority of Site 07 surface soils are categorized as the Udorthents-Urban land complex with a three- to four-acre area in the vicinity of the rock outcrop categorized as the Canton and Charlton fine sandy loams. In addition, soils along the east and southeast coasts are identified as beaches. The Udorthents-Urban land complex is defined as moderately well drained to excessively drained soils where the original soils have been disturbed by cutting or filling to thicknesses of more than two feet [U.S. Department of Agriculture (USDA) 1981]. These soils formed in loamy glacial till and in gravelly outwash with a loamy mantle. They are on glacial till plains and outwash terraces. Udorthents are extremely acid to medium acid. They are dominantly loamy sand, sandy loam, fine sandy loam, or gravelly analogs and, in places, they are very gravelly sand. Permeability and stability of this unit are variable. Available water capacity and runoff are also variable. (USDA 1981). The Canton and Charlton fine sandy loams identified in the northern portion of Site 07 are defined as gently sloping to sloping, well drained soils located on the side slopes and crests of glacial upland hills and ridges. Stones and boulders cover 2 to 10 percent of the surface, and rock outcrops cover up to 10 percent. The soil typically has 3 to 15 percent

slopes and the permeability varies from moderate to rapid. Available water capacity is moderate and runoff is medium. Canton soils are extremely acid through strongly acid while Charlton soils are very strongly acid through medium acid. (USDA 1981). Beaches located along the eastern and southern coast of Site 07 are nearly level to gently sloping areas along the shore of Narragansett Bay and the entrance channel. This unit consists of sand dunes or escarpments of sandy, gravelly, and cobbly areas that are exposed during low tide. Beaches are typically long and narrow and mostly range from 3 to 50 acres. They are unprotected from the ocean and are subject to severe erosion during storms. Slopes range from 0 to 8 percent (USDA 1981).

## 3.6 GEOLOGY

### 3.6.1 Regional Geology

NCBC Davisville is located within the Narragansett Basin, a complex structural syncline approximately 12 miles wide and up to 12,000 ft deep. The Narragansett Basin's western limit is approximately 3 miles west of NCBC Davisville, and its eastern edge is close to Fall River, Massachusetts. Based upon the bedrock geological maps for the Wickford Quadrangle (Williams 1964) and the East Greenwich Quadrangle (Quinn 1952), there are no mapped faults within at least 2 miles of NCBC Davisville Main Center.

According to Williams (1964) and USDA (1981), the principal bedrock unit in the vicinity of NCBC Davisville is the Pennsylvanian age undifferentiated Rhode Island Formation (Figure 3-1), which consists of a micaceous quartzite having a poorly developed schistosity. The original sedimentary rocks were fine- to coarse-grained sandstone and shale. Throughout the Rhode Island Formation, these sedimentary rocks have been metamorphosed into various types of meta-sandstone (quartzite), phyllite, gneiss, and schist. The amount of metamorphism increases from north to south across the formation. The formation is further characterized by cross-bedding and irregular, discontinuous bedding. The color of the rock varies from light to dark gray, and greenish. In the vicinity of NCBC Davisville, the depth to bedrock ranges from approximately 55 ft above MSL at the rock outcrop at Calf Pasture Point just north of Site 07 to approximately -78 ft MSL at MW07-16D and -30D located along the east coast and northern portion, respectively, of Site 07

The unconsolidated Quaternary sediments overlying bedrock were deposited by glacial activity during the Pleistocene epoch. The final deposition of glacial material occurred during the Wisconsin glacial stage 10,000 to 12,000 years ago. As the glacier front melted and receded, unconsolidated glacial till, glacio-fluvial and glacio-lacustrine sediments were deposited. Till, a dense, non-stratified, heterogeneous mixture of sand, silt, clay, and gravel, was emplaced on top of bedrock as the advancing glaciers scraped, ground, crushed, and then deposited the material passively on the bedrock as ablation till. Till is exposed on highlands such as Lippit Hill, the hillside west of the rifle and pistol range at Camp Fogarty, and along the side of the ridge between West Davisville and the Main Center. End moraines and kame terraces, which are both ridges of sediment deposited at the margin of a glacier, are also present in the region.

The composition of end moraines in this area is very similar to that of the ablation till, so that hydrologically, they act the same.

As streams of melt water flowed from the retreating glaciers, sediment from the melting ice was entrained, transported downstream, and deposited as well-sorted sand or gravel (glacio-fluvial deposits). Fine-grained silt and clay were transported by the streams into glacial lakes, where they settled on the lake bottom (glacio-lacustrine deposits). The thickness of the glacial deposits is quite variable. The deposits are generally thin, often less than 10 ft thick at the higher elevations (nonexistent where bedrock is exposed) and more than 100 ft in thickness in portions of the bedrock valley located approximately 3 miles northwest of Site 07 (Rosenshein et al. 1968).

### 3.6.2 Site Geology

The results of the Phase III field investigation and previous investigations, show that the geology at Site 07 is characterized by anthropogenic fill (dredged material) and Quaternary (Pleistocene) glacial deposits mantling quartzite bedrock of the Pennsylvanian age undifferentiated Rhode Island Formation. Based upon the Phase I, II, III RI and the site-related portions of the Site 09 Offshore Investigation logs of borings, the Site is underlain by five main stratigraphic units (from the ground surface to bedrock): (1) the upper sand unit, a brown to gray sand with varying amounts of silt and gravel and occasional shell fragments, and an occasional layer sand and silt facies encountered by only five borings/well, (2) the silt unit, (3) the lower sand unit, consisting of very fine to medium sand with varying amounts of silt, (4) the till unit, silty gravelly sand to sandy gravelly silt, and (5) quartzite, phyllite and gneissic bedrock. The depth to (in ft bgs) and elevation of the top of the various geologic units at each boring/well is summarized in Table 3-1. Figure 3-2 illustrates the location of geologic cross-sections. Figures 3-3 through 3-9A are geologic cross-sections illustrating the generalized distribution and thickness of subsurface features from selected borings at Site 07. Boring logs for the site are included in Appendices A-7 and D. Based upon the Phase I, II, and III RI and the site-related portions of the Site 09 Offshore Investigation boring/well data, the interpretive geological cross sections show the general lateral extent and thickness of the soil units. Figures 3-3 provides stratigraphic view along the perimeter of Site 07. Figures 3-4 through 3-6 provide northwest to southeast stratigraphic views from MW07-22S/D to MW07-03D, MW07-35D/R to MW07-18D, and MW07-12D to MW07-20S/D, respectively. Figures 3-7 and 3-9 provide north to south stratigraphic views from the bedrock outcrop to MW07-24S/D and MW07-32D/R, respectively. Figure 3-8 provides a northwest to southeast and a west to east stratigraphic view in the vicinity of MW07-05S/D/R. Figure 3-9A extends northwest from Spink Neck (MW07-32D/R) under Allen Harbor to Site 09.

The upper sand unit consists mostly of fine to coarse sand with varying amounts of silt and occasional shell fragments or gravel. The upper sand unit was encountered at thicknesses ranging from 4.5 ft in MW07-23D to approximately 47 ft in MW07-32D/R. The layered sand and silt facies was encountered only at the following five borings/wells: MW07-02, MW07-09,

MW07-24, MW07-31, and SB07-02. This unit appears to extend to the shoreline. Offshore, this interval is represented by organic silt and sand that forms the harbor floor.

The silt unit directly underlies the upper sand unit. As shown on Figure 3-10, the upper surface of the gray silt unit ranges from 3.4 ft (MW07-22S) above mean sea level to ⁻23 ft (mid-harbor boring SB09-16) below mean sea level, with a maximum thickness of approximately 36 ft at MW07-29D . The silt unit is not present in two general areas: in the vicinity of exposed bedrock (just north of the Site) and in the southwestern portion of the Site south to the northern portion of Spink Neck at MW07-19, MW07-21, MW07-26, and MW07-32 where the till unit extends up to within about five feet of ground surface. Northwest from Spink Neck (MW07-32) beneath the harbor, the silt unit is present and varies from approximately 25.5 ft (SB09-17) to 32 ft (SB09-16) in thickness (Figure 3-9A). The lower portion of this unit is sandy silt at MW07-16 and MW07-20. At MW07-31I and SB07-03 (the vicinity of the DANC disposal), nearly all of this unit is sandy silt. At three borings/wells (MW07-16, MW07-18, and MW07-20) in the eastern portion of the Site, this unit is generally a clayey silt.

The lower sand unit is comprised of very fine to fine sand with varying amounts of silt and occasional gravel or medium to coarse sand. The lower sand unit was encountered only beneath the eastern to southeastern portion of the Site (MW07-09, -11, -16, -17, -18, -20, -29, and -30) and directly underlies the gray silt unit in areas where the elevation of the top of the till unit is less than –35 ft MSL. The maximum thickness of this unit was 28.2 ft at MW07-30D.

The till unit underlies the gray silt unit, or lower sand unit when present, and is typically comprised of a silty gravelly sand (Figures 3-3 through 3-9A). However, in some areas the till is a sandy gravelly silt: beneath some northern and western portions of the Site (MW07-14D and SB07-03, MW07-04D and SB07-02, and MW07-10D, -12D, and -26S), and beneath the eastern corner of the Site (MW07-16D, -29D, and -30D). Till was encountered at all of the deep well borings, except MW07-11D. Figure 3-11 shows that the top of the till unit ranges from 11.7 ft (above) MSL at MW07-07S in the north corner of the Site to –66.2 ft (below) MSL at MW07-18D in the southeastern portion of the Site. Additionally, in the southwestern portion of the Site, the till is within approximately 5 ft of ground surface forming a hill with 15-30 ft of relief and is approximately 31 to 36 ft in thickness. The thickness of the till beneath other areas of the Site is often less than 12 ft.

Bedrock is comprised quartzite with varying amounts of fracturing and some zones of phyllite and gneiss. Lengths of core were obtained from the Phase III RI deep (D) wells (5-ft to confirm the presence of competent rock) and from the wells screened in rock. The 5-ft cores related to the deep wells showed multiple fractures, with the exception of MW07-16D which had no apparent open fractures and MW07-04D and MW07-20D which each had only one apparent open fracture. For the cores from the rock wells, those from MW07-05R, MW07-16R, and MW07-25R showed minimal fracturing, while those from MW07-09R and MW07-21R had considerably more fracturing. Bedrock was encountered in the borings at depths

ranging from approximately 16 to 84.5 ft bgs. Bedrock outcrops at the center of Calf Pasture Point, just north of the Site, with the top of the outcrop at an approximate elevation of 57 ft above MSL. In general, the bedrock surface beneath the Site slopes downward from -15 to -25 ft MSL in the western area to a maximum depth of -78.4 ft MSL at MW07-16 and MW07-30 (Figure 2-1). Figure 2-1 further shows that there is an apparent localized valley in the bedrock surface which extends southeast from well cluster MW07-05 which then intersects the east trending valley or general surface slope just south of MW07-09.

## 3.7 HYDROGEOLOGY

### 3.7.1 Regional Hydrogeology

The State of Rhode Island is divided into five drainage basins: the Narragansett Bay Basin, the Pawtucket River Basin, the Rhode Island Coastal Basin, the Thames River Basin, and the Massachusetts Coastal Basin. NCBC Davisville lies within the Narragansett Bay Basin (NBB), the largest and most hydrogeologically significant basin in the state. The NBB covers approximately two-thirds of the state and includes a system of waterways that discharge into the Atlantic Ocean between Point Judith and Sakonnet Point. The NBB includes Narragansett Bay and its entire shoreline, the drainage system of three major rivers (Taunton, Blackstone, and Pawtuxet), and a number of small rivers and streams that drain into Narragansett Bay (USDA 1981). Within each drainage basin, smaller sub-basins may be defined based on significant streams, tributaries, and reservoirs.

Rhode Island's abundant precipitation, numerous perennial streams, lakes, and reservoirs provide a significant surface supply of fresh water for the states' industry and domestic consumption. Additionally, three primary aquifers provide fresh ground water for the state. In 1985, the total freshwater withdrawals in Rhode Island were 147 million gallons per day (MGD). Of this, approximately 69 percent was for domestic and commercial use, twenty-seven percent was for industrial and mining use, and 4 percent was for agricultural use. Eighty-one and a half percent of the fresh water was obtained from surface water sources and the remaining eighteen and a half percent was from ground water. The Scituate Reservoir in Providence County accounts for more than eighty percent of the reservoir storage capacity in Rhode Island. Approximately 76 percent of the State's population receives its drinking water from the Rhode Island reservoir system. Approximately 24 percent obtain potable water from public supply wells (USGS 1989). There are also an unknown number of private residential water supply wells.

### 3.7.2 Regional Surface Water Quality

Annual precipitation in the State of Rhode Island ranges from approximately 42- to 48- in. Approximately one-half of the annual precipitation runs off to streams and lakes of the State. As stated in section 3.7.1, 81.5 percent of the fresh water used in Rhode Island is drawn from surface water sources. The quality of Rhode Island's surface water is affected primarily by

land use and commercial factors such as urban runoff, point-source discharge, and municipal/ industrial wastewater discharge (USGS 1993).

In sparsely populated areas, stream water quality is affected mainly by impurities in precipitation and by constituents released from the soil and rock. Because the bedrock, glacial deposits, and soil in Rhode Island are composed largely of insoluble silica minerals, concentrations of dissolved inorganic constituents are low. Surface water in Rhode Island is soft (hardness less than 60 milligrams per liter (mg/L) of calcium carbonate) and slightly acidic (pH values less than 7).

Allen Harbor is located adjacent and west of Site 07 and Narragansett Bay is adjacent and east of Site 07. There are no streams at Site 07.

### 3.7.3. Regional Ground-Water Quality

Ground water in Rhode Island is present in two types of aquifers: unconsolidated Pleistocene glacial deposits and consolidated Paleozoic bedrock. The ground water within the glacial deposits is divided into two hydrologic units; the stratified drift unit and the till unit. The stratified drift unit consists of interbedded lenses of gravel, sand and silt. The till unit consists of boulders, gravel, sand, silt and clay. Both aquifers constitute important water resources for the state. Most domestic wells in Rhode Island obtain water from the bedrock aquifer (USGS 1988).

The quality of ground water in most of Rhode Island is suitable for human consumption with little or no treatment. Typically, the ground water has total dissolved solids (TDS) concentrations less than 200 mg/L, is soft (hardness less than 60 mg/L of calcium carbonate), is slightly acidic (pH 5.5 to 7.0), and is relatively cold (10° to 12° Celsius). The percentage of the State's land with non-potable ground water is relatively small. Although many areas have measurable degradation of water quality, the amount of degradation has not impaired the water quality for human consumption and other major uses. Because the ground water occurs mostly under unconfined conditions with a depth to water less than 20 ft bgs, the ground water in Rhode Island is often vulnerable to contamination and quality degradation (USGS 1988).

In localized situations, specific effects from waste disposal, agricultural, and urbanization have caused significant water quality degradation. The principal sources for ground-water contamination are waste disposal sites, underground fuel storage tanks, surface impoundments of liquid waste, solid waste landfills, septic systems and cesspools, storage areas for highway deicing salts, and oil and chemical spills. The principal ground-water contaminants derived from these sources are volatile organic compounds (VOC), pesticides, metals, nitrate, sodium and chloride (USGS 1988).

### 3.7.4 Regional Aquifer Characteristics

USGS Water Supply Paper 1779 (Rosenshein 1968) describes the aquifer characteristics of the Potowomut-Wickford area of south-central Rhode Island. That study area comprises approximately 60 square miles from East Greenwich to the southern tip of North Kingstown and west into parts of West Greenwich, Rhode Island. NCBC Davisville is located in the east-central part of the study area. The Potowomut-Wickford area comprises parts of five river basins; however, only three basins display major hydrogeologic significance. The three primary basins include: the Potowomut River Basin, the Annaquatucket River Basin, and the Pettaquamscutt River Basin. All three basins are situated west and/or southwest of NCBC Davisville.

The primary aquifer of the Potowomut-Wickford area is the Potowomut-Wickford Aquifer, producing water primarily from the stratified drift unit. That area of ground-water supply production is located generally within a northeast trending valley in the bedrock surface located about 3 miles west and northwest of Site 07. However, the portion developed for municipal ground-water supply is separated from Site 07 by a ridge in the bedrock surface located approximately 1.3 miles west and northwest of Site 07. The Potowomut-Wickford Aquifer is not present on that ridge.

The transmissivity of the Potowomut-Wickford aquifer ranges from 0- > 40,107 $ft^2$/day. The areas of highest transmissivity are concentrated around the three primary river basins. The transmissivity decreases outward from each river basin toward till and bedrock boundaries.

The saturated thickness of the aquifer controls the amount of drawdown, or hydraulic head, in the aquifer, and in part, controls the volume of water storage available in the aquifer. The saturated thickness of the Potowomut-Wickford aquifer ranges from 20 to 120 ft. As with transmissivity, the areas of largest saturated thickness are near the three primary river basins.

Recharge to the Potowomut-Wickford Aquifer occurs primarily from October through April. Under natural conditions, recharge is effectively equal to the discharge plus the change in subsurface storage. Natural discharge from the aquifer occurs as flow to surface water and movement away from source areas. The aquifer displays an upward hydraulic gradient, as the ground water moves from areas of higher hydraulic head to discharge points in surface streams and ponds. Most of the discharge occurs as a component of stream flow; however, some discharge occurs as subsurface underflow and discharges into Greenwich Bay and the west passage of Narragansett Bay.

### 3.7.5 Site Hydrogeology

#### 3.7.5.1 Hydrogeological Zones

The four Site 07 subsurface soil strata, plus bedrock, have been divided into the following three hydrogeological zones (beginning with the shallowest zone):

### Shallow Ground-Water Zone

The shallow ground-water zone is the saturated portion of the upper sand unit (Section 3.6.2 and Figures 3-2 through 3-9) which is under unconfined conditions, and includes ground-water table data from the shallow (S) wells. The upper sand unit extends south to the north side of the entrance channel and appears to extend into the shoreline areas of the adjacent bay and harbor, but ends abruptly north of Site 07 where bedrock is exposed at ground surface. In the southern portion of the Site in the vicinity of wells MW07-19S/D, MW07-21S/D/R, and MW07-26S, the silt unit is not present and the upper portion of the till unit extends to within approximately 5-8 ft of ground surface. Therefore, in that area, the shallow ground-water zone also includes the upper portion of the till unit. During the Phase II RI, the water table interval was designated as "shallow" ground water; and for consistency, that designation is also used in the Phase III RI.

### Deep Ground-Water Zone

The deep ground-water zone is the lower portion of the silt unit, the lower sand unit (where present) and the till unit which is under confined/semi-confined aquifer conditions; and includes ground-water potentiometric water surface data from the deep (D) wells which have screens set in those units or portions of units (Figures 3-2 through 3-9). The deep ground-water zone appears to extend in all directions from the Site except to the north where it ends abruptly in the vicinity of the hill where bedrock is exposed at ground surface. Additionally, the silt unit is not present at wells MW07-19S/D, MW07-21S/D/R, and MW07-26S in the southern portion of the Site, nor at MW07-32D/R at the north end of Spink Neck. However, the till unit thickens to more than 30 ft and the upper portion of the till unit extends to within approximately 5-8 ft of ground surface. Therefore, in that area, the shallow and deep ground-water zones are not separated by the silt unit, but rather, are the upper and lower portions, respectively, of the till unit. During the Phase II RI, the lower portion of the silt unit, the lower sand unit (where present), and the till unit were designated as "deep" ground water because deep (D) monitoring wells screened one or more portions of these units. For consistency with the Phase II RI and because of the aforementioned Phase II RI deep (D) well screen intervals, the Phase II designation of "deep" ground water must also be used in the Phase III RI. Please note that during the Phase II RI, the thickened portion of the till unit and the related absence of the silt unit in the southern portion of the Site was unknown.

### Bedrock Ground-Water Zone

The bedrock ground-water zone is the upper 25-30 ft of competent (solid, coreable) bedrock which responds like a confined aquifer and includes potentiometric water surface data from rock (R) wells with screens set approximately 15-25 ft below the top of competent bedrock (Section 3.6.2 and Figures 3-2 through 3-9).

### 3.7.5.2 Interpreted Ground-Water Flow Direction

Depth to ground water was measured periodically in the Site 07 monitoring wells during the Phase III RI field work and are summarized in Table 3-2. The following presents the interpreted ground-water flow directions observed on 1 December 1995.

**Shallow Ground-Water Zone**

As shown on Figures 3-12 through 3-14, the ground water is interpreted to flow approximately radially from a the bedrock hill (located just north of the Site) toward the nearest shoreline for each of the three tidal stages.

**Deep Ground-Water Zone**

As shown on Figures 3-15 through 3-17, the ground water is interpreted to flow generally southeast for each of the three tidal stages. This general direction of ground-water flow appears to continue southeast beneath the entrance channel based upon the water surface elevations measured on 2 September 1998 in MW07-23D (0.62 ft MSL at 1129 hrs) and MW07-32D (0.55 ft MSL at 1208 hrs), approximately 1.15 and 1.75 hrs after low tide (1022 hrs at Allen Harbor), respectively.

**Bedrock Ground-Water Zone**

As shown on Figures 3-18 through 3-20, the ground water is interpreted to flow generally southeast for each of the three tidal stages. This general direction of ground-water flow appears to continue southeast beneath the entrance channel based upon the water surface elevations measured on 2 September 1998 in MW07-21R (1.59 ft MSL at 1133 hrs) and MW07-32R (0.35 ft MSL at 1206 hrs), approximately 1.20 and 1.75 hrs after low tide (1022 hrs at Allen Harbor), respectively.

**Evaluation of Impacts From Saline/Salt-Water Wedge**

Prior to performance of the Site 09 Offshore Investigation, the simplistic SUTRA model was used to obtain a rough estimation of the potential effects of salinity and a saline/salt-water wedge on the ground-water flow field and where the ground water from beneath the Site may discharge to the surface water body located adjacent to the Site. SUTRA, developed by the USGS (Voss 1990), is a 2-dimensional, finite-element simulation model which includes fluid density dependent ground-water flow. The model was applied at Site 07 along two cross-sections. The first was oriented in a west to east direction across Site 07 from the vicinity of MW07-14 to Narragansett Bay. This cross-section was a composite using geological cross-section B-B' (Figure 3-4) from well MW07-22 to MW07-03, and then interpolated over to cross-section C-C' (Figure 3-5) at the mid-point between wells MW07-09 and -18. The model cross-section extended 900 ft beyond the shoreline into Narragansett Bay.

The second model cross section (north-south) was oriented along geological cross-section H-H' (Figure 3-9) which extends from MW07-07 through -14, -27, -19, and -21. The second model cross-section extends 750 ft beyond the Allen Harbor shoreline. A direct extension of this distance would place the end of the transect under Spink Neck. However, because of the regional northwest to southeast ground-water flow, the actual streamline is most likely southeast toward Narragansett Bay.

For both modeled cross-sections, a 75 ft horizontal and a 5-ft vertical cell size was used across the site. The horizontal cell size was increased to 150 ft beyond the shoreline. A 7.5-ft vertical cell size was used for several rows near the bottom of the model in the bedrock. These cell sizes were a sub-division of the 15 × 150 ft background grid on the geological cross-sections. This facilitated assigning geological properties to each model cell.
For the Site 07 model, ground-water density is a function of salinity. When modeling a density dependent solute, the hydrostatic pressure, and thus the flow-field, varies in time along with the density (salinity) in the water column above the point of interest. Thus, for the examination of salinity at Site 07, SUTRA must be executed in a transient mode for both ground-water flow and solute transport.

For both model cross-sections, a constant pressure boundary was applied at the left (upland) side of the model, and a zero pressure boundary (mean sea level) on the layer one cells extending beyond the shoreline. A zero salinity was assigned to flow through the upland boundary, and a salinity of 30 ppt was assigned to any flow entering the model through the ocean boundary. For model cross-section 1 (west-east) the ground-water heads at the upland boundary varied from 6.6 ft at the surface to 5.0 ft in the bedrock. The hydrostatic boundary pressures for the model input file were calculated using the above pressure equation to represent both the natural hydrostatic pressure and the static head. Recharge was applied at the model surface at a rate of 16.1 in/year. This was the annual average recharge rate calculated for Site 09 based on historical meteorological data. A hydraulic conductivity in the vertical direction was decreased by a factor of ten from the horizontal values provided in the above table.

**Model Results**

The model parameterization as presented above has not been further calibrated to more closely represent site conditions because of the relatively simplistic nature of the model compared to the more complex nature of the actual conditions beneath the Site.

The SUTRA model was first executed with an initialized zero salinity throughout the model domain. This exercise was performed to see if a salinity wedge would naturally develop by pulling high saline water through the ocean boundary. A cell-by-cell initial pressure distribution corresponding to the zero salinity condition, was created by executing a steady state SUTRA run.

The resulting flow field reflects the 5/6-ft ground-water head at the upland boundary flowing towards a 0-ft ocean boundary. Under Narragansett Bay, the vertical static heads increase from 0 ft at the surface to approximately 0.6 ft at a 90-ft depth, bottom of model in bedrock. This natural flow field directed towards Narragansett Bay prevents the inflow of higher saline ocean water during a transient run using the zero salinity and corresponding pressure initial conditions.

For the next set of model runs, a salinity wedge was directly input as an initial condition based upon Site observations. For this initial salinity condition, a steady state ground-water flow scenario was executed to obtain the corresponding hydrostatic pressure field. These initial salinities and hydrostatic pressures were then used to initialize a transient simulation for one year. An examination of these results indicates that after 1 year, the modeled west to east ground-water flow had pushed the initial salinity wedge back toward Narragansett Bay. This shows that the model was not able to fully simulate the actual subsurface conditions.

Based upon the ground-water sample results, in the approximate vicinity of MW07-27D, the deep CVOC plume appears to split, one branch continuing down into bedrock and the other extending upward through MW07-19S and MW07-21S perhaps related to ground-water flow up over the salt water wedge. The SUTRA model particle tracking was not able to reproduce this subsurface condition. Because of the relatively simplistic nature of the model and the relatively complex nature of the Site subsurface conditions, this modeling activity was ended and will not be considered further. It is not recommended for use in predicting future site conditions. Additional site-specific salinity data were collected during part of the Site 09 Offshore Investigation and the results are included in Section 4.6.1.4 Salinity.

### 3.7.5.3 Vertical Gradients

The vertical head differences and gradients are summarized in Table 3-3 for each of the shallow (S)/deep (D) and deep (D)/rock(R) well pairs. Very slightly upward to no vertical gradient has been generally recorded for well pair MW07-21S/D which is located along the southeastern shoreline of the Site (Figure 1-2). Generally, upward vertical gradients have been recorded for only well pair MW07-22S/D, which is an upgradient well located in the northwestern portion of the Site. Variable (up and downward) vertical gradients have been recorded for well pair MW07-24S/D located in the southern corner of the Site. Generally downward vertical gradients have been recorded for the remaining shallow/deep well pairs MW07-03S/D, MW07-04S/D, MW07-05S/D, MW07-10S/D, MW07-13S/D, MW07-19S/D, MW07-20S/D, and MW07-23S/D which are located throughout the Site.

For the five deep(D)/rock(R) well pairs installed onsite during the Phase III RI, slightly downward vertical gradients were present at MW07-05D/R and MW07-25D/R which are located in the central and western portions of the Site, respectively (Table 3-3 and Figure 1-2). For the remaining three onsite D/R well pairs, slightly upward vertical gradients were present at MW07-09D/R, MW07-16D/R, and MW07-21D/R which are located in the central, eastern, and southern portions of the Site, respectively. Based upon the water surface elevations

measured on 2 September 1998 in MW07-32D/R (0.55 ft MSL and 0.35 ft MSL, respectively) approximately 1.75 hrs after low tide (1022 hrs at Allen Harbor), there is a slight downward vertical gradient on the northern portion of Spink Neck.

#### 3.7.5.4 Hydraulic Testing

Slug tests were performed in 33 of the Phase III wells that are screened in various soil units and bedrock, and the data were used to calculate estimated hydraulic conductivities for the material screened by each well. Tables 3-4 and 3-5 summarize the Phase II (TRC 1994) and Phase III results, respectively, along with a summary of the geologic unit, or portions of units, screened by each well. The slug test data are provided in Appendix F.

Packer tests were performed in the bedrock borehole prior to installation of each of the five onsite monitoring wells that were screened in the bedrock. As noted previously in Chapter 2, packer (water pressure) tests were performed to estimate the effective hydraulic conductivity of the upper 15-25 ft of bedrock. The packer test forms and calculations for hydraulic conductivity (K) are provided in Appendix G. Table 3-6 lists the hydraulic conductivity values for the packer tests performed in the boreholes of wells MW07-21R and MW07-25R, which of the five Phase III RI wells installed in bedrock were the only two boreholes into which water could be pumped during the tests. The hydraulic conductivity values calculated from the packer tests are within approximately one order of magnitude of the K values calculated from the slug test data.

### 3.7.6 Ground-Water/Tidal Monitoring

#### 3.7.6.1 Background

A ground-water level and tidal monitoring program was performed to obtain data with which to estimate the hydraulic conductivity of the lower part of the silt unit, the lower sand unit (where present), the till unit, and the upper 25-30 ft of the bedrock unit (in addition to the slug tests, packer tests, and the geologic logs of the Phase III RI wells) and to provide continuous water-level measurements during the tidal cycles for at least a 48-hour period. Gregg (1966) used ground-water levels of a confined aquifer influenced by sea tides to compute the tidal efficiency of wells and the storage of the aquifer. Carr and Van Der Kamp (1969), in a similar study, used ground-water levels of a confined aquifer and tidal fluctuations to calculate the hydraulic conductivity and specific storage of the aquifer. For the Phase III RI, the ground-water level and tidal monitoring program provided information on the hydraulic characteristics of the aforementioned four geological units in addition to water-level data.

The ground-water/tidal level monitoring program included three wells screened in the upper sand unit (MW07-05S, MW07-06S, and MW07-20S); one well screened in the silt unit (MW07-05D); one well screen in the silt and till units (MW07-09D); eight wells screened in the till and/or lower sand units (MW07-16D, MW07-20D, MW07-21S, MW07-21D, MW07-25D, MW07-26S, MW07-27D, and MW07-28D); and five wells screened in the upper portion of bedrock (MW07-05R, MW07-09R, MW07-16R, MW07-21R, and MW07-25R) that

were equipped with pressure transducers. Water-level changes were recorded every 5 minutes using *In-Situ, Inc,* Hermit data loggers for approximately 72 hours beginning during 16 January 1996. Measurements are presented as hydrographs in Appendix J1.

In addition to the 18 monitoring wells in the ground-water/tidal monitoring program, all the wells were measured five times (over periods of approximately 0.75 to 1.5 hours) with portable electronic water-level indicators during 16 to 17 January 1996. These ground-water measurements are presented in Table 3-2. The purpose for measuring the water levels in all the monitoring wells over a short time period was to provide water levels that are representative of approximately the same time period. On 17 January 1996, water levels in all the wells were measured during three segments; low tide, mid tide, and high tide of one tidal cycle.

One tidal gauge (Endeco Model 1029-SSM) was installed at a dock located west and across Allen Harbor from Site 07. The depth of water above the tidal gauge and the water temperature were recorded every 5 minutes for about 8 days from 12 to 19 January 1996. The tidal gauge measurements are presented as a hydrograph (time vs. water level) in Appendix J1.

Barometric measurements were obtained from the National Weather Service at the T. F. Green Airport in Warwick, Rhode Island. Hourly barometric measurements were provided for 5 days from 15 to 19 January 1996. A table of the barometric measurements is included in Appendix J1.

### 3.7.6.2 Tidal Efficiencies of Different Units

The following briefly summarizes the relation of unconfined and confined aquifer conditions to the overall flow of ground water. The treatment of the deep and bedrock ground-water zones as confined aquifers impacts their storage capabilities and their hydraulic gradients. The movement of ground water and solutes dissolved in the ground water is dependent upon the linear velocities within each layer. The linear velocities are dependent upon the aquifer's K, hydraulic gradient, and effective porosity. Therefore, the main difference between ground-water movement in an unconfined and confined aquifer will be the hydraulic gradient. In an unconfined aquifer, the hydraulic gradient is based upon the water level changes over a given distance. However, in a confined aquifer, the hydraulic gradients are based upon hydrostatic pressures, or hydraulic heads, at two points that are separated by a linear distance. Which gradient is larger depends upon the relief along the water table and upon the hydrostatic pressures in the confined aquifers. For the Phase III RI, the hydrostatic pressure relates to tidal efficiencies; that is, larger tidal efficiencies means larger hydrostatic pressures. The tidal efficiency of various units is presented below. The bedrock ground-water zone was treated as a confined aquifer. Ground-water flow within the bedrock was assumed to approximate porous media flow; however, the flow is more accurately described as flow along preferred directions, i.e., along fractures through the bedrock.

The ground-water levels and tidal fluctuations monitoring data for monitoring wells screened in the lower part of the silt unit, the lower sand unit (where present), the till unit, and the upper 25-30 ft of the bedrock unit can be used to compute the tidal efficiency (TE). TE is defined as the amount of water-level change induced upon a monitoring well in a confined aquifer due to tidal influences, divided by the amount of change in the tidal level of Allen Harbor or Narragansett Bay during any given tidal cycle. For this study, a tidal cycle of 740 minutes, from 10:20 p.m. 17 January 1996 to 12:22 p.m. 18 January 1996. The TE procedure is applied to hydraulic materials that respond like confined aquifers. The TE response for most shallow (S) wells screened in the upper sand unit was very poor as expected. Well MW07-06S did not have an interpretable tidal influence; Well MW07-05S had a negative TE, and Well MW07-21S had TE greater than 1.0. Therefore, data for these wells were not completely evaluated.

The apparent tidal efficiency ($TE_{APP}$) for each deep (D) monitoring well was calculated from peaks on the water-level hydrographs and the tidal fluctuations graph. Corrections were made for barometric pressure and density of sea water versus fresh water.

The true tidal efficiency ($TE_{TRUE}$) for each deep (D) monitoring well was calculated from the $TE_{APP}$ by adjusting the values for the time lag that occurs in the water-level peaks compared to the tidal peaks. Table 3-7 lists the $TE_{TRUE}$ and $TE_{APP}$ values for all of the wells monitored during this study, except for MW07-06S. $TE_{TRUE}$ values should be larger than $TE_{APP}$, which is predictable because the $TE_{TRUE}$ includes correction for the time lag.

### 3.7.6.3 Hydraulic Conductivity and Storage

Hydraulic conductivity and storage (where appropriate) of the geological units were calculated from the water-level data and the tidal fluctuations in Allen Harbor and Narragansett Bay. Table 3-8 lists the results of these calculations for 15 monitoring wells. An example of these calculations for monitoring well MW07-16D is included in Appendix J1.

### 3.7.6.4 Tidal Impacts on Ground-Water Movement

The impact of tidal cycles on ground-water flow within the various soil units and bedrock beneath Site 07 have been evaluated. The tide cycles will have their greatest impact on ground-water flow in the upper sand unit (shallow ground-water zone) because the harbor and bay are adjacent to this unit. However, the results presented below show that the tidal impact on ground-water flow in this unit is minor. The lower part of the silt, the till, and bedrock units, which do not have direct horizontal flow contact with the bay or harbor at Site 07, are impacted even less than the shallow ground-water zone. Both downward and upward vertical gradients are observed at several of the Site 07 monitoring well pairs (Table 3-3). The estimated vertical permeability is substantially less than the horizontal permeability resulting in only a very small vertically downward or upward ground-water flow component between upper and lower units.

Changing tide levels will affect the ground-water levels and ground-water flow in the shallow zone (upper sand unit) at the shoreline with the harbor and bay. Ground water and harbor/bay water will mix in this unit in the immediate area near the shoreline. The distance inland from the shoreline that this mixing occurs is limited. The high and low tide ground-water levels (Table 3-2) in the monitoring wells adjacent to the shoreline support the limited extent of this water movement.

Physical parameters like the distance from the shoreline and the hydraulic conductivity of the materials in the upper sand unit between a well and the shoreline will affect the ground-water levels. However, other factors also impact the water levels. For example, when the well was measured during the tide cycle and the TE of each well site, will affect water levels. The TE of the upper sand unit is usually low because this layer is unconfined.

### 3.7.7 Hydraulic Conductivity and Specific Yield/Storage

The hydraulic conductivity (K) of the geological units was determined by using four methods; the slug tests, packer tests for the rock wells, the ground-water level and tidal monitoring procedures, and computations using the geological logs of the monitoring well. Where appropriate, these latter two methods were used to compute the storage (S) and specific yield (Sy) of the different units.

The fourth method for obtaining K and Sy values is based upon the procedure for computing the hydraulic conductivity and specific yield of the aquifer that is based upon the geologic description of the soil materials. This procedure is applicable only to unconsolidated materials. Another limitation of this procedure is that the storage of a confined aquifer can not be computed. Hydraulic conductivity and specific yield values can be assigned to the different soil units based on their geological descriptions. The thickness of each soil unit is multiplied by K and Sy value. The average K and Sy values for each log are computed using the following equation:

$$K_{AV} = \frac{\sum_{i=1}^{i=n} (K_i \times TH)}{TOTTH}$$

where

| | | |
|---|---|---|
| $K_{AV}$ | = | Average hydraulic conductivity or average specific yield ($Sy_{av}$), |
| $K_i$ | = | Hydraulic conductivity or specific yield ($Sy_i$) of each soil unit, |
| TH | = | Thickness of soil unit, |
| TOTTH | = | Total thickness of soil units, and |
| n | = | Number of different soil units in the log. |

This procedure has been used to develop the K and Sy values for several ground-water models in the Great Plains. It is based on Reed and Piskin's table of hydraulic conductivity values and Johnson's specific yield values (Peckenpaugh et al. 1987). Table 3-9 lists the K and Sy values for different soil materials as estimated by the fourth method.

Table 3-10 presents a comparison of the calculated hydraulic conductivity (K) and storage/specific yield (S or Sy) values for the various geological units as estimated from the four methods. Each well site may include more than one well (e.g., shallow, deep, and/or rock) and may have from two to four calculated values for a geological unit depending upon the type of field data available. In addition, there is a selected (SEL) K, S, or Sy value where appropriate for the geological units at each well site. The method or methods that have the most influence on the selected K, S, and Sy values at each well site will vary depending upon the assumed quality of data. Some of the well sites have similar values while others are very different. One problem with the ground-water level and tidal monitoring data technique is the uncertainty of what to use as the horizontal distance from the monitoring well to the surface water in Allen Harbor or Narragansett Bay. This is a problem when there are two directions to surface water. Also, the distance to the surface water was based upon the distance to Allen Harbor or Narragansett Bay where the water depth was 8-10 ft.

# 4. NATURE AND EXTENT

## 4.1 INTRODUCTION

This chapter presents the nature and extent of compounds and analytes detected in subsurface soil and ground water at Site 07, offshore beneath Allen Harbor, and beneath the northern portion of Spink Neck. Section 4.2 presents the possible sources for constituents detected at Site 07. Sections 4.3 and 4.4 have background information on the ground-water supply wells and water quality near Site 07. A discussion on the results of the analyses of subsurface soil samples is presented in Section 4.5. Section 4.6 reviews the results of laboratory analysis of ground-water samples collected from monitoring wells and surface water samples collected from Allen Harbor and Narragansett Bay during the Phase III RI and the Site 07 related results from the Site 09 Offshore Investigation. Based upon the findings of Chapters 3 and 4, Section 4.7 presents the site conceptual model.

## 4.2 REPORTED POTENTIAL SOURCES

Calf Pasture Point was reportedly the site of three distinct disposal incidents. The following summary of these incidents is from Hart (1984). These incidents reportedly involved disposal of 20 five-gal cans of calcium hypochlorite, thirty to forty 35-gal containers of an unidentified chloride compound and approximately 2,500 three-gal cans containing Decontaminating Agent Non-Corrosive (DANC) solution. DANC is a reactive, chlorinated compound. The following is a summary of the historic disposal events:

> Between 1960 and 1974, approximately 20 five-gal cans (100 gals) of calcium hypochlorite (bleach) were disposed in a drainage ditch alongside Bunker 60 at Calf Pasture Point. Between 1978 and 1982, metal cans containing calcium hypochlorite were removed from this site for offsite disposal. This is the only documented remedial activity known to have occurred at the site. Calcium hypochlorite $Ca(OCl)_2$ is a water-soluble solid which degrades rapidly in water. The commercial product usually contains 50 percent or more of $Ca(OCl)_2$. It could not be determined if all of the calcium hypochlorite disposed in this area was removed, and the ultimate location of offsite disposal was not identified.
>
> In 1973, thirty to forty 35-gal cardboard containers of an unidentified chloride compound were stored at Calf Pasture Point. This material reportedly originated from the utilities school, where it was used for water treatment purposes. These containers became very deteriorated over time and were reportedly buried at the site. Although the chloride compound was not identified, it may have been ferric chloride, a black-brown, corrosive solid which is readily soluble in water. It is expected that most chlorides would leach from the cardboard containers during the period of their burial at the site.

At some time between 1968 and 1974, a trench measuring approximately 10 × 20 × 15 ft was filled with 3-gal cans which contained DANC solution. This would be approximately 2,500 cans (Hart 1984). The cans were reportedly buried at an undetermined location at Calf Pasture Point. DANC consisted of two separate chemicals that were mixed to form the decontaminating solution: 1,3-dichloro-5,5-dimethyl-hydantoin, a crystal; and 1,1,2,2-tetrachloroethane (acetylene tetrachloride) (perchloroethane) (1,1,2,2-PCA), a heavy colorless liquid. 1,3-dichloro-5,5-dimethyl-hydantoin and hydantoin products are oxidizing agents and readily break down to release chlorine when contacted by water. The DANC was apparently used during Defense Disaster Preparedness Training activities during which biological and nuclear warfare attacks were simulated.

## 4.3 WATER SUPPLY WELLS

No municipal or private wells were sampled during Phase III activities. Table 4-1A lists the location of private-use ground-water supply wells near the Site. These reported wells are located hydraulically upgradient of the Site. The closest private well is reportedly located on Coolidge Avenue at a distance of more than 2,000 ft north to northwest of Site 07. The nearest municipal supply well is near the intersection of Frenchtown Road and US Route 1 more than 3 miles northwest of Site 07 (GZA 1992).

## 4.4 BACKGROUND RESULTS

Background concentrations for inorganic analytes in ground water at NCBC Davisville have been established (Table 4-1B).

## 4.5 SUBSURFACE SOIL

This section presents the results of laboratory analysis of subsurface soil samples collected at Site 07 during the CS, and Phase I, II, and III RIs.

### 4.5.1 Confirmation Study (CS)

During the CS, VOC were not detected in subsurface soil samples. However, low concentration of metals were detected.

### 4.5.2 Phase I RI

Two subsurface soil samples were collected and analyzed during the Phase I RI. These samples were collected during the drilling for MW07-03D and MW07-04S. VOC and pesticides/PCB were not detected in the samples. One SVOC, bis(2-ethylhexyl)phthalate, was detected at an estimated concentration of 220 $\mu$g/kg in the 2-4 ft bgs sample from MW07-04S.

### 4.5.3 Phase II RI

During the Phase II RI, 1,1,1,-TCA was detected in the soil sample obtained from MW07-07S well boring at a depth of 10-12 ft bgs (3 $\mu$g/kg) and from well boring MW07-08S at a depth of 4-6 ft bgs (2 $\mu$g/kg). Acetone, detected at low concentrations, was attributed to laboratory contamination. The Phase II RI also included a background surface soil investigation of 18 samples collected across NCBC Davisville and analyzed for TCL and TAL.

Eight subsurface soil samples were collected and analyzed for TAL. Seven analytes, including calcium, chromium, cobalt, iron, magnesium, nickel and potassium, were detected above NCBC background concentrations. The highest concentration of metals was detected in a sample from well boring MW07-07S at a depth of 10-12 ft bgs. MW07-07S is located in the northern portion of the site.

SVOC and Pesticides/PCB were not analyzed for during the Phase II RI.

### 4.5.4 Phase III RI, Offshore Investigation, and Interior Wetland Sampling

**Phase III RI**

During Phase III RI field activities, 77 subsurface soil samples, including seven duplicate samples, were collected from Site 07 between July and November 1995. These samples were analyzed for TCL VOC and were collected from either the borings for Phase III RI monitoring wells or one of the three borings (SB07-01, SB07-02, and SB07-03) in which no well was installed. The analytical results for subsurface soil samples are summarized in Table 4-2. Of the 77 soil samples collected, CVOC were detected in 56 of the samples. The highest concentration of total VOC was in the sample collected from the borehole for MW07-05R at a depth of 39-41 ft bgs. In this sample, 1,1,2,2-PCA and TCE were detected at concentrations of 28,000 $\mu$g/kg and 24,000 $\mu$g/kg, respectively. Figures 4-1 through 4-3 present in plan view, the distribution of the VOC detected in the Phase III RI soil samples collected from upper sand unit, the silt unit, and the combined lower sand and till unit, respectively. Figures 4-4 through 4-10 present a summary in cross-section, of total CVOC detected in the soil samples. The analytical lab reports for the subsurface soil samples are maintained in the project file at EA's Bedford, Massachusetts office.

**Offshore Investigation**

During the Site 09 Offshore Geotechnical Sampling and Confirmation Study (Fall 1997), 22 soil samples, including one duplicate, were collected from mid-harbor borings SB09-16 and SB09-17, and Spink Neck monitoring wells MW07-32D/R. The locations are shown on Figure 1-2. These data are included in Tables 4-2, 4-3, 4-4, and 4-5.

CVOC were not detected in soil samples collected from SB09-16, SB09-17, and MW07-32D/R. The VOC which were detected in these samples included methylene chloride at

concentrations ranging from 4 μg/kg (SB09-17, 13-15 ft bg) to 14 μg/kg (MW07-32R, 24-26 ft bg) and acetone at concentrations ranging from 21 μg/kg (SB09-17,55-57 ft bg) to 86 μg/kg (MW07-32R, 22-24 ft bg). These two compounds may be lab contaminants.

**Interior Wetland Sampling**

During the EPA's interior wetland sediment sampling activity (4 December 1997), eight shallow sediment samples (0-6 in. below grade) and two deep sediment samples (18-24 in. below grade) were collected from eight locations near monitoring wells MW07-13 and MW07-19 (Figure 1-2A). EPA analyzed the ten samples by VOC Method 5035, Low Concentration for Soils, and the extracts were analyzed by SW-846, Method 8260B, SW-846, Rev 0. Two split samples collected by EA (SD2MW19, SD8SMW13) were analyzed for VOC (Method 8260) and metals (Method SW-846/6010). VOC were not detected in the split samples analyzed by EA (Table 4-2A). For samples analyzed by EPA, trace concentrations of VOC were detected in all wetlands sediment samples. PCE was detected in two samples at 1 μg/kg (SD2MW19, SD2DMW19). Methylene Chloride was detected in six samples ranging in concentration from 1 μg/kg (SD2SMW19, SD8DMW13, DUP-SD 8DMW13) to 9.4 μg/kg (SD3MW19). Trichlorofluoromethene was detected in three samples at trace concentrations ranging from 1 μg/kg (SD6MW13) to 4.1 μg/kg (SD3MW19). Most of the analytes detected in the EPA-analyzed samples were qualified with an L (estimated value is below calibration range) or a B (analyte is associated with lab blank).

In addition to traditional laboratory analysis discussed above, wetland sediment samples underwent a field screening analysis by EPA utilizing a modified tipless syringe. Results of this screening indicated that two VOC were detected at trace concentrations in five of the samples. Trichlorofluoromethane was detected at concentrations ranging from 1 μg/kg (SD6MW13) to 4 μg/kg (SD3MW19). PCE was detected in two samples at a concentration of 1 μg/kg (SD2MW19, shallow and deep).

### 4.5.4.1 Quality Control Summary

Validation of the 1995-96 and 1997-98 analytical data has been completed (Section 2.9). The data validation reports are presented in Appendix K.

Duplicate field samples were collected to monitor field precision. Seven soil samples were collected in duplicate in 1995. The duplicate samples were collected from SB07-03 (10-12 ft bgs), MW07-05R (29-31 ft bgs), MW07-19S (16-18 ft bgs), MW07-20S (4-6 ft bgs), MW07-22S (10-12 ft), MW07-24D (54-56 ft bgs), and MW07-30D (49-51 ft bgs). If acetone is not considered (Section 4.5.2.6), then acceptable field precision of less than 50 percent difference was observed for all the samples collected except MW07-05S (29-31 ft bgs), MW07-05R (29-31 ft bgs; for TCE), and MW07-19S (16-18 ft bgs; for TCE). The precision results are likely reflective of soil heterogeneity, because the samples collected for VOC analysis were not mixed prior to placing in individual sample containers. Duplicate samples were collected from as similar material as possible as the related sample from within the split-barrel sampler.

Twenty-two soil samples collected from SB09-16, SB09-17, and MW07-32D/R and analyzed in 1997 as part of the Offshore Study. Of the 22 samples collected, one was a duplicate sample (SB09-17A, 17-19 ft bg) for which the organic analytes were not detected in either sample. The inorganic results for the two samples were very similar, showing reproducibility of the data.

The field QC blanks consisted of two field rinsate blanks and two trip blanks. One of the two field rinsate blanks contained acetone (15 $\mu$g/L). There was no detectable VOC reported in the trip blanks.

Forty-three method blanks were analyzed by CEIMIC in association with analyses of the subsurface soil samples. Nine compounds were detected in one or more of these blank samples as follows. Methylene chloride was detected in all but five blanks, ranging in concentration from 2 to 2,600 $\mu$g/L. Acetone was detected in 15 of the blanks, ranging in concentration from 4 to 1,200 $\mu$g/L. 2-Butanone was detected in three of the blanks at 1,200, 2,600 and 800 $\mu$g/L. 2-Hexanone was detected in three blanks, two with a concentration of 1 $\mu$g/L and the third at 310 $\mu$g/L. Bromomethane was detected in 11 blanks, ranging in concentration from 1 $\mu$g/L to 780 $\mu$g/L. Chloromethane was detected in five blanks, ranging in concentration from 130 to 470 $\mu$g/L. Benzene was detected in only one blank and at a concentration of 1 $\mu$g/L. 4-Methyl-2-Pentanone was detected in two blanks, both at 2 $\mu$g/L. Chlorobenzene was detected in one blank and at a concentration of 20 $\mu$g/L.

#### 4.5.4.2 VOC in Subsurface Soil

Of the TCL VOC detected in soil samples, the CVOC are the most prevalent. 1,1,2,2-PCA and TCE are the two most common VOC detected in the soil samples. Other CVOC detected in the soil samples include PCE, 1,2-DCE, 1,1,2-TCA, chloroform, vinyl chloride, and chlorobenzene. CVOC were not detected in the offshore soil samples collected in 1997 from SB09-16, SB09-17, and MW07-32D/R. The following is a summary of the ranges of these VOC detected in all of the geological units:

- 1,1,2,2-PCA was detected in 30 samples and ranged from 7$\mu$g/kg (MW07-23, 18-20 ft bgs) to 38,000 $\mu$g/kg (MW07-14, 12-14 ft bgs).

- TCE was detected in 33 samples and ranged from 3 $\mu$g/kg (MW07-23, 18-20 ft bgs and MW07-26, 18-18 ft bgs) to 26,000 $\mu$g/kg (MW07-05, 44-46 ft bgs).

- Tetrachloroethene (perchloroethene, PCE) was detected in 12 samples and ranged from 2 $\mu$g/kg (MW07-05, 29-31 ft bgs) to 680 $\mu$g/kg (SB07-01, 43-44.5 ft bgs).

- 1,2-DCE was detected in 14 samples and ranged from 5 $\mu$g/kg (MW07-19, 12-14 ft bgs) to 590 $\mu$g/kg, 48-50 ft bgs).

- 1,1,2-TCA was detected in 10 samples and ranged from 2 $\mu$g/kg (MW07-26, 16-18 ft bgs) to 400 $\mu$g/kg (MW07-05, 44-46 ft bgs).

- Chloroform was detected in two samples and ranged from 2 $\mu$g/kg (MW07-27, 18-20 ft bgs) to 6 $\mu$g/kg (MW07-31, 24-25 ft bgs).

- Vinyl chloride was detected in two samples, both at 2 $\mu$g/kg (MW07-09, 48-50 ft bgs and MW07-17, 14-16 ft bgs).

- Chlorobenzene was detected in one sample at a concentration of 1 $\mu$g/kg (MW07-28, 44-45 ft bgs).

**Upper Sand Unit**

Figure 4-1 shows the lateral distribution of VOC reported in the 21 soil samples from the upper sand unit. No petroleum VOC were detected in the samples from this unit. Figures 4-4 through 4-10 present the vertical distribution of total CVOC reported in samples collected from various depth intervals. CVOC were detected in four of the 21 sampled intervals, primarily located in the northern portion of the Site (MW07-04, MW07-14, MW07-17, and MW07-31) (Figure 4-1). The highest concentration of total CVOC (39,510 $\mu$g/kg) was detected in the 12-14 ft bgs sample from MW07-14 (Figures 4-1, 4-4, 4-8, and 4-10). This sample was collected from the bottom of the upper sand unit and the top of the silt unit in the vicinity of the former apparent DANC disposal area. Three CVOC were detected (1,1,2,2-PCA at 38,000 $\mu$g/kg, TCE at 1,200 $\mu$g/kg, and tetrachloroethene (PCE) at 310 $\mu$g/kg). Total CVOC was detected at only 33 $\mu$g/kg, 14 $\mu$g/kg, and 2 $\mu$g/kg in samples from MW07-31, MW07-04, and MW07-17, respectively, located southwest and south of MW07-14 in the northern portion of the Site. CVOC were not detected in samples collected from this unit in the western, southern and eastern portions of the Site (Figure 4-1).

**Silt Unit**

Figure 4-2 shows the lateral distribution of VOC reported in the 14 soil samples collected from the silt unit. The only petroleum VOC detected in the samples from this unit was toluene at 3 $\mu$g/kg in the sample from MW07-15 (18-20 ft bgs). Figures 4-4 through 4-10 present the vertical distribution of total CVOC in soil samples collected from various depth intervals. CVOC were detected in ten of the 14 samples, primarily located in the northern portion of the Site (Figure 4-2). The higher concentrations of total CVOC were detected in the four samples collected from the lower approximately 5 ft or less of the silt unit. The concentration of total CVOC detected in these four samples is: 52,000 $\mu$g/kg for MW07-05 (39-41 ft bgs); 34,000 $\mu$g/kg for MW07-04 (29-31 ft bgs); 25,700 $\mu$g/kg for SB07-02 (28-30 ft bgs); and 16,390 $\mu$g/kg for MW07-14 (22-24 ft bgs). Except for the sample from MW07-14 (23-24 ft bgs, where 1,1,2-TCA was also detected), 1,1,2,2-PCA and TCE were the only VOC detected in these four samples. MW07-14 is located within the apparent vicinity of the former DANC disposal area, while MW07-04, MW07-05, and SB07-02 are located approximately 200 ft

southwest of MW07-14. Additionally, 5,155 μg/kg of total CVOC (5,000 μg/kg of which is 1,1,2,2-PCA) was detected in the sandy silt facies of this unit which is also located within the apparent vicinity of the former DANC disposal area. CVOC were not detected in samples collected from this unit in the northwestern (MW07-22), northeastern (MW07-28), and southern (MW07-18 and MW07-20) portions of the Site (Figure 4-2).

**Lower Sand and Till Units**

Figure 4-3 shows the lateral distribution of VOC reported in the 35 samples collected from the lower sand and till units. Methylene chloride has not been included on Figure 4-3 because it is believed to have been introduced by the laboratory. The only petroleum VOC detected in these samples was toluene at 1 μg/kg (MW07-19, 16-18 ft bgs) and 2 μg/kg (MW07-21, 37-39 ft bgs). Figures 4-4 through 4-10 present the vertical distribution of total CVOC in the soil samples collected from various depth intervals. CVOC were detected in 22 of the 35 samples collected (Figure 4-3). These 22 samples are generally located in an area that extends from the area of highest total CVOC concentrations (the MW07-05 and MW07-31 area) southwest to MW07-21 and MW07-23. The higher concentrations of total CVOC were detected in four samples that are located within the apparent former DANC disposal area (MW07-31), and approximately 125 to 250 ft south (MW07-05, SB07-01, and MW07-17). The concentration of total CVOC detected in these four samples is: 48,400 μg/kg for MW07-05 (44-46 ft bgs); 21,259 μg/kg for MW07-31 (24-25 ft bgs); 13,880 μg/kg for SB07-01 (43-44.5 ft bgs); and 12,960 μg/kg for MW07-17 (44-46 ft bgs). 1,1,2,2-PCA and TCE are main CVOC detected in these four samples. CVOC were not detected in samples collected from the lower sand and till units in the northwestern (MW07-22) and eastern to southern (MW07-16, -18, -20, -24, -29, and -30) portions of the Site (Figure 4-3).

### 4.5.4.3 Acetone Reported in Phase III RI Subsurface Soil Samples

The acetone detected in the Phase III RI subsurface soil samples does not appear to be representative of subsurface conditions at the Site, but appears, in part, to have been introduced by the analytical laboratory, and in large part, introduced in the field during sample collection.

Field personnel followed the field work plan during soil sample collection, including the use of isopropanol as part of the decontamination process of the stainless steel split-barrel soil samplers between the collection of each sampled soil interval. It is believed that the presence of acetone in the soil samples is due to incomplete drying of the split-barrel sampler prior to collecting the next soil sample, resulting in the introduction of the decontamination fluid isopropanol to the sample. A sample of isopropanol (designated ISO1) was sent for laboratory analysis of TCL VOC. The result of that analysis showed the presence of an impurity, acetone at 42,000 μg/L. Other ketone compounds may also be present as impurities in the isopropanol; however, because of sample dilution for the analysis, the detection limit is 10,000 μg/L. The results for acetone range from 6-12,000 μg/kg in the following samples (in μg/kg):

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MW07-26S (16-18 ft) **12,000** | MW07-09R (14-16 ft) **7,100** | MW07-13S (4-6 ft) **5,500** | MW07-13S (8-10 ft) **4,900** | SB07-03 (10-12 ft) **2,700** | SB07-03 (18-20 ft) **1,800** | MW07-18D (44-46 ft) **1,800** | MW07-20S (4-6 ft) **1,700** | MW07-19D (26-28 ft) **1,300** |
| SB07-02 (32-34 ft) **660** | MW07-31I (6-8 ft) **600** | MW07-28D (20-22 ft) **520** | SB07-01 (15-17 ft) **450** | MW07-19D (38-38.5 ft) **450** | MW07-21R (37-39 ft) **280** | MW07-26S (10-12 ft) **280** | MW07-09R (53-55 ft) **230** | MW07-31I (24-25 ft) **190** |
| MW07-15D (18-20 ft) **170** | MW07-25D (6-8 ft) **170** | MW07-30D (49-51 ft) **160** | MW07-19S (16-18 ft) **150** | MW07-30D (64-66 ft) **150** | MW07-16D (10-12 ft) **120** | MW07-29D (69-71 ft) **92** | MW07-17D (14-16 ft) **89** | MW07-25D (34-36 ft) **85** |
| MW07-16D (59-61 ft) **76** | MW07-31I (18-20 ft) **75** | MW07-20D (49-51 ft) **49** | MW07-19S (12-14 ft) **46** | MW07-20D (64-66 ft) **39** | MW07-18D (18-20 ft) **27** | MW07-20D (14-16 ft) **15** | MW07-05R (29-31 ft) **11** | Source Water #2 **6** |

As indicated previously, acetone was detected in 15 of the 43 laboratory method blanks at concentrations ranging from 4 to 1,200$\mu$g/kg.

Acetone was detected at concentrations ranging from 21 ug/kg (SB09-17, 55-57 ft bg) to 86 ug/kg (MW07-32R, 22-24 ft bg) from offshore soil samples collected in 1997 from SB09-16, SB09-17, and MW07-32D/R.

#### 4.5.4.4 Comparison of Phase I, II, and III RI Soil Sampling Results

Different depths and horizontal locations and analytical programs were selected for the Phase I, II and III RI subsurface soil sampling programs. Therefore, it is not possible to compare the data between the RI phases.

#### 4.5.4.5 Total Organic Carbon (TOC) in Subsurface Soil

During the Phase III RI, eight subsurface soil samples were collected for analysis of TOC. The analytical results are summarized in Table 4-3. Two samples were collected from the silt unit at SB07-02 (28-30 ft bgs; 11,400 mg/kg) and MW07-13S (16-18 ft bgs; 7,290 mg/kg). Three samples were collected from the till unit at MW07-17D (44-46 ft bgs, 4,500 mg/kg), MW07-19S (12-14 ft bgs, 7,490 mg/kg), and MW07-21R (37-39 ft bgs; 10,100 mg/kg). Three samples were collected from the lower sand unit at MW07-24D (34-36 ft bgs; 7,670 mg/kg), MW07-29D (44-46 ft bgs; 6,070 mg/kg), and MW07-30D (54-56 ft bgs, 8,000 mg/kg). These data were used in the ground-water modeling work.

TOC analysis was performed on soil samples collected from mid-harbor borings SB09-16 and SB09-17. The TOC results for are summarized in Table 4-3. TOC concentrations ranged from 5,460 mg/kg (SB09-17, 59-60 ft bg in the silty gravelly sand till) to 21,700 mg/kg (SB09-16, 5-6.5 ft bg in the organic sandy silt and fine sand layers).

## 4.6 GROUND-WATER RESULTS

This section presents the results of laboratory analysis of ground-water samples collected from monitoring wells at Site 07 during the Phase I, Phase II, and Phase III RIs.

No free flowing DNAPL or LNAPL was observed in the Site 07 wells during the Phase III RI field work, nor were they reportedly observed during the Phase I or Phase II RIs. During the Phase III RI field work, solvent rather than ground water was not observed draining from the soil samples collected and separate phase fluid was not observed in the water collected during the well development or purging activities, nor in the ground-water samples.

### 4.6.1 General Water Quality

During the Phase III RI (1995), 52 ground-water samples (including five duplicates), one Allen Harbor water sample (NCBC-AH1) and one Narragansett Bay (NCBC-NB1) water sample were collected and analyzed for sodium, chloride, TDS, and salinity to evaluate the potential presence of salt-water beneath Site 07. The results are summarized as part of Table 4-5. In general, the highest concentrations of sodium, chloride, TDS, and salinity were detected in samples collected from the eastern and southern portions of the Site where there appears to be a saline/salt water wedge. The VOC plume is located generally west of this saline water where the ground water is brackish.

During the 1997 Offshore Study, eight Site 07 related ground-water samples were collected from two monitoring wells (MW07-32D/R) and two mid-harbor borings (SB09-16 and SB09-17) for analysis of salinity. The salinity results are included in Table 4-5.

#### 4.6.1.1 Chloride

The average chloride concentrations detected in samples from the shallow, deep and bedrock wells were 2,082.8, 4,925.5 and 6,144.6 mg/L (respectively). Chloride was detected in all of the sampled wells. The maximum observed concentration (16,800 mg/L) was reported in the sample collected from the deep and bedrock wells MW07-16D/R. The results are summarized as part of Table 4-5 and on Figures 4-11A through 4-13A. The highest detected chloride concentrations are from samples collected from the eastern and southern portions of the Site. Figures 4-11A to 4-13A show very similar patterns of concentration increase as do Figures 4-11B through 4-13B for salinity concentrations; i.e., increasing beneath the eastern and southern portions of the Site. The samples collected in 1997 were not analyzed for chloride.

#### 4.6.1.2 Sodium

The average sodium concentrations detected in samples from the shallow, deep and bedrock wells were 1,040,923, 2,390,801 and 2,968,400 $\mu$g/L (respectively). Sodium was detected in all of the sampled wells. The maximum observed concentration (8,240,000 $\mu$g/L) was reported in sample collected from the deep well MW07-16D. The highest detected sodium concentrations are from samples collected from the eastern and southern portions of the Site. The samples collected in 1997 were not analyzed for sodium.

#### 4.6.1.3 Total Dissolved Solids

The average total dissolved solids (TDS) concentrations detected in samples from the shallow, deep and bedrock wells were 5,621.1, 8,893.9 and 11,210 mg/L (respectively). TDS was detected in all but two of the sampled wells. The maximum observed concentration (29,600 mg/L) was reported in the sample collected from well MW07-16R. The highest detected TDS concentrations are from samples collected from the eastern and southern portions of the Site. The samples collected in 1997 were not analyzed for TDS.

#### 4.6.1.4 Salinity

The average salinity detected in samples from the shallow, deep and bedrock wells (1995 data) was 4, 8.7 and 10.7 parts per thousand (ppt), respectively. The highest detected salinity was detected in the sample from well MW07-16R (29.8 ppt). This concentration falls between those detected in the Allen Harbor sample (30.7 ppt) and the Narragansett Bay sample (27.6 ppt). Figures 4-10, 4-11, and 4-12 illustrate the distribution of salinity detected in the groundwater samples collected from the shallow, deep and bedrock monitoring wells, respectively, and from Allen Harbor and Narragansett Bay. The presence of brackish and saline water in the shallow zone beneath Site 07 may be related, in part, to pre-1940 Site conditions (i.e., much of the Site was part of Allen Harbor) and the presence of a salt water wedge. Additionally, during 1942-43, the Navy placed dredged saline material from the development of the pier area in the shallow zone of the eastern portion of the Site (Section 1.2.3).

For groundwater samples collected in 1997 from two monitoring wells (MW07-32D/R) and two mid-harbor borings (SB09-16 and SB09-17), the salinity concentrations ranged from 1.3 ppt (GW09-16, 41-43 ft bg) to 28.4 ppt (MW07-32D, 41.6-51.6 ft bg). Salinity data is summarized in Table 4-5. Figures 4-11B, 4-12B and 4-13B have been updated to include salinity data collected as part of the 1997 Offshore Investigation.

For shallow wells and borings SB09-16 and -17 that were sampled, water from seven wells/borings (MW07-10S, MW07-13S, MW07-19S, MW07-21S, MW07-23S, MW07-26S, and SB09-16) would be categorized as brackish (salinity between 0.5 and 10 ppt). Water from three wells/borings, MW07-20S (23.7 ppt), MW07-24S (28.3 ppt) and SB09-17 (14.8 ppt, 7-9 ft bg), would be categorized as saline (salinity greater than 10 ppt). Salinity concentrations of water from the 10 remaining wells were not detected, and would be categorized as freshwater.

For deep (silt/till) wells and borings SB09-16 and -17 that were sampled, water samples from seven wells had salinity concentration equal to or less than 0.5 ppt. Water from eight wells (MW07-11D, MW07-18D, MW07-20D, MW07-16D, MW07-24D, MW07-29D, MW07-30D, and MW07-32D) would be categorized as saline, and had concentrations ranging from 13.1 ppt to 29.3 ppt. Water from the remaining nine deep wells/borings would be categorized as brackish.

For bedrock wells, water samples indicate that MW07-05R and MW07-21R would be categorized as brackish (1.06 and 7.61 ppt, respectively), MW07-09R, MW07-16R, and MW07-32R as saline (15.2, 29.8, and 28.0 ppt, respectively) and MW07-25R (ND) as freshwater.

Based upon the salinity data for the Phase III RI samples of the ground water and surface water (from Allen Harbor and Narragansett Bay), the extent of fresh, brackish, and saline water beneath the Site was evaluated (Figures 4-11B through 4-13B) and showed the presence of a saline/salt water wedge beneath the eastern and southeastern portions of the Site and the northern portion of Spink Neck. Because of the potential impacts of a salt water wedge on the flow of ground water beneath the Site, additional detailing of the freshwater/salt water transition zone was requested by the U.S. EPA-Region 1. The additional work consisted of two borehole (monitoring well) geophysical logging field activities of selected onsite monitoring wells by the U.S. Geological Survey (USGS) on 19 December 1996 and during 29 and 30 July and 1 August 1997. The raw data logs for the 1996 field activity were provided by the USGS on 10 January 1997 and discussed during a 16 January 1997 BCT Meeting. Results for geophysical data collected the USGS during July and August 1997 were received on 2 July 1998. A copy of the data logs (as received) is provided in Appendix J2. The USGS data have not been finalized or formally presented yet in a report. Seven (7) monitoring wells located within the salt water wedge and the transition zone with the freshwater were logged in 1996 using three geophysical tools/probes to measure resistivity, conductivity, and natural gamma count. The wells logged in 1996 included MW07-10D, -12D, -19D, -21D, -23D, -24D, and -26S (Figures 4-11B through 4-13B). The following 20 wells were logged by USGS in 1997: MW07-03D, -05R, -09D, -09R, -11D, -13D, -16D, -16R, -18D, -19D, -20D, -21D, -21R, -22D, -25R, -27D, -28D, -29D, -30D, and -31D. The geophysical logging methods were chosen to evaluate: (1) the stratigraphy (particularly in the area where the silt unit is not present; i.e., in the vicinity of well clusters MW07-19 and 21, and (2) potential variations in the salinity of the ground water, particularly between the individual depth intervals of the Phase III RI ground-water samples for which salinity had already been measured. The need to better understand the hydrogeology in the vicinity of MW07-19 and 21 is to evaluate whether or not there are additional depth intervals that need to be screened and data collected with regard to evaluation of the extent of the VOC plume.

The following is a summary of the findings for each well logged in 1996 based upon notes of the discussions during the 16 January 1997 meeting.

**MW07-10D**

The conductivity and gamma logs suggest that the deep ground water in the till is fresh water which supports the salinity concentration detected in the sample from that well. The lower portion of the conductivity log appears to show an increase in salinity, i.e. the ground water below the screened interval of this well appears to be saltier than the water in the screened interval. Additionally, the USGS stated that the ground water in the upper sand unit (shallow

ground water) is probably all from local recharge of precipitation, not from deep ground water.

**MW07-12D**

The geophysical logs and the 3.7 ppt salinity concentration detected in the Phase III RI sample indicate that this well is in the transition (brackish) zone between the freshwater and the salt water wedge (located further south).

**MW07-19D**

The gamma log indicates that the till is relatively homogenous and there appears to be a sand lens present approximately 8.75 ft bgs. With regard for the ground-water salinity, the logs indicate a sharp transition zone to salt water approximately 30 ft bgs. Further, the data indicate that the depth interval of approximately 14-22 ft bgs should be monitored with regard for the potential presence of the VOC plume. This recommended interval has already been included in the Site evaluation by well MW07-19S, which is screened from 13 to 23 ft bgs.

**MW07-21D**

The logs support the Phase III RI salinity data for the ground-water samples from this well cluster (MW07-21S/D/R); i.e., nearly "fresh" water in the shallow zone (MW07-21S) and brackish (transition zone) water in the deep zone. The decrease in the conductivity log values at the bottom of MW07-21D may indicate that "fresher" water is flowing up into the till from the bedrock. Further, the data indicate that interval of approximately 12-25 ft bgs should be monitored with regard for the potential presence of the VOC plume. This recommended interval has already been included in the Site evaluation by well MW07-21S, which is screened from 10-20 ft bgs.

**MW07-23D**

The logs indicate that this well appears to be located entirely within the freshwater/salt water transition (brackish) zone.

**MW07-24D**

The logs appear to show the presence of salt water in the shallow ground-water zone and in the lower portion of the deep ground water (till) zone (where this well is screened - approximately 43 to 53 ft bgs), but the upper portion of this zone (just beneath the silt unit) appears to be "fresher", less saline (approximately 30 to 35 ft bgs).

**MW07-26S**

The logs for this shallow well indicate the presence of "fresher" water (perhaps related to rainfall recharge) becoming more brackish with depth (perhaps related to residual salinity from the saline dredged fill historically placed in the eastern portion of the Site).

**Conclusions**

- Preliminary conclusions from the USGS data suggest that, in general, the logs provide additional data between the depth intervals where salinity values have been measured from Phase III RI ground-water samples collected from the monitoring wells. Overall, the geophysical log data appear to support the Phase III RI ground-water sample findings, including (1) the apparent rise of less dense 'fresh' water from the 'deep' zone upward along the interface (transition zone) with the denser 'saline' water in the southern portion of the Site (well clusters MW07-19 and MW07-21) and (2) the apparent presence of 'fresh' water (from the recharge of precipitation) in the 'shallow' ground-water zone (above the silt unit) beneath the eastern portion of the site. Overall, the borehole geophysical logging data appear to support the related portion of the Site Conceptual Model (Section 4.7).

- The log for one well (MW07-21D) appears to show that there may be some upward flowing, fresher ground water coming from the underlying fractured bedrock. It is likely, depending on fracture orientation and connectivity, that near the coast, the fractured bedrock has less conductive water than the overlying unconsolidated deposits.

- In the vicinity of well clusters MW07-19 and -21, the zones that should be monitored have already been included (screened intervals of monitoring wells).

During the well logging performed in July-August 1997 by USGS, four rinsate samples were collected by EA from borehole logging equipment to document the effectiveness of the equipment decontamination between monitoring well locations. Two samples were collected from the borehole logging cable (0730RB1A, 0705RB1A) and two were collected from the gamma probe (0730RB1B, 0705RB1B) at wells MW07-05R and MW07-30D. These samples were analyzed for VOC. Petroleum VOC detected in rinsate samples included: benzene at 2 ug/L (0730RB1B, 0730RB1A), toluene at concentrations ranging from 1 ug/L (0705RB1A, 0705RB1B) to 11 ug/L (0730RB1B), ethyl benzene at concentrations of 1 ug/L (0730RB1B) and 2 ug/l (0730RB1B), and total xylenes at concentrations of 5 ug/L (0730RB1A) and 7 ug/L (0730RB1B). CVOC detected in rinsate samples included: TCE at concentrations of 9 ug/L (0705RB1A) and 11 ug/l (0705RB1B), and PCA at concentrations of 3 ug/L (0705RB1A) and 5 ug/L (0705RB1B).

#### 4.6.1.5 Source Water

During the Phase III RI, four samples of the Base's water supply system were collected for analysis of TCL VOC [one sample was also submitted for TAL Metals analysis (Table 4-5)]. PCE was detected at 1 ppb in the sample collected on 24 August 1995 (Table 4-3). Water from the Base's water system was used during drilling and well installation field activities and as part of the decontamination process for reused field sampling equipment.

### 4.6.2 VOC in Ground Water

#### 4.6.2.1 Phase I RI

Phase I RI ground-water samples were analyzed for full TCL/TAL. VOC detected during the Phase I RI included 1,2-DCE at a concentration of 2$\mu$g/L and vinyl chloride at a concentration of 30 $\mu$g/L from the ground-water sample collected from MW07-01 located in the northern portion of the Site.

#### 4.6.2.2 Phase II RI

Phase II RI ground-water samples were analyzed for the following: TCL/VOC, TAL metals, total chloride and cyanide. Supplemental Phase II investigation ground-water samples were sent for the following analyses: TCL/VOC, TAL metals, total chloride, salinity, and TDS. During the Phase II RI, the highest concentration of VOC was detected in the northern portion of the site in the sample collected from MW07-05D at a total concentration of 57,400 $\mu$g/L (1,2- DCE at 2,400 $\mu$g/l, TCE at 22,000 $\mu$g/L and PCA at 33,000 $\mu$g/L). VOC were also detected in the ground-water samples collected from MW07-02S (37 $\mu$g/L), MW07-03D (64 $\mu$g/L), and MW07-04S (26 $\mu$g/L), all located in the northern portion of the Site. Ground-water samples collected during the Supplemental Phase II RI were all from deep wells. Detected total CVOC concentrations ranged from 5,860 $\mu$g/L (MW07-09D, located in the center of the site) to 6 $\mu$g/L (MW07-11D, in the southern portion of the site). Total CVOC were also reported at MW07-12D (105 $\mu$g/L), MW07-10D (2,044 $\mu$g/L) and MW07-13D (74 $\mu$g/L), all located in the southwestern portion of the site. BTEX was detected in one location, MW07-10D (Benzene, 40 $\mu$g/L).

#### 4.6.2.3 Phase III RI and Offshore Investigation

During the 1995 Phase III field activities, ground-water samples were collected from 47 monitoring wells using low-flow methodology (Section 2.4.6.2) and analyzed for TCL VOC and TAL. The sample aliquot collected for metals analysis also included field filtering to further minimize the inclusion of "fines" in these samples. The analytical results are summarized in Tables 4-4 and 4-5. Figures 4-14 though 4-16 present in plan view the lateral distribution of the VOC detected in the Phase III RI samples collected from the shallow (S), deep (D), and bedrock (R) wells, respectively. Figures 4-17 through 4-19 present interpretive contour maps of the total CVOC detected in the Phase III RI samples from the shallow, deep,

and bedrock wells, respectively. Figures 4-20 through 4-26 present vertical and lateral distribution of total CVOC detected in the Phase III RI samples from the various screened intervals on the various geological cross sections. The analytical lab reports for the ground-water samples are maintained in EA's project file in Bedford, Massachusetts. Petroleum hydrocarbon VOC were not detected in the Phase III RI samples. CVOC were detected in samples from 26 of the 47 wells. The highest concentration of total CVOC (193,680 $\mu$g/L) was detected in the sample from MW07-17D which is located in the northern portion of the Site but south (downgradient) of the apparent former DANC disposal area. The VOC detected in that sample include: TCE at 120,000 $\mu$g/L; 1,1,2,2-PCA at 66,000 $\mu$g/L; 1,2-DCE at 5,700 $\mu$g/L; 1,1,2-TCA at 1,200 $\mu$g/L; PCE at 670 $\mu$g/L; and chloroform at 110 $\mu$g/L.

Eight ground-water samples included in this report were collected from monitoring wells and soil borings as part of the Site 09 Offshore Investigation. Ground-water samples were collected from monitoring wells MW07-32D (2 February 1997) and MW07-32R (28 January 1998). Additionally, groundwater samples were collected from discrete intervals from soil borings in Allen Harbor. Included in this report are analytical data for samples collected during November 1997 from the following soil borings: GW09-16, 7.5-9.5 ft bg in the upper portion of the silt unit; GW09-16, 30-32 ft bg in the lower portion of the silt unit; GW09-16, 41-43 ft bg in the sandy gravel till unit; GW09-17, 7-9 ft bg in the upper portion of the silt unit; GW09-17, 30-32 ft bg in the lower portion of the silt unit; and GW09-17, 48-50 ft bg in the gravelly sand till unit. The VOC results are summarized in Table 4-4, metals and salinity data are summarized in Table 4-5.

**Quality Control Summary**

Validation of the 1995-96 and 1997-98 analytical data has been completed (Section 2.9). The data validation reports are presented in Appendix K.

The following five duplicate field samples were collected to evaluate field precision: MW07-05D, -09D, -20D, -24D, and -29D. The duplicate sample analytical results are also provided in Tables 4-4 and 4-5 and indicate good reproducibility of the data.

The field QC blanks consisted of four field rinsate blanks and 11 trip blanks. Acetone was reported in one of the four field rinsate blanks (11 $\mu$g/L), methylene chloride was reported in all four of the field rinsate blanks (26 to 29 $\mu$g/L), TCE was reported in three of the field rinsate blanks (12 to 99 $\mu$g/L), and 1,1,2,2-PCA was reported in three of the field rinsate blanks (13 to 92 $\mu$g/L).

Two trip blanks were free of detectable VOC. Acetone was reported in seven of the 11 trip blanks (4 to 18 $\mu$g/L), methylene chloride was reported in all 11 trip blanks (5 to 28 $\mu$g/L), and TCE in one of the trip blanks (1 $\mu$g/L).

Twenty-two laboratory method blanks were analyzed by CIEMIC in association with analysis of the ground-water samples. Methylene chloride was detected in 15 of the 22 blanks, ranging

in concentration from 1 to 10 $\mu$g/L. Acetone was detected in 16 of the 22 blanks, ranging in concentration from 3 to 17 $\mu$g/L. Only three of the 22 blanks had compounds other than methylene chloride or acetone detected. 2-Butanone, 2-Hexanone and PCA were detected in one of the three blanks at 3, 2, and 1 $\mu$g/L, respectively. Toluene was detected in the second blank at 2 $\mu$g/L. In the third blank, 4-Methyl-2-Pentanone, 2-Hexanone and PCA were detected at 2 $\mu$g/L each.

In conclusion, these Phase III RI data are valid and useable for evaluation of the Site 07 subsurface conditions.

**Shallow Ground Water**

Figure 4-14 shows the lateral distribution of VOC reported in the samples from the 17 shallow (S) monitoring wells screened in the upper sand unit. Figure 4-17 provides an interpretive contour map of the total CVOC detected in the same samples and also includes data collected from the shallow interval of mid-harbor borings SB09-16 and SB09-17. Figures 4-20 through 4-26A present the vertical and lateral distribution of total CVOC detected in the Phase III RI samples from the various screened intervals on the various geological cross sections. Petroleum hydrocarbon VOC were not detected in the shallow ground-water samples.

CVOC were detected in five of the 17 samples and in one of the mid-harbor borings (SB09-16; 4 ug/L PCA and 2 ug/L TCE). These six samples (wells) are located in three general areas: 1) in the vicinity of the former apparent DANC disposal area (MW07-02S and MW07-01S), 2) in the southwestern portion of the Site (MW07-19S, MW07-21S, and MW07-26S), and 3) mid-harbor at trace concentrations. These three areas are separated from one another by wells where no CVOC were detected, i.e., MW07-03S, MW07-04S, MW07-05S, MW07-10S, and MW07-23S (Figures 4-14 and 4-17). Near the former apparent DANC disposal area, only two CVOC were detected: vinyl chloride at 23 $\mu$g/L (MW07-01S) and PCE at 1 $\mu$g/L (MW07-02S). These data indicate that release of 1,1,2,2-PCA (a major component of DANC) from the former DANC disposal area appears to have migrated vertically downward through a locally present sandy facies of the underlying silt unit rather than laterally. This CVOC plume in shallow ground water is small and is surrounded by wells where no CVOC was detected. The trace concentrations of CVOC (4 ug/L PCA and 2 ug/L TCE) detected in mid-harbor boring shallow sample GW09-16 (7.5-9.5 ft bg) do not appear to be related to disposal activities at Site because shallow ground water from the Site would discharge to the harbor near the Site shoreline; also, CVOC were not detected at MW07-23S located in the southwest corner of the site.

The total CVOC concentrations detected in samples from the three wells in the southwestern portion of the Site range from 5,950 $\mu$g/L (MW07-19S) to 1,481 $\mu$g/L (MW07-21S). The CVOC detected in the samples from MW07-19S and MW07-21S are the same and the relative concentrations decrease from MW07-19S to MW07-21S, suggesting a source area near or upgradient of MW07-19S. MW07-26 is located generally upgradient from MW07-19S

(Figures 3-12 through 3-14). However, the main CVOC detected in the MW07-26S sample is 1,2-DCE versus TCE in the sample from MW07-19S. This suggests that the CVOC detected in MW07-26S may have a separate local source area. There are no reported disposal activities in this portion of Site 07. As indicated previously in Section 3.7.5.3, the vertical hydraulic gradient between the shallow and deep ground water at MW07-19 is downward. However, based upon additional evaluation, including the geophysical borehole logging by the USGS in December 1996, the VOC detected in samples from MW07-19S and MW07-21S could be related to an arm of the original deep plume (which begins in the northern portion of the Site) that may be within "brackish" ground water that is flowing up along the interface with "saline" ground water in that area. Refer also to Section 4.7.

**Deep Ground Water**

Figure 4-15 shows the lateral distribution of VOC reported in the samples from the 25 deep (D) monitoring wells screened in the till unit, lower sand unit, and/or lower portion of the silt unit. Figure 4-18 provides an interpretive contour map of the total CVOC detected in the same samples, and also, includes data from mid-harbor borings SB09-16 (GW09-16, 30-32 ft bg in the lower portion of the silt unit; and 41-43 ft bg in the till unit) and SB09-17 (GW09-17, 30-32 ft bg in the lower portion of the silt unit; and 48-50 ft bg in the till unit) and monitoring well MW07-32D located on Spink Neck. Figures 4-20 through 4-26A present the vertical and lateral distribution of total CVOC detected in the Phase III RI samples and the related Offshore Investigation samples from the various screened intervals on the various geological cross sections. Petroleum hydrocarbon VOC were detected in only one deep ground-water sample (MW07-05D; toluene at 96$\mu$g/L) .

CVOC were detected in 18 of the 25 samples collected in 1995-1996. The eighteen samples (wells) are generally located in the western portion of the Site (Figure 4-18). The available data suggest the presence of one plume in the deep ground-water (generally in the till which directly overlies bedrock). The highest total CVOC concentrations detected in this plume includes four wells which are located just south of the vicinity of the apparent former DANC disposal area and within an interpreted valley in the underlying bedrock surface (Figure 1-2): MW07-17D (193,680 $\mu$g/L), MW07-04D (123,000 $\mu$g/L), MW07-05D (96,750 $\mu$g/L), and MW07-15D (93,890 $\mu$g/L). MW07-05D and MW07-17D appear to be located along the base of the northwest-southeast trending valley in the bedrock surface (Figures 1-2 and 4-25, Cross Section F-F′). This apparent valley appears to have influenced the migration and collection of the original DANC disposal release of separate phase 1,1,2,2-PCA DNAPL. The material appears to have migrated vertically downward through a sandy facies in the overlying silt unit into the till unit and then along the apparent valley in the bedrock surface. Section 5.1.3.3 states that based upon the available data, there may be residual DNAPL TCE and/or 1,1,2,2-PCA in the vicinity of MW07-04D, MW07-05D, MW07-15D, and MW07-17D. Free-flowing DNAPL has not been observed at the Site during the Phase I, II, or III RIs. Dissolved CVOC concentrations detected in deep ground water (till unit, lower sand unit, and lower portion of the silt unit) decrease to "not detected" toward the east and south shoreline with Narragansett Bay as shown on Figures 4-18 and 4-21 through 4-24. The west and southwest extent of the

CVOC in deep ground water continues beneath the Site shoreline with Allen Harbor and the entrance channel. Section 5.3 presents the results of the related ground-water modeling work performed.

Of the five deep ground-water samples collected in 1997-1998, only one contained detectable CVOC. TCE was detected at 3 $\mu$g/L and 1,1,2,2-PCA was detected at 5 $\mu$g/L in the ground-water sample collected from GW09-16, 30-32 ft bg. However, CVOC were not detected in the deeper sample collected from GW09-16, 41-43 ft bg in the underlying till unit.

**Bedrock Ground Water**

Figure 4-16 shows the lateral distribution of VOC reported in the samples from the six bedrock (R) monitoring wells (including MW07-32R located on Spink Neck) screened approximately 15-25 ft below the top of bedrock. Figure 4-19 provides an interpretive contour map of the total CVOC detected in the same samples. Figures 4-20 through 4-26A present the vertical and lateral distribution of total CVOC detected in the Phase III RI samples from the various screened intervals on the various geological cross sections. Petroleum hydrocarbon VOC were only detected in the bedrock ground-water sample from MW07-32R (toluene at 8 $\mu$g/L). This detected toluene does not appear to be related to Site 07 because it has not been detected in samples from upgradient wells located in the southern portion of the site.

CVOC were detected in three of the five samples collected in 1995-1996. CVOC were not detected in ground-water samples collected in 1998. CVOC were not detected in the central (MW07-09R) and eastern (MW07-16R) portions of Site 07. The highest concentration of total CVOC (41,730 $\mu$g/L) was detected in the sample from MW07-05R, including primarily TCE at 27,000 $\mu$g/L; 1,1,2,2-PCA at 12,000 $\mu$g/L; 1,2-DCE at 2,200 $\mu$g/L; and 1,1,2-TCE at 390 $\mu$g/L. MW07-05R is located approximately 150 ft southwest of the apparent vicinity of the former DANC disposal area which occurred at ground surface. Additionally, MW07-05R is located in an apparent valley in the bedrock surface (Figure 2-1) into which the original DANC release may have migrated through the overlying till unit. As stated previously in Section 3.7.5.3 and in Table 3-1, the vertical hydraulic gradient between the shallow (disposal area) and the deep wells (ground-water zones) is downward, as it also is between the deep and rock wells (ground-water zones). The detected total CVOC concentrations are approximately an order of magnitude (ten times) less in the samples from MW07-25R (4,400 $\mu$g/L) MW07-21R (3,639 $\mu$g/L) than the concentration detected in MW07-05R. This suggests the presence of a dissolved CVOC plume in the bedrock ground-water zone from the vicinity of MW07-05R (Figures 4-19 and 4-26). Related ground-water and VOC flow is probably through fractures in the bedrock and through the overlying till unit which appears to be in direct hydraulic connection with the bedrock.

**Comparisons of VOC Detected in Marine ERA Sediment Samples (offshore media) and Phase III RI Ground-Water Samples**

This comparison of VOC detected in the Marine Ecological Risk Assessment (MERA) sediment samples (from the intertidal zone adjacent to the Site) and the Phase III RI ground-water samples collected in 1995/1996 is to evaluate if the data provide evidence for a completed pathway from the Site ground water to the offshore intertidal sediment. The VOC analytical results for MERA samples collected from intertidal wetlands(W), vegetated wetlands(V), surficial sediment(D), and deep core sediment (DC) have been summarized and plotted with Phase III RI shallow ground-water results (Figure 4-27), deep ground-water results (Figure 4-28), and bedrock ground-water results (Figure 4-29). There are offshore sediment samples located close to and west of MW07-25 and south of MW07-21 where VOC have been detected in ground-water samples from locations near the Site shoreline. As shown on these three figures, the VOC detected in the offshore sediment samples collected for the MERA were not detected in ground-water samples from the nearby monitoring wells. These data indicate that there is not a completed risk pathway (ie., sampling and analysis conducted to date by the Navy has identified no related unacceptable risk) from the Site VOC plume in ground water to the adjacent offshore sediment in the intertidal zone.

**4.6.2.4 Acetone Reported in Phase III RI Ground-Water Samples**

Acetone was reported in ground-water samples from only four of the 46 monitoring wells sampled at the Site in December 1995 to January 1996 and May 1996. The reported concentrations are: 200 $\mu$g/L for MW07-04S and MW07-23S, 190 $\mu$g/L for MW07-29D, and 28 $\mu$g/L for MW07-22S. Although acetone was detected in 16 of the 22 laboratory method blanks, acetone ranged from ND to 9 $\mu$g/L in the method blanks that are related to the four ground-water samples in which acetone was detected. This suggests that the acetone detected in the four ground-water samples was probably not introduced by the laboratory. For ground-water samples collected in 1997-1998, acetone was detected in concentrations ranging from 7 $\mu$g/L (GW09-17, 48-50 ft bg) to 73 $\mu$g/L (GW09-16, 7.5-9.5 ft bg).

As explained previously in Section 4.5.4.3, an isopropanol rinse was used as part of the decontamination process for the soil sampling equipment. The same was true for the flow-through cell used during the December 1995 to January 1996 sampling event. As stated previously in Section 4.5.4.3, analysis of an isopropanol sample (ISO1) detected 42,000 $\mu$g/L of acetone.

It is possible that the low acetone concentrations detected in the four ground-water samples may have been introduced in the field from residual decontamination fluid on the flow-through cell. As noted in Section 4.5.4.3, the acetone concentrations detected in soil samples that correspond to portions of screened intervals from which ground water was also sampled are significantly (anomalously) higher than the generally "not detected" reported for the ground-water samples. That is, the acetone detected in some soil samples (collected during drilling from an interval that was subsequently screened by a monitoring well) was substantially higher

than the ground-water sample from the related well. Because acetone is very soluble in water, if high concentrations of acetone are actually present in the subsurface, then a similar acetone concentration would be expected to be detected in the related ground-water sample. However, acetone was "ND" in most related ground-water samples. If acetone is present in ground water beneath the Site, it appears to be present in low concentrations and only in a few isolated areas.

#### 4.6.2.5 Comparison of Phase I, II, and III RI Ground-Water Sampling Results

Wells MW07-01S, -02S, -03S/D, -04S, -05S/D, -06S, -07S, -08S, -09D through -13D sampled for the Phase II RI were also sampled as part of the Phase III RI. Only MW07-01S, MW07-03S, and MW07-04S were sampled for the Phase I RI. Comparison of the detected concentrations from the Phase III RI to the Phase II RI results show general agreement in the VOC detected . The concentrations detected in samples from the shallow (S) wells are very similar for the Phase I, II, and III RIs. For samples from the deep (D) wells, the Phase II and III RI results are similar for MW07-10D, -11D, -12D, and -13D. The Phase III RI results are higher than the Phase II RI results for MW07-03D, -05D, and -09D. There were no deep (D) wells present for the Phase I RI. There were no bedrock (R) wells present for either the Phase I or II RIs. Although some of the Phase III RI results for deep (D) well samples are higher than the Phase II RI results, this is based upon only two data sets which were collected by two different firms, during different years and seasons, and analyzed by different laboratories, and therefore, should not be considered to represent a trend of increasing concentrations between the Phase II and Phase III RI VOC data sets. The samples collected in 1997-1998 are from new offshore and offsite locations not previously sampled; and therefore , can not be compared to previous RI data.

### 4.6.3 Metals in Ground Water

#### 4.6.3.1 Phase I RI

Ground-water samples were collected from three monitoring wells and analyzed for TAL metals during the Phase I investigation during two separate sampling events. Only antimony and lead were detected at concentrations above state and/or federal ground water quality standards. Antimony was detected in the ground-water sample collected from MW07-04S at a concentration of 27.1 $\mu$g/L (federal MCL for antimony is 6 $\mu$g/L). Lead was detected in the ground-water sample collected from MW07-01S at a concentration of 18.2 $\mu$g/L (federal MCL for lead is 15 $\mu$g/L). These samples were collected using a high-flow sampling method and were turbid.

#### 4.6.3.2 Phase II RI

During the Phase II investigation, inorganic analytes were detected at low concentrations in ground water beneath Site 07. However, lead in ground-water samples was detected at elevated concentrations (above Federal MCL and Rhode Island Ground Water Quality

Standards for lead of 15 $\mu$g/L) in two locations: MW07-05S at a concentration of 21.4 $\mu$g/L and MW07-06S at a concentration of 22.7 $\mu$g/L. During the Supplemental Phase II investigation, five deep well ground-water samples were analyzed for TAL metals. Ground-water sampled from MW07-09D had the highest detected concentrations of the following metals (all above Federal MCLs): arsenic (63.5 $\mu$g/L), beryllium (6.4 $\mu$g/L), chromium (292 $\mu$g/L), lead (125 $\mu$g/L), and nickel (320 $\mu$g/L). Lead was detected at elevated concentrations (above federal MCLs) from ground-water samples collected at MW07-10D (22.8 $\mu$g/L) and MW07-11D (39.9 $\mu$g/L). These ground-water samples for metals analysis were field filtered. There does not appear to be a correlation between detected metals concentrations and the turbidity field measurements.

#### 4.6.3.3 Phase III RI

During the Phase III RI, samples were collected from all monitoring wells, and analyzed for TAL metals for the 1995 sampling event. These samples were collected using low-flow methodology and field filtered (Section 2.4.6.2). For samples collected in 1997-1998, SB09-16 and SB09-17 were analyzed for metals. These samples were also collected low-flow methodology using a Deitrich Environmental Sampling Probe, peristaltic pump and Teflon-lined polyethylene tubing, and field filtered.

Validation of the 1995-96 and 1997-98 analytical data has been completed (Section 2.9). The data validation reports are presented in Appendix K and they conclude that these data are valid and useable for evaluation of the Site 07 subsurface conditions.

There are no established criteria for concentrations of metals in Class GB ground water in Rhode Island. Therefore, results were compared to Federal Maximum Contaminant Levels (MCLs) and Secondary MCLs (SMCLs) as well as the NCBC background concentrations. These samples are also compared to the samples collected from Allen Harbor and Narragansett Bay. Although potassium, magnesium, sodium and calcium were detected in the samples, they are not included in the following discussion. In addition, if an analyte was detected, but was not detected above an established MCL, it was not presented here, except for arsenic. Arsenic is presented to show that although it was detected at low levels in some ground-water samples, there is no apparent completed pathway from the Site to adjacent intertidal sediment where it was detected; ie. arsenic was not detected in samples from the monitoring wells located along the perimeter of the Site which are located between the offshore sediment and the area where arsenic was detected in ground-water samples.

There is no MCL for iron. Therefore, results were compared to the SMCL of 300 $\mu$g/L. Iron was detected above the SMCL in 11 of the 17 shallow wells, although it only exceeded the NCBC background concentration of 25,500 $\mu$g/L in the sample from MW07-26S (53,100 $\mu$g/L) Figure 4-30). At MW07-08S, it was detected below the SMCL at 272 $\mu$g/L. Concentrations of iron in shallow wells ranged from not detected (ND) to 53,100 $\mu$g/L (MW07-26S). In samples from the deep wells (including MW07-31I), iron was detected in 22 of the 25 wells and exceeded SMCLs, although only four locations were above the NCBC

background concentration (Figure 4-31). The maximum detected concentration of iron in samples from the deep wells was 46,300 μg/L in MW07-12D. Iron was detected in samples from all five bedrock wells, although only four were at concentrations exceeding SMCLs and none were above the NCBC background concentration. Concentrations ranged from 265 μg/L in MW07-25R to 15,500 μg/L in MW07-09R (Figure 4-32). There is no apparent correlation between the iron concentrations detected in the Phase III RI samples and the disposal of (ferric?) Chloride in the northern portion of the Site. Iron was not detected in either the Narragansett Bay or Allen Harbor water sample. The samples collected in 1997 were not analyzed for iron.

There is no MCL for manganese. Therefore, results were compared to the SMCL of 50 μg/L. Manganese was not detected in either the Narragansett Bay or Allen Harbor sample. Manganese was detected in samples from fourteen shallow wells. Ten of the fourteen samples exceeded the SMCL, although only two of the samples exceeded the NCBC background concentration (3,292 μg/L) (Figure 4-30). Concentrations ranged from ND to a maximum of 3,830 μg/L in the sample from MW07-21S. Manganese was detected above the SMCL in all twenty-five deep wells, although only one (MW07-16D at 3,510 μg/L) exceeded the NCBC background concentration (Figure 4-31). Concentrations in samples from the deep wells ranged from 82 μg/L in MW07-27D to 3,510 μg/L in MW07-16D. Manganese was also detected above the SMCL in samples from all five bedrock wells, although only the sample from MW07-16R (15,500 μg/L) exceeded the NCBC background concentration (Figure 4-32). The remaining rock well samples ranged in concentrations from 767 μg/L in MW07-09R to 2,290 μg/L in MW07-21R. Manganese was not detected in the water samples from Allen Harbor and Narragansett Bay. Manganese was detected above the SMCL, but below NCBC background concentration in the mid-harbor ground-water samples collected in 1997. For these samples, manganese concentrations ranged from 400 μg/L (GW09-16, 41-43 ft bg) to 936 μg/L (GW09-16, 30-32 ft bg).

Thallium has a MCL of 2 μg/L, although the NCBC background concentration for the base is 4.1 μg/L. Thallium was detected in only six of the 17 shallow (S) wells, although all concentrations exceeded the MCL (Figure 4-30). Concentrations ranged from 4 μg/L in the sample from MW07-06S and MW07-19S to a maximum of 29 μg/L in the sample from MW07-24S, equaling or exceeding the NCBC background concentration (Figure 4-31). Thallium was detected in samples from the thirteen deep wells, ranging in concentrations from 4 μg/L in MW07-27D to 32 μg/L in the duplicate sample collected at MW07-20D, exceeding or equaling both the MCL and the NCBC background concentration. Thallium was also detected in the three of the five samples from bedrock wells (MW07-09R [16 μg/L], MW07-16R [29 μg/L], and MW07-21R [9 μg/L]), exceeding both the MCL and NCBC concentration (Figure 4-32). Thallium was detected at 32 μg/L in the Allen Harbor water sample (NCBC-AH1) and at 31.6 μg/L in the water sample from Narragansett Bay (NCBC-NB-1). The locations of the wells in which thallium was detected generally fall within an area located south of a line placed through wells MW07-28D, MW07-27D, and MW07-23D, with the exception of MW07-06S which lies just north of such a line. The highest concentrations of thallium were detected in the samples from wells located in the southern to southeastern approximately 1/3 of

the Site (MW07-20S/D, MW07-16D/R, MW07-30D, MW07-18D, MW07-11D, MW07-24S/D, and MW07-29D). Thallium was detected at 32 $\mu$g/L in the Allen Harbor water sample (NCBC-AH1) and at 31.6 $\mu$g/L in the water sample from Narragansett Bay (NCBC-NB-1). Thallium was not detected in the ground-water samples collected in 1997 from mid-harbor borings SB09-16 and SB09-17.

Arsenic has a MCL of 50 $\mu$g/L, although the background concentration for NCBC is 6.4 $\mu$g/L. The detected arsenic concentrations are summarized on Figures 4-33 through 4-35. Arsenic was detected in only 5 of 17 shallow(S) wells, although none of the concentrations are above the MCL, two samples (MW07-13S; 8J $\mu$g/L and MW07-26S; 46.9 $\mu$g/L) were above the NCBC background value, and one sample was above the Safe Drinking Water Act (SDWA) action level of 15 $\mu$g/L. Arsenic was detected in only one deep(D) well sample (MW07-20D; 2.4J $\mu$g/L) and two duplicate samples (MW07-20D, Dup; 4.4 $\mu$g/L and MW07-29D, Dup; 4 $\mu$g/L). Arsenic was detected in only one bedrock well sample (MW07-16R; 4.2J $\mu$g/L). As shown on these three figures, the arsenic detected in the offshore sediment samples collected for the MERA were not detected in ground-water samples from the nearby monitoring wells. These data indicate that there is not a completed pathway from arsenic detected in a small portion of the Site ground water to the adjacent offshore sediment in the intertidal zone. Arsenic was detected in two of four ground-water samples collected in 1997 from mid-harbor borings SB09-16 and SB09-17: 3.6 $\mu$g/L (GW09-16, 41-43 ft bg) and 6 $\mu$g/L (GW09-17, 7-9 ft bg), both of which are below the MCL, SDWA, and NCBC background concentrations.

In summary, the location of the metals detected in ground-water samples do not correlate with the three reported former storage/release storage areas in the northern portion of the site and; therefore, the source of the generally trace concentrations detected of these metals is unknown. Only thallium was detected at concentrations greater than the MCL, arsenic was detected in one sample at a concentration greater than the SDWA action level, and iron and manganese were detected at concentrations greater than the SMCL. The detected concentrations of thallium, sodium, and potassium correlate with the detected concentrations in the adjacent bay surface water. Although it is possible for iron, manganese, and arsenic to be mobilized from native aquifer materials due to the presence/degradation of organic chemicals, it does not appear to be a dominant process beneath Site 07. This is based upon the location of the higher detected iron, manganese, and arsenic concentrations which are not located in the areas of higher detected CVOC concentrations (which would seem to be the area where the mobilization would have the greatest potential to occur, unless perhaps all of the mobilization from that area has occurred). If this process were dominant, it would seem that there would be a plume of decreasing metal concentrations extending from the areas of higher detected CVOC concentrations. However, the available data do not indicate the presence of such a plume. Additionally, most of the detections are below the related established NCBC background concentrations making it difficult to discern variations in the naturally occurring concentrations from potential site impacted concentrations.

### 4.6.4 SVOC, Pesticides, and PCB In Ground Water

#### 4.6.4.1 Phase I RI

SVOC and pesticides/PCB were analyzed for during the Phase I RI, but were not detected in the ground-water samples.

#### 4.6.4.2 Phase II RI

SVOC and Pesticides/PCB were not included the Phase II RI analytical program.

#### 4.6.4.3 Phase III RI and Offshore Investigation

SVOC and Pesticides/PCB were not included in the Phase III RI analytical program for samples collected in 1995-1996. SVOC and pesticides were not detected in the ground-water samples collected in 1997 from mid-harbor borings SB09-16 and SB09-17. PCB were not included in the 1997 analytical program.

## 4.7 SITE CONCEPTUAL MODEL

Based upon the Site hydrogeology (Chapter 3) and ground-water quality findings (earlier sections of Chapter 4), the following is the Site conceptual model.

**BACKGROUND** (Summarized from Chapter 1)

- Site is approximately 40 acres of the southern portion of the Calf Pasture Point peninsula.

  — Narragansett Bay along the east;
  — Allen Harbor along the west;
  — Allen Harbor Entrance Channel along the south.

- The eastern portion of the Site and the adjacent area northwest of the Site were portions of Allen Harbor prior to 1942 when they were filled in with saline dredged material.

- Site surface topography ranges from about 55 ft MSL where bedrock crops out just north of the Site to sea level along the east, south, and west shoreline perimeter of the Site (Figure 1-3). The approximately southern two-thirds of the Site is less than 8 ft MSL.

- The Site is generally an undeveloped wooded, shrubbed, grass land. There are three former munitions bunkers located just north of the Site. Based

upon historical air photos, the south portion of the Site was used for heavy equipment training of SeaBees.

- There are three reported disposal events:

  — Sometime between 1960-1974: Approximately 20 5-gal cans of bleach were disposed in a ditch adjacent to Bunker 60. The cans were removed sometime between 1978-1982.

  — Sometime in1973: 30-40 35-gal cardboard containers of (ferric?) chloride were stored and deteriorated at the Site. Such material is readily soluble in water.

  — Sometime between 1968 and 1974: Approximately 2,500 3-gal cans of DANC were disposed in a trench at the Site; the exact location unknown.

  DANC was Decontaminating Agent Non-Corrosive and was a mixture of 1,1,2,2-Perchloroethane (PCA) and 1,3-dichloro-5,5-dimethyl-hydantoin (an oxidizing agent that readily breaks down in water to release chlorine).

- Previous studies (soil borings; monitoring wells; soil and ground-water samples; geophysical surveys, soil gas study) were performed to locate the disposal areas and to characterize the hydrogeology and nature and extent of releases.

- A purpose of the Phase III RI was to further characterize the nature and extent and migration of VOC in ground water beneath the Site via additional borings, wells, and ground-water and soil samples. This purpose was expanded so it required the inclusion of actual subsurface data offshore from the Site. This was accomplished as part of the Site 09 Offshore Investigation during September 1997 through January 1998 by the completion of two mid-harbor borings (SB09-16 and SB09-17) and a monitoring well pair (MW07-32D/R) in the northern portion of Spink Neck. Soil and ground-water were sampled from these borings/wells. Refer to Figure 1-2 for the location of these borings and wells.

**HYDROGEOLOGICAL FRAMEWORK** (Summarized from Chapters 3 and 4)

There are four main soil units overlying quartzite bedrock. The soil units "pinch out" to the north where bedrock crops out.

— Upper sand.

— Silt - not present in south portion of the Site (MW07-19, -21, and -26), nor in the northern portion of Spink Neck. It is present beneath Allen Harbor, as observed at mid-harbor borings SB09-16 and -17. It is comprised of sandy facies beneath the apparent DANC release area.

— Till - generally thin in the north beneath the apparent DANC release area, but thickens toward the southern part of Site.

— Lower Sand - present only in eastern portions of the Site.

- Ground water in the upper sand generally flows to the nearest shoreline. Ground water in the silt, till, and rock appear to flow south to southeast beneath the Site toward a salt water wedge which appears to be just offshore in that area.

- Ground water beneath much of the site is in brackish-to-saline range of salinity. The highest salinity values have been detected in samples from wells along the eastern and southern shoreline of the site with the Bay and harbor entrance channel (similar salinity values as the sample from the Bay) and beneath the northern portion of Spink Neck. Therefore, the higher density salt water wedge is present beneath the eastern portion of the Site, the southern shoreline with the entrance channel, and the northern portion of Spink Neck.

  The presence of salt water is not a surprise considering the eastern portion of the Site and much of Spink Neck (just south of the Site) were part of Allen Harbor prior to 1942, and Narragansett Bay is an extensive salt water body east of the Site.

- It appears that only ground water in the northern portion of the Site, in the vicinity of the DANC release (including the area within approximately 200 ft downgradient) and the area upgradient of the DANC release, plus well cluster MW07-25D/R, is within the freshwater range (<0.5 ppt salinity) (Figures 4-11B, 4-12B, and 4-13B).

- Freshwater/salt water interface

  — The brackish transition zone is wide, generally 300-500 ft.

  — Ground-water flow is interpreted to be southeast. The salt water wedge appears to be near the shoreline in the southern portion of the Site (and beneath Spink Neck) and beneath the eastern portion of the Site at depth. The less dense brackish water would then begin to flow up over the more dense salt water wedge to the south to discharge into the surface water in the

zone that is within a few hundred feet from the shoreline. As shown on Figures 4-6 (Geological Cross Section H-H') and 4-17 (Total CVOC detected in shallow ground-water samples) , the shallow ground water flowing south from the Site appears to discharge to the harbor entrance channel. There are slightly varying vertical gradients that were measured along the south, which are perhaps related to the changing tidal stages in the adjacent surface water (Allen Harbor, entrance channel, and Narragansett Bay). Downward vertical gradients were measured in the vicinity of the DANC release.

— USGS performed borehole geophysical logging of seven wells at the Site. The results (Section 4.6.1.4) support the distribution of brackish and salt water shown on Figures 4-11B through 4-13B, and in general, the results appear to support that the appropriate depth intervals have been screened by monitoring wells to evaluate the extent of the VOC plume, particularly in the southern portion of the Site.

**DANC RELEASE AND MIGRATION** (Figures 4-36 through 4-42)

- The DANC release appears to have occurred in the vicinity of wells MW07-14D and MW07-31I (Figures 4-40 and 4-42).

- The detected VOC in ground water are almost entirely PCA and TCE (perhaps an impurity of the DANC) in the inferred vicinity of the release. A third key VOC, 1,2-DCE, is detected downgradient, and may have been a lesser impurity in the DANC and/or may be a degradation product of the TCE.

- Based upon the VOC concentrations detected in subsurface soil samples, it appears as though residual DNAPL may be present in the till unit adhering to the soil and/or present as ganglia in some of the void space between soil grains in the vicinity of wells MW07-04, -05, -15, and -17. However, DNAPL is apparently not present in sufficient volume to flow freely (free-phase) in these areas of the till unit, because it has not been observed as a separate phase at the bottom of these wells.

- Ground water is interpreted to flow south to southeast through the area where the DANC DNAPL release passed, and picks up dissolved phase CVOC, particularly PCA and TCE (particularly in the till and bedrock units).

- The denser than water DANC migrated via gravity vertically downward through a locally present sandy facies of the silt unit (fresh ground-water zone) and into the underlying till unit and fractures of the bedrock unit (brackish and saline ground-

water zones). The bedrock surface may have temporarily impeded the initial migration of the DNAPL by: (1) focusing some horizontal flow along its slope south southeast toward the southeast-trending valley in its surface in the area where MW07-05D and MW07-17D are now located (Figure 2-1), and (2) confining the downward vertical flow to fractures and fracture zones that extend down into the bedrock unit. [An analogy of this situation could be the pouring of a fluid into a bath tub at the upper edge of the end of the tub (the bedrock surface in the vicinity of the DANC release). However, there are many cracks through the tub floor through which the fluid flows (escapes) before reaching the opposite end of the tub.] It is highly probable that most of the DANC DNAPL is at depth in the bedrock fractures (brackish or saline ground-water zone). Regional flow of ground water through bedrock (from areas of higher head to areas of lower head) is typically not along as direct a route as may be thought for flow through sand or gravel units. In bedrock like that beneath the Site, ground water can only flow through (along) fracture, joint, and bedding plains; not between individual grains as in sand and gravel units. It is probable that some of the key fractures and/or fracture zones through which the DNAPL and ground water must flow in bedrock are not be oriented in the same direction as the approximately southeast regional ground-water flow direction. Rather, some fractures may be locally oriented toward the south or southwest. Ground water would locally flow through such fractures in that direction until reaching other fractures/zones that are oriented more closely to the southeast regional ground-water flow direction. This is believed to be a key reason for the southerly extension of the CVOC plume.

Ground-water samples from wells screening the Upper Sand unit around the inferred release area are ND for CVOC. Based upon the shape of the dissolved-phase CVOC plume in the deep zone and the interpreted direction of ground-water flow (south to southeast), migration of the plume appears to be south and southeast (Figure 4-18). As previously stated, the southern flow component may in part be related to, or enhanced by, flow through interconnected fractures in the bedrock (Figure 4-19) and along the interface with the till unit, including dispersion and the flow dynamics in the fresh/salt water interface (brackish water zone).

Due at least in part to dispersion of the plume as it migrates south from the inferred DANC release area and flow through underlying fracture zones, the west side of the plume in the deep and bedrock zones extend west beyond MW07-25D and -25R (Figures 4-18 and 4-19, respectively). Extrapolation of the data shown on Figure 4-18 suggests that the western edge of this plume may be located approximately 200-300 ft west of MW07-25D. Extrapolation of the data shown on Figure 4-19 suggests the western edge of this plume may be located approximately 200 ft west of MW07-25R. A monitoring well cluster will be installed west of MW07-04D/R and northwest of MW07-25D/R to monitor CVOC concentrations in that area during the long-term monitoring plan (LTMP). The very low concentrations of CVOC detected in ground-water samples from the overlying till from MW07-19D

and -21D may be CVOC associated with a slight vertical flow of ground water up to the till from the bedrock along the fresh/salt water transition (brackish) zone in that area.

- The CVOC plume appears to be present at greater depths with greater distance from the inferred source area. The plume appears to be mostly in the bedrock unit in the vicinity of well cluster MW07-21, except for low concentrations in the till unit and a shallower plume in the vicinity of wells MW07-26S, -19S, and -21S (Figure 4-42). This shallow plume appears to by explained by Site ground-water flow from the affected lower part of the till unit upward along the interface with the nearby salt water wedge. The shallow ground water and the associated dissolved-phase CVOC plume flowing south from the Site appears to discharge to the harbor entrance channel (Figure 4-17).

  Based upon the shape of the plume and the relatively consistent detected presence of PCA, TCE, and 1,2-DCE as the main VOC in ground-water samples, the plume seems to be from one source, except perhaps for the VOC detected in the sample from MW07-26S because the detected 1,2-DCE concentration is higher than the TCE concentration and PCA was ND.

- As stated previously, the general direction of ground-water flow in the deep and bedrock zones beneath the Site is southeast to south (Figures 3-15 through 3-20) and not southwest or west toward Allen Harbor. Ground-water flow in the deep and bedrock zones beneath the Site and Spink Neck is part of the regional flow toward the bay and is not anticipated to be affected by the shallower, localized effects of the entrance channel. Based upon the salinity data from mid-harbor borings SB09-16 and SB09-17, well MW07-32R on Spink Neck, and the onsite wells (Figures 4-11B, 4-12B, and 4-13B), the salt water wedge is present beneath the southern and eastern portions of the Site, Spink Neck, and portions of eastern Allen Harbor. This could result in the flow of some less-dense fresh-to-brackish deep zone ground water from beneath the northern and western portions of the harbor upward along the interface with the denser salt water wedge in the vicinity of mid-harbor borings SB09-16 and SB09-17. As shown on Figure 3-16A (deep zone water surface at mid-tide for both Sites 07 and 09), the general ground-water flow direction from both sites is southeast and south. Therefore, it is anticipated that little, if any, deep and bedrock zone ground water from beneath Site 07 would discharge into the harbor. Further, with regard for potential migration of the Site CVOC plume beneath the harbor, CVOC were not detected in the samples collected from the till unit at mid-harbor borings SB09-16 and SB09-17, nor at MW07-32D on Spink Neck. Additionally, CVOC were not detected in the sample from bedrock at MW07-32R on Spink Neck. Based upon the ground-water level and sample results from the onsite monitoring wells, the two mid-harbor borings, and the well pair (MW07-32D/R) on Spink

Neck, no Site-related CVOC plume was detected crossing beneath the harbor in the till unit (Figure 4-18).

- The portion of the CVOC plume detected in the 'deep' ground-water zone, except the immediate source area, is within brackish ground water (fresh/salt water transition zone), which as stated above in the "Hydrogeological Framework" section, is anticipated to discharge to the south or southeast within the zone that is within a few hundred feet from the shoreline. The offshore sediment was sampled in these areas for the Marine Ecological Risk Assessment (EA 1996a). Upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the shellfish and intertidal sediment (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling conducted to date by the Navy have identified no related unacceptable risk. Additionally, the results (VOC analysis) of EPA's December 1997 sediment samples collected from the interior wetlands (near MW07-13S and MW07-19S), detected only trace concentrations of VOC in a few samples and did not identify unacceptable risk from VOC in shallow ground water potentially discharging to these areas. It must be noted that it is highly probable that most of the DNAPL migrated under the influence of gravity and is at depth in the bedrock fractures within saline ground water. Dissolved-phase CVOC in the saline ground water flowing through this would continue to migrate at depth along with interpreted regional southeast direction of flow.

# 5. FATE AND TRANSPORT

This chapter evaluates environmental fate and transport mechanisms for chemical constituents detected in ground water at the Site to assess the potential for continued migration both on and offsite. This information is critical to the determination of the: (1) current or future potential for contaminant exposure to human populations, and (2) for the evaluation of potential technologies that may be appropriate for remediation of the site. As previously noted in Chapter 1, the Phase III RI addresses the collection and evaluation of data related to the Site 07 ground water, i.e., potential migration of chemical constituents via the ground water from Site 07 east, south, and west toward Narragansett Bay, the entrance channel, and Allen Harbor, respectively.

Two principal factors affect a compound's fate and transport in the environment: (1) physico-chemical characteristics of the compound, and (2) site environmental characteristics. Section 5.1 describes the properties and processes affecting fate and transport. Section 5.2 summarizes the characteristics of the geologic media which can affect chemical fate and transport. Section 5-3 presents the introduction, development, results, and limitations of the solute transport modeling (part of a two-step screening process including: (1) hand calculations using Site data and sediment partitioning theory, and (2) the relatively simplistic computer model AT123D) to assess the viability of modeling the Site subsurface and to obtain a rough estimate of potential site-related sediment and surface water concentrations for comparison to screening criteria.

## 5.1 PROCESSES AND PROPERTIES AFFECTING FATE AND TRANSPORT

Tables 5-1 and 5-2 summarize some of the physico-chemical characteristics of the VOC detected at the Site that can influence their fate and transport. These characteristics are presented in the following sections.

### 5.1.1 Partitioning

Partitioning can control the transport of chemicals in the environment. It is defined as the equilibrium concentrations of a chemical in a system containing multiple phases. The three most common partitioning control mechanism observed in the environment include aqueous-solid phase partitioning, aqueous-gaseous phase partitioning, and solid-gaseous phase partitioning.

#### 5.1.1.1 Aqueous-Solid Phase Partitioning

Aqueous-solid phase partitioning represents the degree to which VOC adsorb (water to solid phase exchange) or desorb (solid to water exchange) between the phases. Although it is often assumed in VOC fate modeling that VOC adsorption is a fully reversible process, several studies have shown that the process is only partially reversible, with the amount of reversibility decreasing the longer the material has been adsorbed (Di Toro and Horzempa 1982, 1983; Voice and Weber 1983). Strongly adsorbed VOC are not available for loss processes such as

hydrolysis and oxidation, and are not readily transported in the dissolved phase. However, because they bind strongly to solid matrices, they can be readily transported via particle transport mechanisms (e.g., surface runoff, suspended sediments in rivers or streams). Partition coefficients are used to quantitate the adsorption and desorption values for the various partitioning phases.

#### 5.1.1.2 Aqueous-Vapor Phase Partitioning

Aqueous-vapor phase partitioning can occur when chemicals dissolved in surface water or ground water comes into contact with overlying air. An equilibrium is established between the chemical's concentration in the aqueous phase and in the air. The commonly applied index for this is the Henry's Law Constant, the ratio of the compound's vapor pressure and water solubility, and has units of atm-$m^3$/moles. This is further presented in Section 5.1.5.

#### 5.1.1.3 Solid-Vapor Phase Partitioning

Solid-vapor phase partitioning occurs in vadose zone soils containing volatile compounds. This partitioning is one of the sources of soil vapor present at sites (the other source is ground water containing these chemicals).

Volatilization from the soil is a mechanism for organic compounds to migrate from soil to the air. Compounds with low vapor pressure (e.g., PAH and some pesticides) will not migrate in the vapor phase but will be associated with suspended and entrained dust. When the VOC associated with soil are exposed to the air, there is the potential for volatilization into the overlying air.

To calculate the flux rate, the concentration of the chemical in the vapor phase $C_g$ (g/$cm^3$) is calculated using the Henry's Law Constant H (atm-$m^3$/mol), gas constant R (8.19 x $10^{-5}$ atm-$m^3$/mol-K), and soil temperature in degrees Kelvin (293 K) as follows:

$$C_g = (C_s * 2E-9 * H)/RT$$

where

$C_s$ = Constituent concentration on the solid phase ($\mu$g/kg)
2E-9 = Conversion factor for bulk density ($\mu$g/kg[g/$cm^3$]$^{-1}$).

Values for H were obtained from U.S. EPA (1992a). The effect of the soil characteristics on vapor phase diffusion is accounted for by using the following equation (Millington and Quirk 1961):

$$D_s = \frac{D_o * (P_a)^{10/3}}{(P_t)^2}$$

where

$D_s$ = Effective vapor phase diffusion coefficient in soil ($cm^2/s$)
$D_o$ = Vapor phase diffusion coefficient in air ($cm^2/s$)
$P_a$ = Air filled porosity ($m^3/m^3$), assumed = 0.14
$P_t$ = Total porosity ($m^3/m^3$), assumed = 0.5.

Values for $D_o$ were obtained from U.S. EPA (1988a) using the calculated $C_g$. The effective diffusion coefficient $D_s$, and the average depth of the volatile chemical in soil (cm), are used to calculate the steady-state flux ($g/m^2$-sec). The model used is that reported by Karimi et al. (1988):

$$J = \frac{-D_s * (C_2 - C_g) * X}{L}$$

where

X = Conversion factor = $10^4$ $cm^2/m^2$
L = Assumed to equal 12 ft or 363 cm (the average depth to ground water).

Table 5-3 summarizes the estimated potential flux rates for VOC from the vadose zone at the site. However, the majority of the VOC detected beneath the Site are at least 10 ft bgs and are below the water table, i.e., below the vadose (unsaturated) zone. A review of Table 5-1 shows that the benzene derivatives, chlorinated alkanes and alkenes, and non-chlorinated alkanes identified at the site would readily volatilize when in contact with the air.

### 5.1.2 Transformations

Compounds present in environmental media may undergo reactions to form new compounds. These are typically subdivided into chemically-induced, photochemically-induced (e.g., photolysis) and biologically-mediated transformations.

#### 5.1.2.1 Chemical-induced Transformations

The most common chemical-induced transformation in the environment is hydrolysis. Hydrolysis is the reaction between the compound and hydrogen ions (H+) or hydroxyl ions (OH-) in the water. Compounds subject to hydrolysis must have functional groups susceptible to attack, such as -COOH or -OH. Hydrolysis is also a pH-dependent process because the susceptibility of the functional groups varies with pH.

Most of the non-acidic compounds identified at the site are not susceptible or are only weakly susceptible to hydrolysis. Those that may be susceptible show the presence of chlorinated groups which are likely the functional groups of attack.

Aromatic acids and phenolic compounds are special cases of hydrolysis, since they can exist in charged or neutral states, depending upon the pH of the water and dissociation constant ($K_a$) of the chemical. The proportions of measured concentration of an organic acid that is dissociated (i.e., charged) is calculated with the following equation (Lyman et al. 1990):

$$\log \frac{M_{A-}}{M_{HA}} = pH - pK_a$$

where

pH = Observed pH in sample
$pK_a$ = Log of $K_a$
$M_{A-}$ = Molar concentration of the dissociated compound
$M_{HA}$ = Molar concentration of the undissociated compound.

Quantification of the extent of the dissociation of an aromatic acid in an aqueous system is important in the evaluation of the chemical's fate and transport. Ionized volatiles differ from their corresponding neutral form in solubility, adsorption, bioconcentration, and toxicity. Aromatic acids and phenolic compounds were not quantified during this investigation. They were not chemicals of concern in the prior phases of the RI.

#### 5.1.2.2 Photochemical Transformations

Photolysis is a chemical degradation process whereby radiant energy (e.g., sunlight) activates covalent bonds within the compound chemical structure making the molecule susceptible to degradation or attack by other chemicals present in the system. Photolysis is a significant process in surficial soil and sediment, surface water, and in the air. Dissolved organic carbon (e.g., humates) in the water column tends to attenuate photolysis of compounds because it can act as a light receptor.

One mechanism for photochemical transformation is by oxidation. Oxidation is the reaction of an oxygen derivative (e.g., oxygen radical, alkyl peroxy radicals) with the compound. The oxygen derivatives required for these reactions are formed via radiant energy so that the potential for oxidation would occur in similar environmental conditions as photolysis. Oxidation involves the removal of electrons from the constituent atoms or functional groups in a compound, while reduction represents the reverse process. Both reactions can influence the mobility and fate of a compound.

Although some of the chemicals reported from the site are susceptible to photolysis, it is not anticipated that there would be significant amounts of photolysis because most of the chemical constituents were detected in the subsurface soil and ground-water samples.

#### 5.1.2.3 Biotransformation

Biotransformation/biodegradation of VOC can be accomplished by both micro-organisms and higher biota. Products of these biotransformations may or may not be toxic to the organism and these products may be further biotransformed by other organisms. Biotransformation includes a variety of enzyme-catalyzed oxidation and reduction reactions.

Several studies have shown that there is the potential for extensive biotransformation of organic compounds in subsurface soil by micro-organisms (Ghiorse and Wilson 1988; Swindoll et al. 1988). Methyl-substituted aromatics, such as toluene and xylenes, degrade in the environment by oxidation to methylbenzaldehyde and methylbenzoate derivatives. The oxidation increases the solubility of the compounds and their mobility in the environment.

The chlorinated alkenes are also susceptible to environmental dechlorination. The typical degradation is shown below:

**tetrachloroethene → trichloroethene → dichloroethene → methylene chloride or vinyl chloride**

The final step represents a splitting of the ethene group to the methyl derivatives, methylene chloride, and vinyl chloride. The degradation products of tetrachloroethene and trichloroethene were identified in site samples. If biotransformation occurs, typically at least two of the chlorinated compounds are observed in the same sample. Review of the analytical results from subsurface soil and ground-water samples suggests that some of biodegradation has occurred at the site. Table 5-4 summarizes the half-lives (in hours) of Site-related compounds in various environmental media. A half-life is the estimated time period for one half of a compound's concentration to degrade.

### 5.1.3 Non-aqueous Phase Layers

Chemical constituents present in excess of their solubility limits can "break" phase with water and form a non-aqueous phase liquid (NAPL) or immiscible phase. NAPL whose prevailing constituent has a density greater than water "sinks" forming a DNAPL. NAPL whose prevailing constituent has a density lower than water "floats" forming a light non-aqueous phase liquid (LNAPL).

Cohen et. al. (1993) have identified 5 characteristics which one can infer the presence of NAPL at a site:

1. The ground-water concentration exceeds 1 percent of the pure phase or effective aqueous solubility of the chemical;

2. NAPL chemical concentrations in the soil exceed 10,000 mg/kg;

3. NAPL chemical concentrations in ground water calculated from soil-water partitioning relationships and soil sample analyses exceed their effective solubility;

4. Organic vapors detected in soil vapor (or sample head space) exceed 100 to 1,000 ppm; or

5. The observed chemical distribution patterns suggest NAPL presence (e.g., large number of chemicals of the same class in the samples).

All but the third characteristic can be evaluated directly from the review of the analytical results. The chemical analysis of soil does not distinguish the true adsorbed portion from the portion dissolved in the pore water, or present as a vaporous phase in the soil pores. Feenstra et al (1991) derived the following equation for saturated soils (i.e., the vapor component is nil) which allows the estimate of the pore water concentration of the chemical.

$$C_{w,eff} = \frac{C_{tot} * \rho_b}{((K_{oc} * f_{oc}) * \rho_b) + n_w}$$

where

$C_{w,eff}$ = Effective pore water concentration (mg/L)
$C_{tot}$ = Observed soil concentration (mg/kg)
$\rho_b$ = Soil dry bulk density
$f_{oc}$ = Organic carbon content of soil (%)
$n_w$ = Water-filled porosity of soil.

The effective pore water concentration is then compared to the water solubilities of the chemicals. If the latter are exceeded, then there is the potential for NAPL to form. The results of this assessment are provided in Section 5.1.3.3.

#### 5.1.3.1 NAPL Properties

The three principal NAPL properties are viscosity, density, and surface tension.

**Viscosity**

Viscosity is given by two terms - absolute (or dynamic) and kinematic viscosity. Dynamic viscosity is the property of a fluid which offers resistance to flow. Kinematic viscosity is the ratio of dynamic viscosity to the density of the fluid. Kinematic viscosity is more useful in

defining the physical state of a fluid as it incorporates the affects of both viscosity and density. Generally, viscosity increases with molecular size, polarity and complexity, and decreases with increasing temperature and degree of halogenation. The rate of vertical migration of NAPL with higher kinematic viscosity was found to be lower than NAPL with lower kinematic viscosity.

**Density**

Density is given by the ratio of the chemical's mass to the chemical's volume and can affect the mobility of the chemical in the subsurface. NAPL with density lower than water (known as lighter than water NAPL - LNAPL) float on the ground water and the NAPL with density higher than water (known as denser than water NAPL - DNAPL) sinks through the ground water. The mobility of LNAPL is different from DNAPL. Generally DNAPL has higher molecular weight compounds and greater degree of halogenation. Small differences (approximately 1 percent) in density can affect the NAPL mobility in the subsurface. Density depends on temperature; higher the temperature lower the density. The mole fraction of individual components within the NAPL contributes to the overall density of the NAPL.

**Surface Tension**

Surface or interfacial tension is the surface energy at the interface between immiscible phases and is given by the ratio of force acting on the interface to the interface area. Generally, surface tension increases with halogenation and decreases with temperature. Surfactants and hydrophobic solvents can reduce the interfacial tension between two phases, which can result in dissolution of the NAPL. NAPL in the subsurface can be held in the pore space, as discontinuous droplets (called ganglia) due to surface tension, thereby reducing its mobility in the subsurface. Upon dehalogenation, due to chemical or biological reactions, the products become more mobile as the surface tension between the ganglia and soil surface is reduced. Also, addition of surfactants or hydrophobic solvents reduce the surface tension between the ganglia and the soil surface. The NAPL molecule attached to the soil surface is preferentially replaced by the hydrophobic portion of the surfactant or molecules of hydrophobic solvent, thus increasing the mobility of NAPL in the subsurface.

### 5.1.3.2 NAPL Processes

Migration of the NAPL in the saturated zone is primarily effected by relative permeability of the aquifer solids. The soil's retention capacity can decrease the volume of the NAPL that is moving, resulting in the formation of discontinuous NAPL or ganglia in the saturated layer.

**Gravity Flow**

Gravity is more predominant on DNAPL than LNAPL and it promotes the vertical downward migration of DNAPL. The pressure of DNAPL on water during its migration in the saturated

zone is given by product of the length of DNAPL, gravity and the difference in the densities of DNAPL and water.

**Advective Flow**

Advection is the process of transportation of non-reactive constituents by the bulk motion of the ground water and is given by the average velocity of ground water. Without any retardation factors in the subsurface, the extent of constituent transport can be predicted by the advective flow of ground water. However, many factors such as partitioning, constituent transformation reactions, dissolution, and dispersion affect the constituent mobility. Hydraulic conductivity, porosity, and hydraulic gradient control the advective flow of the ground water.

**Residual Saturation**

This is the term typically applied to where NAPL is sorbed to the soil particles and may fill the voids between the soil particles, but is not of sufficient quantity to overcome the capillary force and flow freely in the subsurface.

### 5.1.3.3 Site Evaluation

The VOC concentrations detected in ground-water samples were compared to the NAPL characteristics presented in Section 5.1.3. Table 5-5 summarizes pertinent data for the comparison of the detected ground-water concentrations to the 1 percent criterion (NAPL characteristic 1 of Section 5.1.3) and the effective pore water concentration (NAPL characteristic 3 of Section 5.1.3). The latter values were calculated assuming the soil dry bulk density of 1.88 g/cm3, soil organic carbon content of 0.6 percent, and a water-filled soil porosity of 0.3. Review of this table shows that the maximum detected concentrations for TCE (120,000 $\mu$g/L; MW07-17D) and 1,1,2,2 PCA (77,000 $\mu$g/L; MW07-04D) were approximately 10.9 percent and 2.7 percent, respectively, of the corresponding water solubility and thus, exceeding the 1 percent criterion. The 1 percent criterion was also exceeded for TCE as detected in four other ground-water samples (MW07-04D, MW07-05D, MW07-05R, and MW07-15D) and for 1,1,2,2-PCA as detected in three other ground-water samples (MW07-05D, MW07-15D, and MW07-17D). The calculated effective pore water concentrations were less than the corresponding water solubilities. These results suggest that residual NAPL may be present in subsurface soil in the vicinity of MW07-04D, MW07-05D/R, MW07-15D, and MW07-17D. Down the slope of the upper surface of the bedrock from this area into which DNAPL may have flowed, three hydroprobes (HP-10, -24 and -14) were driven to refusal to in part evaluate the potential presence of DNAPL ( Figure 2-1A). The deep hydroprobe-sample depths are approximately at the interpreted depth to the top of competent bedrock. Ground-water samples were collected from the bottom of these hydroprobe locations and total CVOC was detected at 7890 $\mu$g/L, 408 $\mu$g/L, and 24 $\mu$g/L, respectively, which is not suggestive of the presence of DNAPL.

Additionally, the potential presence of free flowing separate-phase liquid DNAPL was evaluated via field observations (e.g., solvent rather than ground water draining from a soil sample with a strong solvent odor similar to that from a dry cleaner, and/or presence of anomalously high soil sample headspace measurements, presence of observable separate-phase liquid in water samples collected during the hydroprobe survey, or in water collected from wells obtained during well development or purging/sampling along with a strong solvent (dry cleaner) odor). However, DNAPL was not measured in any of the wells during the installation, development, purging, or sampling of the hydroprobes or monitoring wells; and none of the aforementioned field conditions were observed that would indicate the presence of DNAPL.

### 5.1.4 Dissolved Phase

Dissolved phase properties are chemical-specific characteristics which affect the ability of the chemical to dissolve in water.

#### 5.1.4.1 Dissolved Phase Properties

**Water Solubility**

Water solubility is a measure of the compound's ability to dissolve in water, and is typically expressed in a unit of mass/volume (e.g., mg/L or $\mu$g/L). Aqueous solubility is one factor that can affect the compound's water concentration and residence time in water. Compounds with high water solubility tend to remain in solution while compounds with low water solubility tend to go out of solution or are lost to more hydrophobic surfaces. A review of Table 5-1 shows that aromatic volatiles (including xylene and toluene) have a lower water solubility than some of the chlorinated compounds (e.g., trichloroethene) that were identified at the site.

**Partition Coefficients**

Partition coefficients are concentration ratios of the chemical between two phases, and include $K_{ow}$, $K_d$ and $K_{oc}$; all have units of L/kg. The $K_{ow}$ is the octanol-water partition coefficient, quantifying the concentration ratio of the compound in the octanol (organic) phase and aqueous phase. The octanol is used as a surrogate for lipids. Hence, the $K_{ow}$ is often related to compound partitioning from water to biota. The $K_d$ is the concentration ratio of the compound between a solid and aqueous phase at steady-state. The $K_d$ is a constant for inorganic analytes (i.e., metals) but varies for organic analytes. The latter phenomenon led to the use of the $K_{oc}$, which is the organic carbon-water partition coefficient. The product of the compound's $K_{oc}$ and the organic carbon content of the site soil or sediment is the site-specific $K_d$ for the compound. High values for $K_{ow}$, $K_{oc}$, and $K_d$ indicate a preference of the compound for non-aqueous phases. Low partition coefficients indicate that the compound has a preference for the aqueous phase which results in increased mobility due to the movement of ground water. Compounds such as VOC are soluble and when in the aqueous phase tend toward a dissolved form.

**Molecular Weight**

The molecular weight of the chemical can also affect a compound's transport in the environment. It is a fundamental parameter, which is correlated with the compound's other physico-chemical parameters. Generally, within a class of compounds (e.g., alkanes), the greater the molecular weight, the lower the water solubility, the lower the volatility, and the longer residence time (longer time to mineralization) in the environment. These generalities do not cross-over between chemical classes.

### 5.1.4.2 Dissolved Phase Processes

Dissolved phase processes affecting a compound's fate include advection and dispersion.

**Advection**

Advection is the transport of non-reactive compounds by the bulk motion of the ground water and is given by the average velocity of ground water. Without any retardation factors in the subsurface (due to partitioning to the aquifer solids), the extent of compound transport can be predicted by the advective flow of ground water. However, many factors such as partitioning, compound transformation reactions, dissolution, and dispersion affect compound mobility. Hydraulic conductivity, porosity, and hydraulic gradient control the advective flow of the ground water through the aquifer solids.

**Dispersion**

Dispersion of a compound in ground water is given by two factors: (a) mechanical dispersion coefficient which is proportional to ground water velocity and is influenced by the pore scale velocity profile and pore geometry, and (b) effective molecular diffusion coefficient which is given by the compound diffusion coefficient and is influenced by tortuosity of the medium. Dispersion accounts for the variation in the longitudinal migration of the compound (along the ground- water flow path) and transverse migration of the compound (perpendicular to the ground water flow). Large transverse dispersivity could spread the compound plume in ground water over the entire thickness of the aquifer. Longitudinal dispersivity of a compound is affected by the aquifer heterogeneity. Compound plumes in ground water move more rapidly in layers with higher permeability than in layers with lower permeability.

### 5.1.5 Gaseous and Vapor Phases

Vapors are defined as chemicals which under standard temperature and pressure can exist in liquid and diffuse phases. Gases are those chemicals (e.g., methane) which under standard temperature and pressure can exist only in the diffuse phase.

#### 5.1.5.1 Vapor and Gaseous Phase Properties

**Vapor Pressure (Raoults Law)**

Volatilization describes the movement of a VOC from the surface of a liquid or solid matrix to the vapor phase. Generally, only the neutral (uncharged) form of a VOC can volatilize. Volatilization is calculated from the equilibrium vapor pressure which is essentially the solubility of the VOC in air (quantified as a partial pressure).

**Vapor Pressure (Henry's Law)**

For purposes of quantifying a VOC's fate in the environment, a more manageable index is the Henry's Law Constant, which is the ratio of the compound's vapor pressure and water solubility, reported in units of atm-$m^3$/moles. Lyman et al. (1990) proposed that compounds with Henry's Law Constants of $> 10^{-3}$ are readily volatilized, compounds with Constants of $10^{-3}$ to $10^{-5}$ are significantly volatilized, and compounds with Constants of $< 10^{-5}$ have limited volatility.

#### 5.1.5.2 Vapor and Gaseous Phase Processes

The two environmentally pertinent inter-media transport processes for vapors are water-to-soil pore diffusion, and soil-to-air diffusion. Vapors may undergo dispersive transport once in the air. Gases may also diffuse within the aqueous phase.

## 5.2 SITE ENVIRONMENTAL CHARACTERISTICS AFFECTING CHEMICAL FATE AND TRANSPORT

The environmental characteristics of the site that can influence the fate and transport of compounds present, including geology, hydrology, and climate. This information is presented in Sections 3.3, 3.6.2, and 3.7.5.

### 5.2.1 Soil

The six principal soil characteristics affecting chemical transport are porosity, permeability, organic carbon content, density, pH and Eh.

#### 5.2.1.1 Porosity

Porosity is defined as the percentage of the volume of bulk soil that contains pore spaces, and is an index of how much water can be stored in the saturated soil. Because of the horizontal and lateral variability of silt and/or sand content of the unconsolidated soil geological units underlying the Site, the porosity of each unit would not be a single number, but rather a range of values. Therefore, selecting values from published literature is reasonable for the

geological materials observed to comprise each of the units beneath the Site. Porosity values used in the solute transport model are presented in Sections 5.3.6.2, 5.3.7.1, and 5.3.7.3.

The following presents published total porosity ranges (Sharp-Hansen 1990). The effective porosity typically used in a model is less than the total porosity.

**Porosity Ranges**

| Material | Total Porosity |
|---|---|
| Silt | 0.34-0.61 |
| Sand, fine | 0.26-0.53 |
| Sand, course | 0.31-0.46 |
| Gravel, fine | 0.25-0.38 |
| Gravel, course | 0.24-0.36 |
| Granite, weathered | 0.34-0.57 |
| Schist | 0.04-0.49 |
| Fractured crystalline rock | 0.0-0.10 (a) |

a) Freeze and Cherry, 1979

### 5.2.1.2 Permeability

Permeability, also called hydraulic conductivity, is a measure of the ability of ground water to move through a geologic formation. Hydraulic conductivity for the hydrogeological layers was determined using three data sources (slug test data, water level and tidal monitoring data, and the geological material) which has been previously described in Section 3.7.7.

### 5.2.1.3 Organic Carbon Content

The organic carbon content of the solid phase (typically quantified as total organic carbon, TOC) can significantly affect the retardation of organic chemicals in ground water. As stated in Section 5.1.4.1, the organic carbon content is used with the $K_{oc}$ values to calculate partitioning of organic chemicals to solids. TOC has a less significant affect on the partitioning of inorganics to the solid phase. The TOC concentrations detected in eight soil samples from the Site are summarized in Table 4-3. The measured TOC concentrations at Site 07 are typical of low organic sand and gravel. Based upon these results, it is not anticipated that there would be significant retardation of chemicals exhibiting $K_{oc}$ values of less than $10^3$.

### 5.2.1.4 Density

Soil density is the mass of soil per unit volume of soil, and is most commonly reported as a soil bulk density. It is inversely related to particle size. As the particle size decreases (e.g., as

one moves from sand to clay) the soil density increases. Accordingly, retardation is directly related to soil density.

Soil bulk density was not determined at this site. Similar to porosity, the selection of values from published literature is considered reasonable to represent the geological materials beneath the Site.

**Bulk Density Ranges**

| Material | Bulk Density ($g/cm^3$) |
|---|---|
| Silt | 1.01-1.79 |
| Sand, fine | 1.13-1.99 |
| Sand, course | 1.42-1.94 |
| Gravel, fine | 1.60-1.99 |
| Gravel, course | 1.69-2.08 |
| Granite, weathered | 1.21-1.78 |
| Schist | 1.42-2.69 |

(Sharp-Hansen 1990).

### 5.2.1.5 pH and Eh

The relationship between pH and Eh influences the valence state of metal constituents, which in turn affects its behavior in the environment. Therefore, the pH and Eh of the soil (and ground water) can influence the apparent $K_d$ of metal constituents.

## 5.2.2 Ground Water

The pertinent characteristics of ground water which can influence chemical fate and transport include salinity, pH and Eh, temperature, dissolved oxygen, and biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

### 5.2.2.1 Salinity

Salinity is defined as the weight (in grams) of dissolved inorganic chemicals per kilogram of water, after the bromide and iodide ions are converted to equivalent chloride ion, and all bicarbonate and carbonate ions are converted to the oxide (Stumm and Morgan 1981). The salinity of the water affects the water solubility of the chemicals. As salinity increases, the potential regions between the water molecules decreases (since they are occupied by the cations and anions from the salt), which can reduce the solubility of the test chemical. Lyman et al (1990) has provided the following equation defining this phenomenon:

$$\log[\frac{S^o}{S'}] = K_s * C_s$$

where

$S^o$ = Molar solubility of the chemical in pure water
$S'$ = Molar solubility of the chemical in salt solution
$K_s$ = Empirical salting parameter
$C_s$ = Molar salt concentration.

Refer to Section 4.6.1.4 for the Site-specific evaluation of the effect of salinity (salt water wedge) on ground-water flow.

#### 5.2.2.2 pH and Eh

The pH of the ground water is directly related to the solubility of organic acids (e.g., benzoic acid) and inversely related to the solubility of the organic bases, although it is not anticipated to significantly affect the solubility of neutral organic compounds.

Ground-water pH and Eh can affect the mobility of metals by two mechanisms. First, as the pH of the ground water lowers, there is greater potential for the "extraction" of metals from the solid phase. Second, the relationship between pH and Eh influences the valence state of the metal, which in turn affects its behavior in the environment. Therefore, the pH and Eh of the ground water can influence the apparent $K_d$ of the metal.

The pH of the ground water at this site was close to neutral, with the measured Eh falling within the slightly reduced to slightly oxidized range (i.e., Eh ranging from $-10^2$ to $+10^2$ mV). Therefore, published $K_d$ values would be appropriate for evaluating the retardation of metals in the ground water at the Site.

#### 5.2.2.3 Temperature

The chemical's solubility in water is a function of temperature, but the magnitude and direction of the solubility change is not consistent over all chemical classes (Lyman et al. 1990). Generally, it is anticipated that the solubility of the chemical can increase with increasing temperature.

#### 5.2.2.4 Dissolved Oxygen

The dissolved oxygen content of the ground water determines whether there is the potential for aerobic or anaerobic biodegradation of dissolved chemicals. It is also an indicator of the potential exchange between the ground water and atmosphere.

#### 5.2.2.5 BOD/COD

BOD measures the oxygen uptake in the microbiologically-mediated degradation of organic matter, while COD measures the amount of oxidizing agent required to oxidize the organic matter under sterile conditions (Stumm and Morgan 1981). Lyman et al (1990) used the ratio of BOD and COD as an index for potential biodegradability, as follows:

- BOD/COD ratio < 0.01: relatively undegradable
- BOD/COD ratio of 0.01 to 0.1: moderately degradable
- BOD/COD ratio > 0.1: relatively degradable

The ground-water samples for this phase of the investigation were not analyzed for BOD and COD, so the assessment of potential biodegradation at the site could not be performed.

### 5.2.3 Atmosphere

The pertinent site environmental characteristics affecting the air quality at the site include local meteorology, and the affect of site topography and demography on atmospheric mixing and chemical sources, and potential exposure receptors.

#### 5.2.3.1 Meteorological Data

Meteorological data for the site vicinity was summarized in Section 3.3, and was based upon information collected at the National Weather Service Station located at the T.F. Green Airport in Warwick, Rhode Island. This airport is located approximately 6.5 miles north of the site. Local weather patterns are continuously modified by the dynamic effects of Narragansett Bay and the Atlantic Ocean.

#### 5.2.3.2 Site Topography and Atmospheric Mixing

Site topography, and the topography of adjacent areas, can influence atmospheric mixing at the site. The elevation of Site 07 surface ranges from mean sea level (at the east, south, and southwest perimeters of the Site) to about 20 ft above MSL (MW07-07S). Approximately 400 ft north of the area where the DANC release is inferred to have occurred, there is a single, localized topographic high of approximately 55 ft above MSL, a hill of outcropping rock, which is not anticipated to have significant overall impact on the air flow across the site.

Box models are commonly applied to assess chemical exposures from air. Because the Site surface shows only minor changes in elevation across the Site (typically 20 ft) coupled by low emission rates for constituents of concern (COC), the effects of mixing are anticipated to be minor and therefore, a box model was not used for the Site. Additionally, much of the detected COC are below the water table, i.e., typically 10-18 ft bgs, and thus, not directly exposed to the atmosphere. The ambient concentration ($C_i$; $g/m^3$) of the $i^{th}$ analyte can be calculated using the following equation:

$$C_i = \frac{Q_i}{(H/2) * W * V}$$

where

$Q_i$ = Emission rates of compound I (gm/sec)
H = Height of the box (mixing height; m)
W = Cross wind width of the source (m)
V = Wind velocity (m/sec).

The mixing height (H) of the box model is related to the receptor distance and site topography. It can be calculated using the following equation by successive substitution:

$$X = 6.25 \times (H/Z \ln [H/Z] - 1.58[H/Z] + 1.58)$$

where

X = Downwind receptor distance (m)
Z = Roughness height of the site (m).

Cowherd et al. (1985) has provided a scale for the value of Z corresponding to different site conditions. As the Z-value increases, the amount of turbulence increases, increasing the mixing height of the box.

## 5.3 FATE AND TRANSPORT SCREENING PROCESS

### 5.3.1 Purpose, Limitations, and Introduction Of Work Performed

The ground-water modeling portion of this screening process was based upon a Technical Memorandum of Understanding, in which it was agreed to preliminarily evaluate the potential pathways from the Site via hand calculations (first step) and/or simple models (second step)...under selected worst-case scenarios. The sediment partitioning theory and Site data were used in the hand calculations step and the AT123D model was used in the simple modeling step of the screening process. The computer modeling was not intended to be robust or to be used for prediction of future plume conditions. Rather, the purpose of the modeling

work was to preliminarily assess: (1) VOC in ground water beneath the site along a 2-dimensional North-South slice through the Site (along the plume, where the silt unit pinches out, toward the harbor entrance channel), (2) the appropriateness of continued model refinement and/or development of a site-wide 3D model, and (3) roughly estimate the potential Site contribution of VOC and dissolved metals in shallow ground water to near shore sediment and Allen Harbor. This modeling work was performed prior to the Site 09 Offshore Investigation, during which offsite CVOC and metals ground-water sample data were collected from beneath the adjacent Allen Harbor and Spink Neck. These data added to the understanding of the offsite nature and extent of VOC and metals. The results of that Offshore Investigation are included in Sections 4.6 and 4.7, Ground-Water Results and Site Conceptual Model, respectively. The following provides documentation of the work and results of the screening process and the variation from actual conditions. Although VOC were not identified in the Marine or Freshwater/Terrestrial Ecological Risk Assessments (MERA and TERA, respectively) as COC with unacceptable risk to the environment, VOC have been selected for this screening process because they are the organic compounds detected at the site and they provide an indication of the plume presence and migration from the inferred release area.

In the first step (hand calculations), the direct discharge of ground water to surface water was examined using site average and near shore well concentrations with particular emphasis on the elevated CVOC concentrations at MW07-19S and MW07-21S, as well as the sediment partitioning theory to roughly estimate related sediment concentrations for comparison to sediment screening criteria. For estimated CVOC and metals values which were not below screening criteria in the first-step analysis, the AT123D model (second-step analysis) was applied to evaluate if dispersion and/or decay processes occurring between the near shore wells and the shoreline would provide additional attenuation that may result in the estimated CVOC or metal concentration decrease to below the screening criteria. The AT123D model was, therefore, applied to only small areas of Site 07 and used site parameters ( hydraulic conductivity, hydraulic gradient, aquifer thickness) specific to those areas.

The two-step screening evaluation primarily used the more extensive Phase III RI chemistry data and had the following two principle work elements:

- Assessment of the contribution to near shore sediment and Allen Harbor entrance channel surface water from VOC and dissolved metals detected in Site shallow ground-water samples as modeled from the vicinity of shallow wells MW07-19S and MW07-21S which are located approximately 240 and 100 ft, respectively, north of the shoreline with the Allen Harbor entrance channel. This was the only area along the Site shoreline where site-related VOC were detected in shallow ground-water samples. Overall, the Site hydrogeology was found to be more complex than could be well simulated by the relatively simplistic AT123D computer model. However, because of the relatively short distances assessed in this work element, the results are presented as a rough estimates for comparison to the results of samples collected for the MERA and Offshore Investigation. The HHRA and MERA

used the results of analyzed samples and not those estimated from this screening work.

- Assessment of the constituent plume from the area of maximum detections to the shoreline in the deep ground-water zone (deep/rock wells). Overall, the Site hydrogeology was found to be more complex than could be well simulated by the relatively simplistic AT123D computer model. However, a description of the work performed and the results are provided as important documentation of this activity and the related limitations Additionally, please refer to Sections 4.6 and 4.7, Ground-Water Results and Site Conceptual Model, respectively, where the site-specific CVOC and metals ground-water data are presented for samples that were collected during part of the Offshore Investigation after completion of this modeling work. The results of that investigation did not confirm the presence of VOC plume from the Site crossing beneath Allen Harbor or the entrance channel.

The two-step screening was performed for both the shallow and deep/rock well groupings. For the shallow well group, the first-step VOC screening was performed for both the site-wide geometric mean of detected VOC concentrations and the VOC concentrations detected in samples from MW07-19S and MW07-21S. The geometric mean was calculated using only the well samples where an analyte (constituent) was detected; i.e., nondetects were not included. The geometric mean and the two near shoreline well concentrations were used to estimate sediment concentrations using equilibrium sediment partitioning theory. In the second-step VOC screening, the AT123D model was used to estimate shoreline VOC concentrations resulting from detected concentrations in samples from MW07-19S and MW07-21S with the inclusion of retardation effects and biodegradation.

The first-step metals screening for the shallow well group used the site-wide geometric mean concentration and the maximum concentration from one of 6 selected wells (MW07-13S, -19S, -20S, -21S, -23S, and -24S) located in the southern portion of the Site in the vicinity of the Allen Harbor entrance channel.

As part of the shallow well group analysis, the estimated mass loading from the Site at the shoreline was input to the Allen Harbor surface water model, developed as part of the Site 09 Phase III RI, to estimate surface water concentrations that may result from Site 07.

For the deep/rock well group, first-step screening employed sediment partitioning using a site-wide geometric mean concentration (calculated from only the well samples where an analyte was detected) and a site-wide maximum detected concentration. Second-step screening for the deep/rock well group employed the AT123D model to estimate the extent of the constituent plume from the area of maximum concentration towards the shoreline, and also to estimate the potential extent of a plume under the Allen Harbor entrance channel.

### 5.3.2 Screening Criteria And Partitioning Coefficients

A sediment screening criteria was determined for each VOC and metal constituent detected in the Site ground-water data (Table 5-6). The principle reference for these values was the Marine and Facility-Wide Freshwater/Terrestrial ERA reports (EA 1996a and EA 1996b, respectively). The Marine report contained sediment screening criteria based upon the selection of a minimum value from several effects concentrations (EA 1996a, Table 3.3-2). The Facility-wide Freshwater/Terrestrial ERA report (EA 1996b, Table 4-16) was used for values not available from the Marine ERA report. Sediment screening criteria for some constituents in the Freshwater/Terrestrial ERA report are based on 1 percent total organic carbon (TOC) and in the Marine report on a 5 percent TOC. For use in the ground-water modeling screening evaluation, the criteria have been adjusted to be uniformly based on 1 percent TOC, i.e., those based on 5 percent TOC were divided by 5. Sediment screening criteria were calculated for the remaining constituents based upon equilibrium partitioning using a chronic AWQC value and a 1 percent TOC. The use of a 1 percent TOC for calculating many of the screening criteria, and the use of a 5 percent TOC for performing the modeling evaluation results in a five-fold safety factor.

The marine ecological risk pathway from sediment is primarily considered to be through the shallow ground water. Therefore, estimated ground-water constituent concentrations will also be compared to AWQC. Directly comparing ground-water to surface water quality also avoids potential inconsistencies which may arise due to variation in the selection of the sediment partitioning coefficients. The AWQC provided in Table 5-6 are preferentially marine chronic values. If a marine chronic value was not available, then the freshwater chronic value was used. If only an acute value was available, it was divided by a factor of 20 to represent a chronic-criteria, the procedure followed in the Freshwater/Terrestrial ERA report.

Table 5-6 also includes sediment partitioning coefficients, Koc for VOC and Kd for metals. The Koc were obtained from several sources (SRC 1995, Howard 1990, Karickoff et al 1991). The Kds were initially taken from Baes (1984). It is recognized that considerable variation is present in the literature for partitioning coefficients. A second reference (EPA 1994), was used for comparison and the higher of the two Kd values used. The values from Baes exceeded the values from the second reference for arsenic, nickel, and thallium. An EPA value of 420 was used for zinc rather then the 40 from Baes. For copper, an upper range value of 336 was obtained from Battelle (1989) rather than using the value of 35 from Baes.

### 5.3.3 Detection Frequency

The Phase II and III RI sample detection frequency (for the shallow wells, the deep/rock wells and for the total site), Site geometric mean, and Site maximum detected values for VOC in ground-water samples are provided in Table 5-7. The geometric means are calculated from only the samples where a constituent was detected; i.e., nondetects were not included. Similar statistics for metals detected in Site ground-water samples are provided in Table 5-8.

Table 5-8 also indicates which metals were reported as sediment COC from the MERA and TERA reports. No VOC were reported as sediment COC in the Marine or Freshwater/Terrestrial ERA reports.

An examination of Table 5-7 indicates that Site geometric mean and Site maximum detected VOC concentrations were greater during the Phase III RI sampling than during Phase II. In general, this is because the Phase III RI ground-water sample database is considerably more extensive and includes more sample locations from within the source area and plume. Therefore, the VOC screening analysis used the recent and more extensive Phase III RI data set. Also, the metals screening analysis used the recent and more extensive Phase III RI ground-water sample data set. These samples were collected using the low-flow purge and sample method.

### 5.3.4 First-Step Screening - Shallow Wells

The first-step screening for shallow wells estimated sediment concentrations using equilibrium sediment partitioning theory. For VOC, this was performed using the shallow site-wide geometric mean concentration and the concentration at wells MW07-19S, and particularly MW07-21S. These are the only two wells screened near the water table (shallow zone) for which VOC were detected in the ground-water samples and which are located near the Site shoreline, and specifically along the Allen Harbor entrance channel.

For metals, the first-step screening analysis was performed using the maximum concentration detected samples from the six wells located near the Allen Harbor entrance channel, and also, for the shallow site-wide geometric mean concentration.

#### 5.3.4.1 VOC

The Phase III RI shallow well sample detection frequency, site-wide geometric mean, detected concentrations at MW07-19S and MW07-21S, and the related AWQC are provided in Table 5-9. This Table indicates that of the 9 VOC detected in samples from the site, only 1,1,2,2-PCA, 1,1,2-TCA, 1,2-DCE, and TCE were detected in the ground-water samples from MW07-19S and MW07-21S. For the sample from MW07-19S, the detected value for 1,1,2-TCA and TCE was the Site maximum for shallow ground water; and for 1,2-DCE, the detected value exceeded the Site geometric mean for shallow ground water.

The screening analysis summarized in Table 5-9 was performed using a 5 percent TOC value for sediment. Estimated sediment concentrations for four parameters (1,1,2,2-PCA, 1,1,2-TCA, 1,2-DCA, and 2-butanone) were below screening criteria as a result of this analysis. Sediment screening criteria are not available for acetone or vinyl chloride. Three parameters did not screen out, 1,2-DCE and TCE which were detected in samples from MW07-19S and MW07-21S, along with PCE based on the Site-wide geometric mean value, but was not detected at the near shore wells. The VOC which were estimated to not be below sediment screening criteria are discussed in further detail below.

**1,2-Dichloroethene (1,2-DCE)**

The sediment screening criteria was calculated using a 1 percent TOC and a water quality criteria determined by dividing a freshwater-acute by twenty. The detected 540 $\mu$g/L concentration in the sample from MW07-21S is below the AWQC (580 $\mu$g/L) and is located closest to the shoreline (within approximately 100 ft).

**Tetrachloroethene (PCE)**

PCE was not detected in samples collected from shallow wells located along the perimeter/shoreline of the Site, and is not expected to migrate from the Site shallow ground-water to Allen Harbor, the entrance channel, or Narragansett Bay.

**Trichloroethene (TCE)**

The sediment screening criteria from the MERA report of 230 $\mu$g/Kg is consistent with a value which would result from the 100 $\mu$g/L AWQC (marine-acute/20).

No VOC were identified as sediment COC in either the Marine or Freshwater/Terrestrial ERA Reports.

**5.3.4.2 Metals**

The six shallow (S) wells in the vicinity of the shoreline with Allen Harbor, the entrance channel, and Narragansett Bay (between wells MW07-23S on the west and MW07-20S on the east), were examined to identify the highest concentration for inclusion in the shallow ground-water metals screening analysis. The macro-nutrients calcium, magnesium, potassium, and sodium were not included in the analysis. Of the remaining 10 metals detected in ground-water samples from the Site, seven were detected in samples from the six selected shoreline wells. Metal concentrations at these six wells and the maximum concentration from any one of the six wells which was used in the screening analysis are provided in Table 5-10. The Phase III RI shallow (S) well sample detection frequency, site-wide geometric mean, maximum concentration from the six selected shoreline wells, and the related AWQC are provided in Table 5-11.

The sediment screening was performed for the maximum near shoreline concentration detected in samples from the six selected wells and also for the Site-wide geometric mean concentration for the 10 metal constituents (analytes). The results of this shallow well sediment screening analysis for metals is provided in Table 5-11. Using the site-wide geometric mean concentration, all metals were below sediment screening criteria except for iron. Using the maximum concentration of the seven metals detected in samples from the six selected near shoreline wells, only iron and manganese were above sediment screening criteria. However, the site-wide maximum detected concentration of manganese (3,830 $\mu$g/L) in ground-water is only slightly above the NCBC background concentration of 3,292 $\mu$g/L (Stone & Webster

Environmental Technology & Services 1996), and only four of the site-wide samples had detected concentrations above the NCBC background concentration.

Iron was not identified as a sediment COC in the Marine or Facility-Wide Freshwater/Terrestrial ERA reports. However, manganese was identified as a sediment COC, but in only the Freshwater/Terrestrial ERA report.

### 5.3.5 First-Step Screening Of Deep/Rock Wells

The first-step screening for deep/rock wells estimated sediment concentrations using the sediment partitioning theory. For both the VOC and metal analysis, the site-wide geometric mean and maximum concentrations were used.

#### 5.3.5.1 VOC

The Phase III RI sample detection frequency, site-wide geometric mean, site-wide maximum concentration of VOC detected in samples from the deep and rock wells, and the related AWQC are provided in Table 5-12. Of the 22 VOC detected, 12 VOC had only a single detection among the samples from the 29 deep/rock monitoring wells. The results of the equilibrium sediment partitioning analysis is also provided in Table 5-12 for the site-wide geometric mean and maximum detected concentration values for each constituent. Using the geometric mean concentrations, 11 VOC were below the sediment screening criteria and screening criteria were not available for three constituents (acetone [probably from the isopropanol decontamination fluid], chloromethane, and vinyl chloride). The remaining eight VOC which exceeded sediment screening criteria when using the geometric mean concentrations and a 5 percent TOC are summarized in the following table.

**VOC in Deep/Rock Wells Above Sediment Screening Criteria After First-Step Screening**

| Parameter | Phase III RI Sample Detection Frequency | Concentration in Water (μg/L) | | Estimated Sediment Conc. (μg/kg) | |
|---|---|---|---|---|---|
| | | Site GeoMean | AWQC | Estimated Sed. Conc. for 5% TOC | Sediment Screening Criteria |
| 1,2-DCE | 16/29 | 253 | 580 | 443 | 203 |
| cis-1,3-Dichloropropene | 1/29 | 66 | 244 | 307 | 227 |
| Benzene | 1/29 | 550 | 700 | 2,695 | 610 |
| Chlorobenzene | 1/29 | 100 | 50 | 1,375 | 588 |
| Styrene | 1/29 | 72 | not determined | 3,132 | 1,750 |
| PCE | 5/29 | 294 | 450 | 5,329 | 60 |
| TCE | 17/29 | 2,195 | 100 | 11,414 | 230 |
| Xylenes | 1/29 | 220 | 1,340 | 2,123 | 40 |

Of these eight VOC, only chlorobenzene and TCE exceeded the AWQC. This indicates that the remaining VOC would not be expected to pose a significant risk to Allen Harbor sediment or surface water. The constituents 1,2-DCE, cis-1,3-dichloropropene, benzene, and styrene, would meet sediment screening criteria with a 1 percent TOC.

The 11 VOC constituents which were estimated to be below the sediment screening criteria when using a geometric mean concentration were also below the sediment screening criteria when using the maximum detected value, except for 1,1,2,2-PCA (Table 5-12).

Based upon the results of the MERA and TERA which used sediment sample data in the assessments, VOC were not identified as COC, ie. they do not pose unacceptable risk to the environment.

### 5.3.5.2 Metals

The Phase III RI sample detection frequency; site-wide geometric mean, and the site-wide maximum concentration of metals detected in samples from the deep (D) and rock (R) wells, and the related AWQC are provided in Table 5-13. Two metals (beryllium and nickel) which had a single detect in samples from the shallow wells, were not detected in samples from the deep/rock wells. However, cobalt and mercury were detected in samples from the deep and rock wells, but not in samples from the shallow wells.

The results of first-step screening of metals for the deep/rock well group using equilibrium sediment partitioning analysis are presented in Table 5-13 and are very similar to the results for the shallow wells (Section 5.3.4.2). The only metal which was not estimated to be below sediment screening criteria using a site-wide geometric mean concentration was iron. Using the site-wide maximum concentration, one additional metal, manganese, was estimated to be above the sediment screening criteria. Site-wide concentrations and sediment screening criteria for iron and manganese are summarized below.

**Metals in Deep/Rock Wells Above Criteria After First-Step Screening**

| | Concentration ($\mu$g/L) | | | Sediment Concentration ($\mu$g/Kg) | | |
|---|---|---|---|---|---|---|
| | GeoMean | Max | AWQC | GeoMean | Max | SedCriteria |
| Iron | 5,479 | 46,300 | 1,000 | 137,000 | 1,157,500 | 25,000 |
| Manganese | 951 | 15,500 | 2,500 | 61,800 | 1,007,500 | 162,500 |

### 5.3.6 Second-Step Screening Of Shallow Wells

#### 5.3.6.1 Set Up of the AT123D Model

The AT123D model (G.T. Yeh 1987) was used to simulate solute transport from the vicinity of wells MW07-19S and MW07-21S to the shoreline, an approximate distance of 240 ft and 100 ft, respectively. The objective was to obtain a refined estimate of potential sediment concentrations and mass flux from the Site shallow ground water to the Allen Harbor entrance channel. At both of these monitoring well locations, the silt unit is absent and the till unit is thicker, extending to within approximately 5-7 ft of the ground surface, and is directly overlain by the upper sand unit. As a result, these two shallow wells are screened in the upper portion of the till unit. At both locations, the overlying upper sand unit is approximately 5-7 ft in thickness and the total saturated thickness to top of bedrock is approximately 35 ft, including an approximately 4-6 ft saturated thickness of the upper sand unit.

The CVOC concentrations detected in samples from the deep (D) wells at the two near shore well cluster locations, just above the bedrock, were only 3 $\mu$g/L and 140 $\mu$g/L at MW07-19D and MW07-21D, respectively; compared to 5,950 $\mu$g/L and 1,481 $\mu$g/L detected in the shallow samples from MW07-19S and MW07-21S, respectively. The source term in the model representing the two shallow wells was therefore placed in the upper portion of the modeled till unit. The concentrations in MW07-19S and MW07-21S were assumed to extend from the bottom of the shallow screen upward through the saturated zone, including the overlying saturated portion of the upper sand layer. The average model source thickness at the two shallow wells was approximately 19 ft. The mid-tide ground-water elevation at MW07-19S, approximately 240 ft from the shoreline, was 2.44 ft MSL during the 1 December 1995 measurements. At MW07-21S, approximately 100 ft from the shoreline, water elevations exhibited greater variation, making the selection of a value difficult. An average hydraulic gradient of 0.0102 ft/ft was calculated using the 2.44 ft MSL elevation and the approximately

240 ft distance from MW07-19S to the shoreline. The resulting estimated ground-water elevation at the 100 ft distance of MW07-21S of 1.02 ft is within the observed range of tidal variation and similar to the 1 December 1995 mid-tide measurement of 0.75 ft MSL.

The hydraulic conductivity was estimated to be 80 ft/day and 175 ft/day at MW07-19S and MW07-21S, respectively. The average value of 127.5 ft/day was used in the model. The hydraulic conductivity at MW07-24S (upper sand unit) and MW07-23S (silt unit), east and west of the subject wells, was less than or equal to 40 ft/day. The higher value at the two wells being modeled is consistent with their being in the till (silty gravelly sand) unit.

The width of the source term at in the model at MW07-19S and MW07-21S was assumed to be 200 ft, approximately one-half the distance between the neighboring wells MW07-23S and MW07-13S in which samples chlorinated and petroleum VOC were not detected.

The parameters used in the AT123D model from wells MW07-21S and MW07-19S to the shoreline are summarized as follows:

| | |
|---|---|
| Aquifer thickness: | 35 ft |
| Aquifer width: | infinite |
| Hydraulic Conductivity: | 127.5 ft/day |
| Model source width: | 200 ft |
| Model source thickness: | 19 ft (located in the upper portion of the 35 ft-thick modeled unit |

With the above model configuration, the 19 x 200 ft source area can disperse both laterally and downward. However, within the approximately 240 ft distance from MW07-19S to the shoreline, there is not enough time or distance for significant dispersion to occur. The plume centerline concentration at the shoreline, when the model is executed with just dispersion (no retardation or decay), is reduced to only 91 percent of the source concentration.

### 5.3.6.2 Estimated Shoreline Concentration - VOC

The AT123D model was executed from MW07-19S to the shoreline using the four VOC detected in samples from MW07-19S and MW07-21S (1,1,2,2-PCA, 1,1,2-TCA, 1,2-DCE, and TCE). The VOC 1,1,2,2-PCA and 1,1,2-TCA had screened out during the first-step analysis, but are included here to help illustrate plume attenuation near the shoreline. Retardation factors were calculated using a bulk density of 1.69 gm/cc (representing the finer material in the upper portion of the till unit and the upper sand unit which is included as part of the modeled source thickness) and an effective porosity of 0.3. TOC was assumed to be 0.75 percent. This TOC value was obtained from a 10- to 12-ft bgs soil sample from MW07-19S and is also the approximate average of three soil samples collected from the till unit during the Phase III RI field work (4,500 mg/kg, 7,490 mg/kg, and 10,100 mg/kg). The resulting calculated retardation factors and biodegradation half-lives (Howard 1991), are provided below.

**Retardation and Half-Life Used in Shallow Model**

| Parameter | Calculated Retardation | Published Half-Life Ranges (yrs) | Half-Life Used in Model (yrs) |
|---|---|---|---|
| 1,1,2,2-PCA | 4.3 | 0.01-0.1 | 0.5, 1 |
| 1,1,2-TCA | 4.2 | 0.4-2.0 | 1, 2 |
| 1,2-DCE | 2.5 | 0.2-7.9 | 4, 6 |
| TCE | 5.4 | 0.9-4.5 | 2, 4 |

The VOC concentrations estimated by the model from MW07-19S to MW07-21S and the shoreline, and the estimated model concentrations from MW07-21S to the shoreline are provided in Table 5-14. Each parameter was executed using a near maximum half-life and an alternative half-life of approximately half that value, except for 1,1,2,2-PCA. Because 1,1,2,2-PCA has a very short half-life, increased half-life values closer to the other VOC were selected to maximize the migration which would occur in the model. The estimated concentrations from MW07-19S at the shoreline are typically from 40 to 80 percent of the concentration detected at MW07-19S. Shoreline concentrations estimated from the concentrations detected at MW07-21S are typically 60-90 percent of the initial value. These estimated reductions in concentration were not enough to cause any additional constituents to screen out, which had not already screened out (below sediment screening criteria) during the first-step analysis in Section 5.3.4.1.

Table 5-14 indicates that shoreline values of 1,1,2,2-PCA and 1,1,2-TCA estimated by the model were below both AWQC and sediment screening criteria. However, the TCE and 1,2-DCE concentrations estimated by the model were both still above AWQC and sediment screening criteria when using an estimated shoreline value. Shoreline concentrations of 1,2-DCE and TCE estimated by AT123D from MW07-19S and MW07-21S, and the sediment screening criteria are provided below:

**Estimated Shoreline VOC Concentrations Above Criteria after Second-Step Screening**

| Parameter | Half-Life (yrs) | Estimated Shoreline Conc. ($\mu$g/L) | | Est. Sediment Conc. ($\mu$g/Kg) | | |
|---|---|---|---|---|---|---|
| | | -19S | -21S | -19S | -21S | SedCriteria |
| 1,2-DCE | 6 | 745 | 481 | 1304 | 842 | 200 |
| | 4 | 727 | 474 | 1272 | 829 | 200 |
| TCE | 4 | 2448 | 500 | 12730 | 2600 | 230 |
| | 2 | 2176 | 478 | 11315 | 2486 | 230 |

### 5.3.6.3 Limitations of the Results

An examination of Table 5-14 indicates that the model over estimated concentrations assuming that the decrease in detected sample concentrations between MW07-19S and MW07-21S results from plume transport processes. The estimated concentrations at MW07-21S based on an assumed source at MW07-19S are approximately 1.5 to 5 times greater than the concentration detected in the sample from MW07-21S. This indicates that the model is conservative and may be underestimating dispersion and/or biodegradation. This over estimation by the model may also result from processes such as volatilization which are not included in the model. The modeled shoreline values from MW07-19S for 1,2-DCE and TCE are approximately 4 and 10 times greater than sediment screening criteria when using a 5 percent TOC. For both constituents, after accounting for the over estimation of the model, the resulting shoreline values estimated by the model would still be approximately a factor of 2 greater than the sediment screening criteria. However, based upon the results of the MERA and TERA which used sediment sample data in the assessments, VOC were not identified as COC, ie. they do not pose unacceptable risk to the environment.

### 5.3.6.4 Estimated Shoreline Concentration - Metals

The environmental fate of metals is very complex and dependent on site chemistry, including parameters such as pH and Eh and the presence of additional compounds for the potential formation of precipitates. The environmental fate of metals was not included in the present screening analysis which treated metals as a dissolved conservative substance. Even though metals have very high retardation rates, when executed as a conservative constituent until reaching a steady state solution, the ultimate concentration is the same as if retardation was not included. The difference being that the travel time from MW07-19S to the shoreline would be on the order of years rather than weeks. As already discussed in Section 5.3.6.1, the centerline plume concentration estimated at the shoreline resulting from the 19 × 200 ft modeled source area with only dispersion, was only reduced to 91 percent of the initial value at MW07-19S over the 240-ft distance to the shoreline. The 240-ft distance is representative of the distance from the shoreline to the six wells along the Allen Harbor entrance channel included in the shallow well metal screening. Thus, within the scope of the present analysis, conclusions for step-two screening of metals detected in samples from the six shallow wells do not change from the first-step screening results in Section 5.3.4.2.

### 5.3.6.5 Assessment of Potential Impact on Allen Harbor Entrance Channel Surface Water from Site 07 Shallow Ground-Water

The estimated mass flux for VOC and dissolved metals (that have not screened out) from the shallow ground-water in the vicinity of wells MW07-19S and MW07-21S to the Allen Harbor entrance channel surface water was estimated based upon estimated near shoreline concentrations in ground-water and the flow field used in AT123D for the second-step screening of the shallow wells.

For VOC, two cases were performed: (1) shoreline concentrations estimated by AT123D from MW07-19S, and (2) the concentrations from MW07-21S (100 ft from shore) were used directly.

The ground-water flow through the 200 ft x 19 ft source area used in the AT123D model (hydraulic conductivity of 127.5 ft/day, gradient of 0.0102 ft/ft) is 4,942 $ft^3$/day (139,900 L/day). This flow, multiplied by the estimated shoreline ground-water concentration, provides a mass flux to the entrance channel water. It was assumed that the entire resulting mass flux enters the channel in the near shore zone. This is a conservative assumption because the assumed 19-ft source thickness would result in possibly a small portion of the plume under flowing the channel floor which is between 14 ft and 19 ft below MSL.

**Model Description**

A surface water model of Allen Harbor was developed as part of the Phase III RI for Site 09 (Allen Harbor Landfill). The surface water modeling was performed with RMA-2 which is a 2-dimensional, vertically averaged, finite element hydrodynamic model suitable for calculating the flow field associated with tidal flushing in an embayment (harbor). The associated water quality modeling system is contained in RMA-4. The model was developed for and is supported by the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi (the TABS modeling system) (King 1990a, 1990b).

Allen Harbor is approximately 3,000 ft long and varies in width between approximately 700 and 1,200 ft. At mean low water, the depth of the harbor is typically 10 ft. The entrance channel from Narragansett Bay narrows to an approximately 450-ft width. The flow through the inlet is driven by a 3.8-ft tide range.

In order to apply the RMA-2 model, a finite element grid was constructed for Allen Harbor and the entrance channel from Narragansett Bay. The depth data was taken from the most recent NOAA chart of the local area (Chart Number 13233). Allen Harbor was parameterized with 80 elements and 295 nodes. The model places a node at each corner of an element and at the mid-point along each element side. Velocity and concentration are calculated at each model node for each time step. The element grid used for the RMA-2 model of Allen Harbor is provided in Figure 5-1.

The RMA-2 model provides a file of velocities at each model node for every 30-minute time step over a tidal cycle. The velocity file was input to RMA-4 for the calculation of Allen Harbor concentrations resulting from the ground-water mass loading. RMA-4 was executed for 12 tidal cycles to allow the concentration distribution to reach steady state. The reported results were taken from the twelfth tidal cycle.

## Surface Water Model Results

The estimated mass loading from the 200 ft × 19 ft source area was input to a single shoreline model element within the entrance channel. The resulting surface water concentrations, for a similar mass loading, are smaller at Site 07 than at Site 09 because the mass loading is to a more dynamic portion of the harbor (i.e. the entrance channel) which has higher potential for tidal dilution. Applying the total mass loading from the assumed source area to one model element is a worst-case assumption which maximizes the local surface water concentration.

The four VOC which were detected at MW07-19S and MW07-21S (1,1,2,2-PCA, 1,1,2-TCA, 1,2-DCE, and TCE), along with iron and manganese, were executed in the Allen Harbor surface water model. Table 5-15 provides the near shore VOC concentrations detected in the sample from MW-21S (located within about 100 ft of the shoreline) and the shoreline concentration estimated by AT123D based upon the VOC concentrations detected in the sample from MW07-19S (located about 240 ft from the shoreline). The maximum near shore metal concentration (detected in the six selected wells in the vicinity of the entrance channel) was used for iron and manganese, the two metals which were estimated to be above the sediment screening criteria.

The maximum surface water concentration for a single node at any time step over a tidal cycle is provided in Table 5-15. The average concentration in the entrance channel would be lower than this maximum value. Table 5-15 indicates that estimated surface water concentrations in the channel resulting from Site shallow ground-water transport are significantly less than AWQC. The estimated surface water concentrations for the four VOC based upon concentrations detected in a sample from MW07-21S and iron and manganese based on the maximum detected in samples from the six wells near the entrance channel are summarized below.

**Estimated Surface Water Concentration from Shallow Site Ground Water**

| Parameter | Estimated Surface Water Conc. ($\mu$g/L) | AWQC ($\mu$g/L) |
|---|---|---|
| 1,1,2,2-PCA | 0.5 | 2400 |
| 1,1,2-TCA | 0.1 | 9400 |
| 1,2-DCE | 0.9 | 580 |
| TCE | 1.0 | 100 |
| Iron | 13.1 | 1000 |
| Manganese | 6.2 | 2500 |

### 5.3.7 Second-Step Screening Of Deep/Rock Wells

The AT123D model was executed from a source area in the vicinity of MW07-4D/5D for a 780-ft distance south towards the shoreline near the Allen Harbor entrance channel using the Site-wide maximum detected VOC concentrations. This analysis was performed to evaluate the relationship between the constituents detected on Site and the reduced number of constituents and lower concentrations detected in samples from the near shoreline wells.

#### 5.3.7.1 Set Up of the AT123D Model

Eight VOC detected in ground-water samples from deep/rock (D/R) wells did not screen out during the first-step analysis (Section 5.3.5.1) based on Site-wide geometric mean concentrations and, additionally, 1,1,2,2-PCA which did not screen out using the Site-wide maximum. Five of these VOC had a detection frequency of 1/29 resulting from the duplicate sample for MW07-05D. The remaining four parameters had their maximum detected concentrations in samples from MW07-04D, MW07-15D, or MW07-17D. These wells are located in a triangle around MW07-05D. These nine non-screened parameters were modeled assuming a pathway from the vicinity of MW07-04D/05D, south between MW07-10D/25D, and through MW07-12D to the vicinity of the near shore well MW07-23D. A second model configuration was used to extend the estimated near-shore concentrations 1,000 ft beyond the shoreline (Section 5.3.7.3). The average ground-water surface elevation was used at each of these wells based upon the 1 December 1995 (low, mid, high) tidal monitoring. The hydraulic gradient from an average of MW07-04D and MW07-05D to MW07-23D of 0.00492 ft/ft was used in the model. The hydraulic conductivities at these six wells ranged from 15.0 to 81 ft/day. A higher conductivity is a more conservative model assumption because the resulting higher velocity allows less time for dispersion and biodegradation to occur. The 15 ft/day (bedrock) low value was dropped and the remaining five-well average of 38.2 ft/day was used. The source width was assumed to be 100 ft, the distance between MW07-04D and MW07-05D projected along the pathway. At wells MW07-04D, -05D, -10D, and -25D the till unit (silty gravelly sand) thickness is much less than at wells MW07-21D and MW07-23D. The layer was modeled using a 30-ft thickness, characteristic of wells MW07-21D and MW07-23D. In the vicinity of the source area for the model (e.g. MW07-04D/05D/05R), the modeled layer was assumed to extend into the rock to include the VOC concentrations detected in the sample from MW07-05R. The source height was assumed to be 20 ft which overlaps a portion of the MW07-05D and MW07-05R screens. The aquifer parameters used in AT123D are summarized below:

| | |
|---|---|
| Aquifer thickness: | 30 ft |
| Aquifer width: | infinite |
| Hydraulic gradient: | 0.00492 ft/ft |
| Hydraulic conductivity: | 38.2 ft/day |
| Source width: | 100 ft |
| Source thickness: | 20 ft (located in the lower portion of the 30-ft thick modeled unit) |

Retardation factors were calculated using a bulk density of 1.88 gm/cc (for till) and an effective porosity of 0.3. This bulk density is the same as used at Site 07 for the silty gravelly sand (till) layer. TOC was assumed to be 0.6 percent. This is an average value for the till samples from MW07-17D (44-46 ft bg; 4,500 mg/kg) and MW07-19S (12-14 ft bg; 7,490 mg/kg). The calculated retardation factors and biodegradation half-lives (Howard 1991) for the modeled parameters are provided in the following table. Model sensitivity for biodegradation was performed for 1,2-DCE and TCE, the two VOC estimated previously to be above sediment screening criteria.

**Retardation and Half-Life Used in Deep/Rock Unit Model**

| Parameter | Calculated Retardation | Published Half-Life Ranges (yrs) | Half-Life Used in Model |
|---|---|---|---|
| 1,1,2,2-PCA | 3.97 | 0.01-0.1 | 1 |
| 1,2-DCE | 2.32 | 0.2-7.9 | 4,6 |
| Benzene | 4.68 | 0.03-2.0 | 2 |
| Chlorobenzene | 11.34 | 0.4-0.8 | 1 |
| PCE | 14.65 | nd | 6 |
| TCE | 4.91 | 0.9-4.5 | 2,4 |

Execution of the model for a distance of approximately 780 ft (analogous of from the vicinity of MW07-04D/05D to the vicinity of MW07-23D) with only dispersion, no retardation or biodegradation, resulted in concentrations 34 percent of the initial value. The factor of 2.9 reduction in concentration was more than needed for estimated concentrations of cis-1,3-dichloropropene and styrene to be less than the sediment screening criteria and were therefore dropped from the analysis. These two parameters were each detected in only one sample and were already below the AWQC. They had not screened out previously during step-one as a result of the 1 percent TOC used for calculating the sediment screening criteria and the 5 percent TOC used for the estimation of concentration in sediment.

### 5.3.7.2 Estimated Near-Shore Concentrations - VOC

The results of modeling the remaining six VOC parameters approximately 780 ft (analogous to the distance from the vicinity of MW07-04D/05D [near the inferred release or source area] to the vicinity of MW07-23D) are summarized in Table 5-16. The maximum concentration detected site-wide in a ground-water sample from the deep (D) and rock (R) wells was used for the source term and two biodegradation rates were used for 1,2-DCE and TCE to examine model sensitivity to variation in the half-life values. The table provides modeled concentrations at three approximate distances along the pathway from the modeled source area in the vicinity of MW07-04D/05D: (1) at approximately 300 ft (vicinity of MW07-10D/25D), (2) at approximately 550 ft (vicinity of MW07-12D), and (3) at approximately 780 ft (vicinity of MW07-23D). Also, included in Table 5-16 is an estimated sediment concentration for 5 percent TOC based upon the estimated ground-water concentration in the vicinity of MW07-23D.

Table 5-16 indicates that estimated ground-water concentrations for benzene, chlorobenzene, 1,1,2,2-PCA, and PCE are below both AWQC and sediment screening criteria before migrating beyond the modeled Site 07 southern edge. This is consistent with the fact that benzene, chlorobenzene, and PCE were not detected in the samples from the deep/rock wells near the Allen Harbor entrance channel. Model estimated shoreline concentrations of 1,2-DCE and TCE are above sediment screening criteria.

A comparison between model estimated near shore VOC concentrations based upon a site-wide maximum concentration and concentrations detected in samples from near shore deep/rock wells is provided below, along with a comparison between model predictions at a distance of 300 ft and the concentrations detected in the samples from MW07-25D/R. The following table also indicates if the detected values at the near shore wells are below sediment screening criteria (yes - Y and no - N).

**Estimated Near Shore VOC Concentrations vs. Detections from MW07-23D and -21D/R**

| Parameter | Half-Life (yrs) | Estimated Near Shore Conc. ($\mu$g/L) | Detected Concentration ($\mu$g/L) | | |
|---|---|---|---|---|---|
| | | | -23D | -21D | -21R |
| 1,1,2,2-PCA | 1 | 13.8 | 370 (Y) | 22 (Y) | 1700 (Y) |
| 1,2-DCE | 6 | 854 | 170 (N) | 35 (Y) | 890 (N) |
| | 4 | 561 | | | |
| TCE | 4 | 2980 | 460 (N) | 82 (N) | 5800 (N) |
| | 2 | 289 | | | |

**Estimated VOC Concentrations at 300 ft vs. Detections from MW07-25D/R**

| Parameter | Half-Life (yrs) | Estimated Conc. at 300 ft (μg/L) | Detected Conc. (μg/L) | |
|---|---|---|---|---|
| | | | -25D | -25R |
| 1,1,2,2-PCA | 1 | 29,370 | 3600 (Y) | 510 (Y) |
| 1,2-DCE | 6 | 2,550 | 61 (Y) | 990 (N) |
| | 4 | 2,198 | | |
| TCE | 4 | 27,500 | 3000 (N) | 2900 (N) |
| | 2 | 11,855 | | |
| NOTE: Y, N - Below sediment screening criteria. | | | | |

### 5.3.7.3 Limitations of the Results

An examination of the above two tables indicates that the model was not consistent in estimating concentrations, ie. sometimes the estimated values are higher than the sample data and sometimes they are lower. Overall, the Site hydrogeology was found to be more complex than could be well simulated by the relatively simplistic AT123D computer model. This problem was exaggerated by the nearly 800-ft length of the modeled section. Although Site parameters were used as possible to try to simulate subsurface, the results of the screening-level modeling work indicated that continued model refinement and/or development of a site-wide 3D model is not appropriate. However, based upon the results of the MERA and TERA which used sediment sample data in the assessments, VOC were not identified as COC, ie. they do not pose unacceptable risk to the environment.

### 5.3.8 Screening Process Conclusions

**First-Step Screening - Shallow Wells**

Analysis of VOC detected in ground-water samples from the near shore wells MW07-19S and MW07-21S indicated that only 1,2-DCE and TCE were estimated to be above sediment screening criteria (5 percent TOC). 1,2-DCE at MW07-21S, the closer well to the shoreline, meets sediment screening criteria at a 1 percent TOC.

Analysis of metals using the maximum concentration detected in ground-water samples from the six selected shoreline wells estimated that only iron and manganese were above sediment screening criteria. However, the maximum detected concentration of manganese, 3830 μg/L, is only slightly above the NCBC background concentration of 3,292 μg/L (Stone & Webster Environmental Technology & Services 1996). Additionally, only four of the site-wide samples had detected concentrations above the NCBC background concentration.

### First-Step Screening - Deep/Rock Wells

Eight VOC were estimated to exceed the sediment screening criteria when using the site-wide geometric mean concentration and 5 percent TOC. Five of these VOC, with detection in only one sample each, and PCE were estimated to be below screening criteria before reaching the site boundary (second-step screening). The two remaining VOC, TCE and 1,2-DCE, are detected in samples from two near-shore deep/rock wells (MW07-21D/R and MW07-25D/R).

Iron at a site-wide geometric mean and manganese at a site-wide maximum concentration were the only metals detected in samples from the deep/rock wells which were not estimated to be below sediment screening criteria.

### Second-Step Screening - Shallow Wells

Transport of 1,2-DCE and TCE from MW07-21S to the shoreline, a 100 ft distance, with environmental fate, reduced the detected concentrations by only 10-20 percent. Estimated shoreline concentrations of these two VOC were above sediment screening criteria.

Similarly, second-step screening did not alter the first-step screening results for metals, i.e., iron and manganese remained as the only two metals estimated to be above the sediment screening criteria.

**Comparison of Estimated Shallow Ground-Water Shoreline Concentrations to Criteria**

| Parameter | Half-life (yrs) | Ground Water ($\mu$g/L) | | Sediment($\mu$g/Kg) | |
|---|---|---|---|---|---|
| | | Estimated Shoreline Conc | AWQC | Estimated Conc. | Screening Criteria |
| 1,2-DCE(a) | 6 | 481 | 580 | 842 | 200 |
| | 4 | 474 | 580 | 829 | 200 |
| TCE (a) | 4 | 500 | 100 | 2600 | 230 |
| | 2 | 478 | 100 | 2486 | 230 |
| Iron (b) | | 8050 | 1000 | 201250 | 25000 |
| Manganese (b) | | 3830 | 2500 | 248950 | 162500 |

(a) Estimated shoreline value based on MW07-21S
(b) Maximum of six selected near shore shallow wells.

The Allen Harbor surface water model indicates that surface water concentrations estimated from shallow ground-water mass loadings of site VOC and dissolved metals are substantially

below water quality criteria as summarized in the following table:

**Estimated Allen Harbor Surface Water Concentrations**

| Parameter | Surface Water Conc. ($\mu$g/L) | AWQC ($\mu$g/L) |
|---|---|---|
| 1.2-DCE | 0.9 | 580 |
| TCE | 1.0 | 100 |
| Iron | 13.1 | 1000 |
| Manganese | 6.2 | 2500 |

**Second-Step Screening - Deep/Rock Wells.**

The AT123D model was not consistent in estimating concentrations. Overall, the Site hydrogeology was found to be more complex than could be well simulated by the relatively simplistic AT123D computer model. This problem was exaggerated by the nearly 800-ft length of the modeled section. Although Site parameters were used as possible to try to simulate subsurface, the results of the screening-level modeling work indicated that continued model refinement and/or development of a site-wide 3D model is not appropriate.

**Site-Wide Summary**

The result of the screening process has provided a rough estimate that for the metals, only iron and manganese may result in sediment concentrations that are above sediment screening criteria at the Allen Harbor entrance channel shoreline. Iron was not identified as a sediment COC in the Marine or Facility-Wide Freshwater/Terrestrial ERA reports. However, manganese was identified as a sediment COC, but only in the Freshwater/Terrestrial ERA report.

The result of the screening process has provided a rough estimate that for the CVOC only TCE and 1,2-DCE may result in sediment concentrations that are above sediment screening criteria (5 percent TOC) at the Allen Harbor entrance channel shoreline in either the shallow or deep/rock ground-water zones. However, VOC (including TCE and 1,2-DCE) were not identified as COC in either the Marine or Facility-Wide Freshwater/Terrestrial ERA reports. Additionally, the screening process estimated that CVOC and dissolved metals concentrations in Allen Harbor entrance channel surface water potentially resulting from Site 07 shallow ground-water mass loading are significantly below AWQC.

The two-step screening process has provided rough estimation of the CVOC in ground water beneath the site when considered over short distances, eg. from MW07-19S and MW07-21S to the shoreline of the Allen Harbor entrance channel. However, the AT123D model was not consistent in the estimation of VOC concentrations across the length of the site (approximately 800 ft). Overall, the Site hydrogeology was found to be more complex than could be well

simulated by the relatively simplistic AT123D computer model. Although Site parameters were used as possible to try to simulate subsurface, the results of the screening-level modeling work indicated that continued model refinement and/or development of a site-wide 3D model is not appropriate because of the relative complexity of the site subsurface, including geological variations, tides, and the flow dynamics in the interface between the fresh and saltwater zones.

# 6. HUMAN HEALTH RISK ASSESSMENT

## 6.1 INTRODUCTION

This chapter presents the results of a human health risk assessment (HHRA) for Site 07 of the Naval Construction Battalion Center in Davisville, Rhode Island (NCBC Davisville). NCBC Davisville is located in the northeastern section of the Town of North Kingston, Rhode Island, approximately 18 miles south of the state capital, Providence (Figure 1-3). Site 07 is commonly referred to as Calf Pasture Point.

The purpose of this assessment was to determine whether there is a potential human health risk associated with surface and subsurface soils, ground water, surface water, and ambient air containing chemicals of concern (COCs) at Site 07 (onsite media) and/or with shellfish and sediment from the intertidal zone adjacent (offshore) to Site 07. Risks associated with potential onsite exposures to the COCs by: (1) future construction/remediation workers, (2) future recreational users, (3) consumers of locally caught shellfish, and (4) hypothetical future residents were evaluated in this HHRA.

This HHRA has been prepared to be consistent with the *Comprehensive Reuse Plan for the Davisville Naval Construction Battalion Center* prepared by the Base Reuse Committee and subsequently adopted by the Town of North Kingston and the State of Rhode Island. This HHRA has been prepared in accordance with recommended guidance from the EPA for evaluating potential public health risks associated with Superfund sites. NCBC Davisville is a Superfund site, and assessment and cleanup are being conducted under the Federal Facilities Compliance Act (FFCA) as a part of the Department of Defense IR Program (IR Program). Accordingly, EPA risk assessment guidance is appropriate for use in evaluating potential human health risks at NCBC Davisville Site 07. The following EPA guidance documents were consulted in preparing this HHRA:

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual* (EPA 1989a);
- EPA Region I *Supplemental Risk Assessment Guidance for the Superfund Program* (EPA 1989b);
- EPA Region I *Risk Updates* (EPA 1994a);
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992b);
- *Integrated Risk Information System (IRIS)* (EPA 1995a), a computer database containing up-to-date health risk and EPA regulatory information for numerous chemicals;

- *Health Effects Assessment Summary Tables (HEAST)* (EPA 1994b);
- *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA 1993b);
- *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening* (EPA 1993a);
- *EPA Region III Risk-Based Concentration Tables* (EPA 1995b).
- *Superfund Exposure Assessment Manual* (EPA 1988a);
- *Exposure Assessment Guidelines* (EPA 1992a);
- *Exposure Factors Handbook* (EPA 1990);
- *Standard Default Exposure Factors* (EPA 1991), and
- *Dermal Exposure Assessment: Principles and Applications* (EPA 1992c).

The above documents were designed to provide guidance for conducting health risk assessments. For some aspects of this HHRA for NCBC Davisville Site 07, professional judgment was used in application of the guidance.

Ultimately, the HHRA presented in this chapter is expected to be used within a risk management framework. In making decisions concerning what actions, if any, should be taken at the site (including, for example, the collection of additional data or implementation of a remedial program), the results of the HHRA should be used in concert with other information about NCBC Davisville. The HHRA identifies whether current and future anticipated land use conditions present unacceptable risks to human health. Potential risks to ecological receptors are discussed in an accompanying document, the sitewide ecological risk assessment. The HHRA identifies the contaminants and exposure pathways contributing the greatest risk to the human receptor populations. From this information, recommendations for future activities at Site 07 (including remedial actions) can be made such that public health is protected.

### 6.1.1 Organization of the Chapter

This chapter follows the four-component risk assessment paradigm: hazard identification, dose-response assessment, exposure assessment, and risk characterization.

- In the hazard identification, presented in Section 6.2, key COCs are selected for inclusion throughout the remainder of the risk assessment and the scientific weight of evidence regarding the potential for each COC to cause adverse health effects in exposed populations is briefly summarized.

- In the dose-response assessment, presented in Section 6.3, the relationship between extent of exposure and extent of toxic injury or disease is estimated for each COC. Chemical-specific toxicity values, such as cancer slope factors (SFs) and reference doses (RfDs) or reference concentrations (RfCs) for health effects other than cancer, are presented along with a discussion of their scientific underpinnings and derivation.

- In the exposure assessment, presented in Section 6.4, potential receptors and pathways of exposure are identified. The exposure assessment includes a discussion of the magnitude, frequency, and duration of these exposures.

- Risk characterization, presented in Section 6.5, integrates the results of the dose-response assessment and the exposure assessment to derive quantitative estimates of human health risk, including both the risk of cancer and of health effects other than cancer. The major uncertainties and limitations associated with the estimates of risk and their potential ramifications are presented in this section.

- A summary and conclusions are presented in Section 6.6.

### 6.1.2 Site Characterization

#### 6.1.2.1 Site Description

Site 07, Calf Pasture Point, is a large, grass-covered peninsula which slopes to the south and southwest toward Allen Harbor and to the east toward Narragansett Bay (Figure 1-3). Site 07 is surrounded by mud flats, tidal marshes, and sandy beaches. The area is located across Allen Harbor from the Allen Harbor Landfill (Site 09). Access to Site 07 is limited by a fence that impedes land access to the Allen Harbor Landfill and Calf Pasture Point area. Public access from the shoreline is not restricted.

Three magazine bunkers at Calf Pasture Point were formerly used for munitions storage. Refer to Sections 1.2.4.4 and 1.2.4.5 which present a summary of the investigation, removal action, and close-out of these three structures. This area was also reportedly the site of three distinct disposal activities. Sometime between 1960 and 1974, about twenty 5-gal cans of calcium hypochlorite were reportedly disposed of in a ditch adjacent to a bunker. Between 1978 and 1982, cans containing this material were removed for offsite disposal. In 1973, thirty to forty 35-gal cardboard drums of a chloride constituent, possibly ferric chloride, were stored in the area and eventually buried. Between 1968 and 1974, an estimated 2,500 3-gal cans of Decontaminating Agent Non-Corrosive (DANC) solution were buried in the area. DANC was comprised of 1,3-Dichloro-5,5-dimethylhydantoin and 1,1,2,2-tetrachloroethane (perchloroethane, PCA). Refer to Sections 1.2.1 through 1.2.3 for additional site description and history information.

### 6.1.2.2 Media Sampling

Environmental media sampling at NCBC Davisville was conducted in three phases (two by TRC and one by EA) and a series of shellfish sampling. The samples collected for this HHRA are from both onsite and offshore media. The offshore media sampled include shellfish and sediment from the intertidal zone adjacent to the Site. The remaining media sampled are all onsite media. Upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the shellfish and intertidal sediment (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling and analyses conducted to date by the Navy have identified no related unacceptable risk. The HHRA results for both onsite media and offshore media are presented in this chapter. The activities comprising the sampling phases are discussed separately below. Samples were collected:

- From subsurface soil, surface soil, ground water, and sediment at Site 07 during a previous RI (Phase I and Phase II),
- From shellfish in a series of studies conducted by the Naval Ocean Systems Center (NOSC) and the EPA Environmental Research Laboratory at Narragansett (ERLN), and
- From ground water, during the current phase of the RI (Phase III).
- From shellfish and intertidal sediment during the Marine Ecological Risk Assessment (Allen Harbor Landfill and Calf Pasture Point) (February 1996).

Exposures to surface water were assessed based upon the concentrations of 1,2-DCE, PCA, 1,1,2-TCA, and TCE detected in the shallow ground-water sample from MW07-21S and the modeled concentration of each at the shoreline approximately 100 ft south of MW07-21S.

**Phase I RI sampling**

The Phase I RI sampling at NCBC Davisville was conducted from July 1989 to March 1990 (TRC 1994). During this investigation, samples of soil gas, surface soil (less than 2 ft),[1]

[1] Surface soil is defined as any sample taken within 2 ft of the ground surface. This definition was used in previous phases of this RI (TRC 1991, 1994) and is preserved here.

subsurface soil (from depths greater than 2 ft), ground water, aqueous seeps, and sediment were collected at one or more of the NCBC Davisville sites.

Soil gas samples were collected at a depth of 2 ft below grade and were analyzed using modified EPA Method 601 for 12 chlorinated VOCs and modified EPA Method 602 for benzene, toluene, ethylbenzene, and xylenes (BTEX).

Soil samples were collected at the immediate surface (0–6 in.), using hand augers (down to approximately 4 ft), as surface (0–2 ft) and subsurface (greater than 2 ft) borings, and as surface (0–2 ft) and subsurface (greater than 2 ft) test pit samples. Soil samples were analyzed for the Target Compound List (TCL) and the Target Analyte List (TAL). Selected soil samples were also analyzed using the Toxicity Characteristic Leachate Procedure (TCLP), which evaluates the amount of chemicals that might leach from the soil.

Ground-water samples were collected from existing and newly installed wells. Unfiltered and filtered ground-water samples were obtained from each well. Ground-water samples were analyzed for TCL, TAL, and cyanide.

Aqueous seep or leachate samples were collected and analyzed for TCL, TAL, and cyanide. The sediment samples were obtained using a stainless steel ladle and were analyzed for TCL, TAL, total petroleum, and/or hydrocarbons, depending on the site.

Phase I sample analyses were conducted by Compuchem Laboratories, Inc. in Research Triangle Park, North Carolina.

**Phase II RI sampling**

The Phase II RI sampling at NCBC Davisville was conducted from May 1993 to July 1993 (TRC 1994). During this investigation, samples of surface soil (depths up to 2 ft), subsurface soil (depths greater than 2 ft), ground water, surface water, and sediment were obtained at one or more of the NCBC Davisville sites.

Surface soil samples were collected at intervals of 0–1 ft, 0.5–1 ft, and 0–2 ft below grade. Subsurface soil samples were collected at intervals beginning at 2 ft below grade, with depth to the water table at each site determining the deeper end of the intervals. Soil samples were generally analyzed for TCL, TAL, and cyanide. Selected soil samples were also analyzed for total organic carbon (TOC), acid volatile sulfides, total chloride, archived dioxins/furans, sulfides; while others were analyzed using the TCLP.

Ground-water samples were consistently analyzed for TCL, TAL, and cyanide. Selected ground-water samples were also analyzed for total chloride.

Surface water and sediment samples were typically analyzed for TCL, TAL, and cyanide, with selected analyses for TOC and acid volatile sulfides.

Phase II sample analyses were conducted by Pace in Hampton, New Hampshire, Geotesting Express in Concord, Massachusetts, or Compuchem Laboratories, Inc. in Research Triangle Park, North Carolina.

**Shellfish Sampling**

Shellfish sampling was conducted in Allen Harbor and Narragansett Bay in three phases from November 1988 to October 1991. The studies were collaborative efforts by the NOSC and the ERLN (TRC 1994; NOSC/ERLN 1990). Four indigenous species were collected, including hard-shell clams (*Mercenaria mercenaria*; quahogs), soft-shell clams (*Mya arenaria*), ribbed mussels (*Modiolus demissus*), and oysters (*Crassostrea virginica*). Blue mussels (*Mytilus edulis*) were deployed in cages. The samples were generally collected as composites, with more than one composite typically obtained from a given station. The resulting samples were analyzed for inorganics, semivolatile organic compounds (SVOCs) (primarily polycyclic aromatic hydrocarbons, or PAH), pesticides, PCB, and butyltins. With the exception of the butyltin analyses, the shellfish samples were analyzed by the ERLN. The butyltin analyses were performed by the NOSC facility in San Diego, California.

**Phase III RI sampling**

Sampling efforts in Phase III consisted of collecting additional ground-water samples in 1995 and 1996 — from both new and existing wells and subsurface soil. Phase III RI sampling conducted for this RI is described in Section 2 of this report.

**Marine Ecological Risk Assessment Sampling (MERA)**

Sampling efforts during the MERA included the portion of the shellfish and sediment from the intertidal zone in Allen Harbor and the entrance channel adjacent to the Site. The sampling conducted for the MERA is described in the Draft Final Allen Harbor Landfill and Calf Pasture Point Marine Ecological Risk Assessment Report (February 1996).

## 6.2 HAZARD IDENTIFICATION

Chemicals were selected for inclusion in this HHRA by first establishing the potential health hazards associated with each selected chemical according to an established set of selection criteria (i.e., presence above background, potential for human exposure, and toxicity). Once the list of selected chemicals was complete, the human health hazard associated with each chemical was identified by examining the scientific literature on its toxicity. Information sought in this exercise included:

- A causal relationship between the chemical and its potential for adverse human health effects;

- The health effect that is considered to be the most "critical" according to best professional judgment, based on such factors as severity of the health effect and toxicity; and

- The scientific weight of evidence for the "critical" health effect.

This methodology was employed to confirm that the selected chemicals were those that should be investigated further for their potential health risk at Site 07. Finally, this method established the toxicological basis for selecting the appropriate chemical-specific toxicity values to be used later in calculating risk (Section 6.3).

### 6.2.1 Selection of Chemicals Used to Estimate Human Health Risks

This screening process utilized to identify and select COCs for inclusion in the HHRA involved the following steps:

- Analytical data quality evaluation to identify potential COCs;

- Utilization of a risk-based concentration screening approach (EPA 1993a, 1995b) to identify candidate COCs; and

- Further reductions in the list of COCs based on criteria from RAGS (*Risk Assessment Guidance for Superfund*; EPA 1989a), followed by chemical-specific reevaluations of COCs that were previously excluded but subsequently warranted inclusion in the quantitative risk assessment.

The process of identification and selection of COCs at Site 07 encompassed the following considerations: the presence or absence of specific analytes across media, the presence of analytes in blanks, the frequency with which analytes were reported, and the relative toxicities of analytes. The following sections discuss the COC selection process in more detail.

#### 6.2.1.1 Data Quality Evaluation

Detailed chemical analyses of soil, ground-water, sediment, and shellfish samples from Site 07 were obtained. Potential COCs were defined as chemicals identified in environmental media samples that were considered likely to have originated from site-related activities. Selection processes for potential COCs in each individual medium are discussed in subsequent sections on a medium-specific basis. Potential COCs in the soil, sediment, ground water, and shellfish were identified according to the following management conventions:

(1) The first step in the process of selecting COCs was the evaluation of analytical data on the basis of their qualifiers and detection frequencies in individual and collective media. Inclusion or exclusion of data on the basis of analytical qualifiers was performed in accordance with EPA guidance (EPA 1989b).

- Analytical results bearing the "U" qualifier (indicating that the analyte was not detected at the given sample quantitation limit (SQL)) were retained in the data set and regarded as a nondetect. For statistical purposes, the analyte was assumed to be present at a value of one-half the reported SQL.

- Analytical results bearing the "J" qualifier (indicating that the reported value is "estimated" because either the analyte was detected at a level below the SQL or for other reasons) were retained in the data set and regarded as a detected concentration at the given value.

- Analytical results bearing the "UJ" qualifier (indicating that the analyte was not detected at the estimated SQL) were eliminated from the data set due to an unusually high degree of uncertainty.

- Analytical results bearing the "R" qualifier (indicating that quality control suggests that the data are unusable and that the analyte may or may not be present) were eliminated from the data set.

- Analytical results bearing the "M" qualifier (indicating that duplicate injection precision criteria were not met) were treated as detected concentrations.

- Analytical results bearing the "*" qualifier (indicating that the duplicate analysis was not within control limits) were treated as detected concentrations.

(2) In instances where duplicate samples were taken or duplicate analyses were conducted on a single sample, the following conventions were employed:

- If both samples/analyses indicated presence of the analyte, then the higher detected concentration was retained;

- If only one sample/analysis indicated presence of the analyte, then this detected concentration was retained; and

- If both samples/analyses were nondetects, then the higher SQL was retained.

(3) If the chemical was not reported in any sample in a particular medium, it was not considered to be a potential COC for that medium.

(4) Common laboratory contaminants, including acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters were considered to be COCs unless there was reason to believe that their presence was not related to past site activities but was solely the result of laboratory contamination. Individual analytical results were evaluated following EPA (1989b) guidance concerning the occurrence of common laboratory contaminants in blank samples. For these common laboratory

contaminants, individual samples results bearing the "B" or "BJ" qualifiers, indicating that the chemical was found in an associated blank, were treated as nondetects at the blank-related concentration if the reported concentrations were not more than ten times the concentration reported in any blank. Where blank data were not available, this comparison could not be made, and analytical results bearing the "B" qualifier were retained as a default.

#### 6.2.1.2 Environmental Sampling Data Management and Evaluation

Analytical data collected for this RI were further evaluated for each chemical that was not eliminated from consideration in the above steps. As stated above, only those analytes that were found to be detected in at least one environmental sample were included in the list of potential COCs. The sections below describe data management and evaluation steps that were taken in each medium.

**Soil Sampling**

A total of 38 soil samples collected from the surface and at depths of up to 10 ft were used in this risk assessment (TRC 1991; TRC 1994). Two surface and two subsurface soil samples from Phase I were included in this HHRA. Fourteen surface and nine subsurface soil samples from Phase II were included in this HHRA. Three surface and eight subsurface soil samples from Phase III were included in this HHRA. Several additional subsurface soil samples taken during the Phase III RI were not included in the HHRA because they were collected at depths greater than 10 ft. The analytical soil data for the Phase III RI are summarized in Table 4-2.

**Ground-Water Sampling**

A total of 25 shallow ground-water samples (collected at the depth to ground water, which ranged from 4 ft to 25 ft), 31 deep ground-water samples (collected at the depth ranging from 25 ft to 84 ft), and 5 bedrock ground-water samples (collected at the depth ranging from 64 ft to 110 ft) were used in this HHRA (TRC 1991; TRC 1994). The analytical ground-water data for the Phase III RI are summarized in Tables 4-4 and 4-5 for detected TCL volatile organic compounds (VOCs) and TAL metals, respectively.

Both filtered and unfiltered ground-water samples were collected. However, only unfiltered ground-water samples were used in estimating potential exposures and risks in this risk assessment because, as described in Section 6.4.2.4, the future uses of the site include as exposure pathways the incidental ingestion of ground water by remediation/construction workers while excavating on site and showering by recreational users, neither of which would likely entail filtration prior to exposure. This procedure is also consistent with EPA Region I preference for using unfiltered samples in the HHRA (EPA 1994c).

**Sediment Sampling**

A total of eight sediment samples were used in this HHRA (TRC 1991; TRC 1994). Phase I/II sediment sampling locations selected for inclusion in the HHRA were: SD05, SD06, and SD07. The five MERA intertidal sediment sampling locations selected for inclusion in the HHRA were AHW10–AHW14. All sampling locations included in the HHRA were either sampled at shallow depths near the harbor shoreline such that people could be expected to contact the sediments while wading or swimming in the harbor or were sampled in shallow streams/wetlands at points inland. Upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the intertidal sediment (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling and analyses conducted to date by the Navy have identified no related unacceptable risk.

Reported data for specific PCB congeners were converted to equivalent concentrations of Aroclor-1242, -1254, and -1260 using an algorithm based on weight-percents of the individual congeners in Aroclor mixtures.

**Shellfish Sampling**

Of the depurated shellfish samples that were collected in Allen Harbor, six (four from Phases I and II and two from the MERA) were judged to have been collected from locations sufficiently near the site to have been potentially impacted by site contaminants. However, upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence (direct relation) was found for a completed risk pathway from the Site (onsite media) to the shellfish (offshore media) in the adjacent portions of Allen Harbor and the entrance channel; ie. sampling and analysis conducted to date by the Navy have identified no related unacceptable risk. Samples from Phase I and II included in the data set were those collected from locations AH3, AH10, AH14, and FDA. MERA locations included those samples collected from AHW10 and AHW12. Shellfish data are based on wet weight analyses.

Both nondepurated and depurated shellfish samples were collected for this RI. The Navy has assumed, for the purposes of this risk assessment, that shellfish consumers will sufficiently rinse and/or soak (i.e., depurate) the shellfish as part of food preparation, prior to consuming the shellfish. This type of depuration process removes sand, grit, and particulate matter. Therefore, depurated samples were used in the HHRA to estimate potential exposures by humans consuming locally caught shellfish. Nondepurated shellfish samples were not used in the HHRA because such samples were not believed to be representative of actual human exposures to shellfish. However, it should be noted that there would be greater risk to receptors consuming nondepurated shellfish than to receptors consuming depurated fish. Since

the potential risks for consumption of depurated shellfish in this HHRA are estimated to be unacceptable under both average and reasonable maximum exposure conditions, the analysis is not repeated for nondepurated shellfish consumption exposure scenarios. Nondepurated samples were utilized in the ecological risk assessment.

Butyltin in shellfish data were evaluated to assess potential human intake of consumers of Allen Harbor shellfish. However, in the absence of toxicity values for butyltin compounds, potential human health risks due to exposure to shellfish with butyltin compounds were evaluated qualitatively. Ribbed mussels are not generally eaten due to their unpleasant taste. Accordingly, the data associated with ribbed mussels were not included in the HHRA.

Data for specific PCB congeners were reported for two samples. The reported PCB congener concentrations were converted to equivalent concentrations of Aroclor-1242, Aroclor-1254, and Aroclor-1260 using an algorithm based on weight-percents of the individual congeners in Aroclor mixtures. Four samples reported concentrations for Aroclor-1242, Aroclor-1242/54, and Aroclor-1254. For these samples, the reported concentrations of the mixed Aroclor-1242/54 were not used because examination of the data indicated that the 1242/54 and 1254 data were duplicates. Analytical data reported as concentrations of "chrysene and triphenylene" were assumed to consist entirely of chrysene because toxicity values are available for chrysene but not for triphenylene. These data were combined with the other chrysene data. Data reported as benzofluoranthene were assumed to represent benzo(b)fluoranthene, the more toxic of benzo(b)fluoranthene and benzo(k)fluoranthene, and were combined with other data for benzo(b)fluoranthene.

#### 6.2.1.3 Risk-Based Concentration Screening

The risk-based screening process utilized for Site 07 followed that developed by EPA Region III. The purpose of the risk-based screen was to identify for inclusion in the HHRA only those chemicals that would likely impact the overall estimation of potential health risks. The risk-based concentration screen was performed by following the steps outlined below (EPA 1993a):

(1) The maximum concentration of each potential COC detected in each medium was identified.

(2) If the maximum concentration exceeded the risk-based concentration (RBC)[2] for that medium, the contaminant was retained for risk assessment for all routes of exposure involving that medium. Otherwise, the contaminant was omitted from further consideration in that medium.

(3) If a specific contaminant did not exceed its risk-based concentration for any medium, the contaminant was dropped from the risk assessment entirely.

(4) If a specific medium did not contain any chemical at concentrations that exceeded their RBCS, the medium was omitted from the risk assessment.

(5) All omitted chemicals and exposure routes were reconsidered for inclusion at a later time based on special considerations (see Section 6.2.1.4).

In this HHRA, the RBCs for soil, water, and fish were utilized in the risk-based screening as described above. When a RBC was not available for a particular chemical in a particular medium, that chemical was retained for further evaluation as a potential COC as described in the next section.

While direct ingestion of water is not likely to be a source of potential exposures at this site, consumption of ground water by hypothetical future residents was included for evaluation as a conservatively prudent measure. Incidental ingestion of shallow ground water while performing excavation activities was also included as an exposure pathway of concern for remediation/construction workers. For the purposes of the screening, RBCs for tap water were applied to both of these exposure pathways. The application of RBCs based on tap water ingestion to incidental ingestion of ground water was considered to be sufficiently protective of human health because the tap water RBCs were developed assuming ingestion of 2 liters of drinking water per day, whereas incidental ingestion of ground water was associated with ingestion of approximately 25–50 milliliters of water per day. RBCs for soil were used to screen potential COCs detected in sediment based on a similar rationale (i.e., that likely sediment exposures are lower than the exposures assumed in developing the RBCs for contaminants in soil).

Finfish RBCs were applied to shellfish data. Finfish ingestion RBCs were developed assuming a consumption rate (54 g/day; EPA 1993a) that is approximately equal to the upper limit on the distribution of consumption rates recommended for use in New England

[2] Risk-based concentrations have been estimated for hundreds of chemicals in soil, water, fish, and air as the chemical concentration in each medium, which under default exposure assumptions, corresponds to an increased lifetime cancer risk of $1\times10^{-6}$ or a noncancer hazard quotient (HQ) of 1.0 (EPA 1993a). Following EPA Region I guidance, RBCs for noncarcinogens were set at an HQ of 0.1 (EPA 1995f) in this risk assessment. Soil Screening Levels (SSLs), which are similar in concept to RBCs, have been recently established for chemicals in soil based on protection of air and ground water (EPA 1995b). SSLs based on protection of air are soil concentrations that, under default conditions, will not give rise to fugitive dust or volatilized chemical concentrations that would be associated with unacceptable risks (EPA 1994e). SSLS function much like RBCs in that further evaluation as a COC is warranted if a chemical is detected at concentrations greater than its SSL.

(55 g/day; EPA 1994a). Therefore, because the consumption rates for shellfish and finfish are essentially the same, the use of RBCs for fish ingestion to screen COCs in shellfish was considered to be protective of human health.

Air samples were not collected at Site 07. Therefore, for risk-based screening, chemical concentrations in soil were compared to soil screening levels SSLs that were designed to protect the ambient air (EPA 1994e). Since the SSLs were developed assuming a residential exposure scenario, application to situations involving less opportunity for potential exposures (such as would be expected under the exposure scenarios developed for Site 07) were considered to be protective of human health in this HHRA.

RBCs and SSLs were not available for all chemicals detected at Site 07. For these contaminants, the RBC or SSL for a structurally similar compound was used, where possible. For example:

- RBCs for endrin were applied to all forms of endrin, including endrin aldehyde and endrin ketone,
- RBCs for chlordane were applied to both alpha and gamma chlordane,
- RBCs for pyrene were used for structurally similar noncarcinogenic PAH, such as acenaphthylene, benzo(e)pyrene, benzo(g,h,i)perylene, coronene, perylene and phenanthrene,
- RBCs for "PCB" based on carcinogenic effects were used for screening all Aroclor mixtures.

In some cases the analytical data were not sufficiently specific. For example, chromium III and chromium VI were not analyzed for separately and benzo(b)fluoranthene and benzo(k)fluoranthene were sometimes reported as benzo(b/k)fluoranthene. In these cases, as a conservatively prudent measure, the reported data were assigned to the more toxic compound, chromium VI and benzo(b)fluoranthene, respectively, and the corresponding RBC was used.

Table 6-1 contains a summary of maximum detected concentrations of all detected analytes in total soil (i.e., surface soil and subsurface soil to a depth of 10 ft) and EPA Region III RBCs for industrial soils. RBCs for industrial soils were used because total soils are of interest in the future remediation/construction scenario, which is industrial rather than residential. Use of industrial RBCs in this case were considered to be protective for remediation/construction workers. Chemicals detected at maximum concentrations in soil greater than their RBCs were evaluated further as potential COCs in total soils.

Table 6-2 contains a summary of maximum detected concentrations of all detected analytes in surface soil and EPA Region III RBCs for industrial soils. RBCs for industrial soils

were used because they were considered to be sufficiently protective of recreational users who will come into contact with the soil infrequently. Chemicals detected at maximum concentrations in soil greater than their RBCs were evaluated further as potential COCs in surface soil.

Table 6-3 contains a summary of maximum detected concentrations of potential COCs in sediment and RBCs for residential soils. Industrial RBCs for soil were used because they were considered to be sufficiently protective of recreational users who will come into contact with sediments only infrequently. Chemicals detected at maximum concentrations in sediment greater than their RBCs were evaluated further as potential COCs in sediment.

Table 6-4 contains a summary of maximum detected concentrations of potential COCs in shallow ground water and RBCs for tap water. Tables 6-5a and 6-5b contain a summary of maximum detected concentrations of potential COCs in deep and bedrock ground water, respectively, and RBCs for tap water. In these three cases, chemicals detected at maximum concentrations in water greater than their RBCs were evaluated further as potential COCs.

Table 6-6 contains a summary of maximum detected concentrations of potential COCs in shellfish and RBCs for fish. Chemicals detected at maximum concentrations in shellfish greater than their RBCs were evaluated further as potential COCs in shellfish. Since RBC for butyltin was not available, it was retained for further evaluation as a potential offshore media COC in shellfish. Maximum detected concentrations of tributyltin in soft shell clam, hard shell clam, and oyster were 297.77, 29.79, and 13.74 ng Sn/g dry weight, respectively (see Table 4.3-3). Mean concentrations were reported as 46.13, 8.49, and 3.16 ng Sn/g dry weight for the same species listed above, respectively.

Table 6-7 contains a summary of maximum detected concentrations of potential COCs in total soils and RBCs for soil contaminants based on the transfer of contaminants to air.

Chemicals for which the maximum concentration did not exceed the medium-specific RBC were marked "No" in the RBC screening tables and were eliminated from further consideration unless a separate evaluation indicated a compelling reason to re-include the particular chemical in the HHRA (see Section 6.2.1.4). Tables 6-1 through 6-7 also detail the additional screening steps applied to screen the list of potential COCs for inclusion on the list of final COCs.

### 6.2.1.4 Additional Screening of COCs

For inorganic chemicals in soils (i.e., metals), statistical comparisons between naturally-occurring background concentrations (summarized in Table 6-8) and onsite concentrations were made using the student's t-test, assuming lognormal concentration distributions. Because only seven background samples were available—only one of which was collected from an area adjacent to Site 07—these statistical comparisons were judged not to be

sufficient to influence the selection of COCs. Statistical comparisons to background could not be performed for:

- Antimony in soil because no background data for this constituent were available,
- Other environmental media (e.g., ground water and sediment) because appropriate background data were not available, or
- Organic contaminants in soil because of the lack of a scientific basis for a "naturally occurring background level."

Potential COCs with maximum detected concentrations greater than the RBC were eliminated from consideration if they were detected in less than five percent of samples in a particular medium. This evaluation required at least 20 samples, which may not have been available for some analytes in some media. For these media, a chemical was eliminated if the following conditions were met: (1) at least 10 samples were collected, (2) it was detected in only 1 of those 10 samples, and (3) it was not a COC in a related medium (e.g., deep ground water and shallow ground water).

A chemical was eliminated from the list of potential COCs if it was known to be an essential nutrient and if the detected concentrations were not expected to be associated with adverse health impacts. Inorganic contaminants detected at Site 07 that were judged to be essential nutrients were: calcium, iron, magnesium, potassium, and sodium.

Chemicals without SSLs based on transfers to air were eliminated from the list of potential COCs in air if they were not COCs in soil (e.g., aluminum, zinc).

Potential COCs without EPA-verified toxicity values were not included in the quantitative risk assessment. Contaminants lacking appropriate toxicity values include lead, benzotriazole, and chlorinated benzotriazole. Exposures and associated risks for these contaminants are discussed qualitatively in Section 6.5.

EPA (1995d,e) has added new guidance for screening COCs associated with health effects other than cancer. First, the list of chemicals with maximum concentrations in excess of the RBC were segregated by the organ or endpoint, e.g., kidney, blood, neurotoxity, reproductive toxicity, on which the chemical's reference dose is based, as identified in IRIS (EPA 1995a) or HEAST (EPA 1994b). Second, hazard quotients (HQs) for each chemical were calculated using the following formula (EPA 1995d):

$$HQ = \frac{0.1 \times C_{max}}{RBC}$$

where

$HQ$ = Hazard index
$C_{max}$ = Maximum detected concentration
$RBC$ = Risk-based concentration at a hazard quotient of 0.1.

From these HQs, hazard indices were summed for each separate endpoint. If the hazard index (HI) per endpoint group exceeded 1.0, all of the chemicals in that group were retained as COCs. If the HI per endpoint group was less than 1.0, individual chemicals were included as COCs only if they were also identified as COCs in another medium. Otherwise, chemicals in endpoint groups with an HI less than 1.0 were not included in the final list of COCs. Chemicals eliminated from the list of COCs on the basis of this noncancer endpoint evaluation are labeled "Endpoint HI < 1" in the "Additional considerations" column in Tables 6-1 through 6-7.

This method could not be applied to the selection of noncarcinogenic COCs in air because the Soil Screening Levels are not necessarily risk-based. Some SSLs are based on chemical-specific soil saturation concentrations. Consequently, selection of COCs in air did not include this step. Based on the SSL screening, no COCs were identified in air, with the exception of lead. However, because lead exposures and risks are discussed in terms of comparing soil concentrations to RIDoH and U.S. EPA guidelines (see Section 6.5.2.4), quantitative assessment of exposures and risks via air was not conducted in this HHRA.

Before the COC list was finalized, additional steps were taken to reevaluate the appropriateness of including contaminants that had been removed from the list of COCs in the steps above. Considerations involved in these reevaluations included the following:

- A contaminant present at levels close to, but below, the RBC for a particular medium was included as a COC for that medium if it was determined to be a COC in a related medium (e.g., arsenic in soils and sediment).

- For shallow ground water, a chemical was included as a COC in shallow ground water if it was detected in at least one sample and if it was identified as a COC in deep ground water (e.g., 1,2 dichloroethane, aluminum, nickel, vinyl chloride).

- For deep ground water, a chemical was included as a COC in deep ground water if it was detected in at least one sample and if it was identified as a COC in shallow or bedrock ground water (e.g., acetone, 1,1-dichloroethene).

- For bedrock ground water, a chemical was included as a COC in bedrock ground water if it was detected in at least one sample and if it was identified as a COC in deep ground water (e.g., arsenic, vinyl chloride).

The step-by-step process of selecting the final list of COCs for each environmental medium is illustrated in Tables 6-1 through 6-7. The final list of COCs in all media is summarized in Table 6-9. Summary statistics (e.g., frequency of detection, range of detection, mean, and the upper 95th percentile confidence limit on the mean) for COCs in all media are presented in Tables 6-10 through 6-15. Chemical and physical properties constants for all COCs are summarized in Table 6-16.

#### 6.2.1.5 Uncertainty in Application of a Risk-Based Screening Level Approach

As stated in *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening - Technical Guidance Manual* (EPA 1993a), the EPA Region III RBCs are likely to be protective as no-action levels for human health for sites where: (1) a single medium is contaminated; (2) a single contaminant contributes nearly all of the health risk; (3) volatilization or leaching of that contaminant from soil is expected not to be significant; and (4) the exposure scenarios used in developing the values in the RBC table are appropriate for the site. In addition, site-specific conditions that would affect the tendency of chemicals to volatilize or leach from soil introduces additional uncertainty in the use of SSLs.

At NCBC Site 07, more than one medium exhibited elevated chemical concentrations, and a number of COCs may contribute to the overall health risk. In addition, volatilization and leaching could be significant for a number of the COCs. However, the exposure scenarios for future use of the site are conservative overestimates. As described above, application of RBCs developed for ingestion of tap water and finfish have been applied to other exposure pathways (e.g., incidental ingestion of water and consumption of shellfish) in such a manner that the RBCs are protective of human health.

Because screening level concentrations were not available for several COCs and RBCs were applied to exposure pathways with exposure conditions different from those for which they were originally developed, the risk-based screening may not accurately reflect the potential health risks at Site 07. However, the screening was conducted so as not to eliminate chemicals which could present serious risks. Finally, where no RBC was available, the contaminant in question was retained for evaluation.

### 6.2.2 Hazard Identification of Chemicals Selected for Assessment of Human Health Risk at Site 07

The hazardous properties of the chemicals addressed in this chapter are summarized below. A detailed description of their toxicities is located in Appendix L of this report. For

carcinogens, EPA has assigned a scientific weight-of-evidence classification (A, B1, B2, C, D, or E)[3] to a chemical that represents a qualitative indication of its ability to cause cancer, based on an examination of the scientific literature.

**Acenaphthene**

The chronic or subchronic systemic toxicity of acenaphthene has been studied to a limited extent. No studies have been reported on the repeated and prolonged skin contact with, or inhalation of, acenaphthene (ATSDR 1990).

A single long-term ingestion study has been reported for this chemical. The daily administration by gavage[4] of acenaphthene to mice over 90 days resulted in liver weight changes accompanied by minimal to mild microscopic alterations and increases in blood cholesterol levels (EPA 1989b). Animal data indicate that systemic oral toxicity of noncarcinogenic PAH such as acenaphthene is of mild severity, and appears to involve mainly reversible enzyme and/or organ weight changes (ATSDR 1990).

No studies have been reported on the carcinogenic potential of acenaphthene in humans or animals by any route of administration (ATSDR 1990). The carcinogenicity of acenaphthene has not been classified by EPA.

**Acetone**

In a subchronic oral study (EPA 1986b), albino rats were dosed 0, 100, 500, or 2,500 mg/kg-day. The critical effects were increased liver and kidney weights and nephrotoxicity.

The EPA weight of evidence classification for the carcinogenicity of this compound is "not classifiable as to human carcinogenicity" (EPA 1995a) based on inadequate data.

**Aldrin**

Aldrin is a Category B2, probable human carcinogen (EPA 1995a). This classification is based on studies in which orally administered aldrin produced significant increases in

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[3] EPA weight-of-evidence classifications for carcinogens are as follows:

| | |
|---|---|
| A | Known human carcinogen |
| B1 | Probable human carcinogen, based on sufficient animal data and limited human data |
| B2 | Probable human carcinogen, based on sufficient animal data and inadequate or no human data |
| C | Possible human carcinogen, based on limited animal data |
| D | Data are inadequate or nonexistent and chemical is not classifiable as to human carcinogenicity |
| E | Evidence of noncarcinogenicity for humans |

[4] "Gavage" is a form of forced ingestion in which a tube, containing the chemical under study, is forced through the mouth directly into the esophagus or stomach.

tumor responses in three different strains of mice in both males and females. Tumor induction has been observed for structurally related chemicals, including dieldrin, a metabolite. Data in humans are inadequate.

Two epidemiologic studies of workers exposed to aldrin and dieldrin (a metabolite of aldrin) did not find an excess risk of cancer. However, both studies were limited in their ability to detect an excess of deaths from cancer (EPA 1995a).

Davis and Fitzhugh (1962) fed a group of 215 male and female C3HeB/Fe mice a dietary mixture containing 10 ppm aldrin for up to 2 years. The control group consisted of 217 mice. The aldrin-treated mice died 2 months earlier than controls. Intercurrent disease, pneumonia, and intestinal parasitism may have influenced the long-term survival rate. A statistically significant increase of hepatomas was reported in the treated animals as compared with controls. An independent reevaluation of the liver lesions showed most of the hepatomas to be liver carcinomas (Epstein 1975). In a follow-up study, Davis (1965) administered aldrin at 0 or 10 ppm in the diet to 100 male and 100 female C3H mice for 2 years. The incidence of hepatic hyperplasia and benign hepatomas in the aldrin group was approximately double that of controls, whereas the number of hepatic carcinomas was about the same. Neither study provided a detailed pathologic examination or data separated by sex.

Aldrin (95 percent pure) was administered in the diet to 50 male and 50 female B6C3FI mice at doses of 4 and 8 ppm or 3 and 6 ppm (NCI 1978a). Treatment was for 80 weeks, and animals were observed for an additional 10 to 13 weeks. In male mice, there was a significant dose-related increase in hepatocellular carcinomas when compared with matched or pooled controls.

Groups of 24 rats (12/sex) were fed aldrin in the diet at levels of 0, 0.5, 2, 10, 50, 100, or 150 ppm for 2 years (Fitzhugh et al. 1964). Liver lesions characteristic of chlorinated insecticide poisoning were observed at dose levels of 0.5 ppm and greater. These lesions were characterized by enlarged centrilobular hepatic cells, with increased cytoplasmic oxyphilia, and peripheral migration of basophilic granules. A statistically significant increase in liver-to-body weight ratio was observed at all dose levels. Kidney lesions occurred at the highest dose levels. Survival was markedly decreased at dose levels of 50 ppm and greater (EPA 1995a).

**Aluminum**

The toxicity of aluminum can be divided into three major categories: (1) the effect of aluminum compounds in the gastrointestinal tract; (2) the effect of inhalation of aluminum compounds; and (3) systemic toxicity of aluminum. Aluminum compounds can alter absorption of other elements in the gastrointestinal tract (i.e., fluoride, calcium, iron, cholesterol, phosphorus) and later gastrointestinal tract mobility by inhibition of acetylcholine-induced contractions. Inhalation of aluminum dusts can lead to the

development of pulmonary fibrosis, producing both restrictive and obstructive pulmonary disease. A progressive fatal neurologic syndrome has been noted in patients on long-term intermittent hemodialysis treatment for chronic renal failure and may be due to aluminum intoxication. Symptoms in these patients include a speech disorder followed by dementia, convulsions, and myoclonus. Aluminum content of brain, muscle, and bone tissues is increased in these patients. Sources of the excess aluminum may be from oral aluminum hydroxide commonly given to these patients or from aluminum in dialysis fluid derived from tap water used to prepare the dialysate fluid. The available data have been evaluated and found to be inadequate for quantitative non-cancer risk assessment (EPA 1995a). EPA (1995a) has not evaluated aluminum with respect to its potential human carcinogenicity.

**Anthracene**

The chronic systemic toxicity of anthracene has been studied to a limited extent. No studies have been reported on the repeated and prolonged skin contact with, or inhalation of, anthracene (ATSDR 1990).

Two long-term ingestion studies have been reported for anthracene. The daily administration by gavage of up to 1 g/kg-day of anthracene to mice over a 13-week period showed no evidence of systemic toxicity (EPA 1989c). The daily dietary administration of anthracene at doses ranging from 5 to 15 mg/kg-day for 550 days resulted in no treatment-related pathology in rats over the course of their lifetime (Schmähl 1955). Animal data indicate that systemic oral toxicity of such noncarcinogenic PAH as anthracene is of mild severity, and appears to involve mainly reversible enzyme and/or organ weight changes (ATSDR 1990).

No studies have been reported on the carcinogenic potential of anthracene in humans or animals by any route of administration (ATSDR 1990). Anthracene is currently assigned an EPA carcinogen classification of Category D.

**Antimony**

Therapeutic administration of antimony-containing chemicals has produced cardiac effects, liver toxicity, pulmonary congestion, skin reactions, vomiting, diarrhea, gastric discomfort, and ulcers in treated humans (ATSDR 1990a).

Inhalation exposures in industrial settings have produced respiratory tract irritation, pneumoconiosis, and impaired pulmonary function in workers (Cooper et al. 1968; Potkonjak and Vishnijich 1983). Dermatosis and ocular irritation have also been reported in humans following exposure to airborne antimony (Potkonjak and Vishnijich 1983).

Antimony is currently assigned an EPA carcinogen classification of Category D.

**Arsenic**

Arsenic (As), a ubiquitous metalloid element, exists in one of three chemical states: (1) trivalent ($As^{3+}$) ion, (2) pentavalent ($As^{5+}$) ion, and (3) organic, much of which is in the pentavalent state.

The toxicity is chemical-state-dependent, with the relative potency being $As^{3+} > As^{5+} >$ organic As (ATSDR 1991a). Much of the chronic toxicity, including the carcinogenicity, is attributable to the trivalent state (Bhamra and Costa 1992).

Dermal exposure to high concentrations of arsenic is reported to induce dermatitis (Pinto and McGill 1953; Holmqvist 1951). There is no evidence to indicate that dermal exposure alone is associated with increased risk of cancer.

Chronic human ingestion of relatively high doses of arsenic via drinking water has been reported to produce hyperpigmentation, keratosis, and potential vascular complications (Tseng 1977; Tseng et al. 1968).

Symptoms of chronic inhalation of arsenic include lesions of the skin and mucous membranes, and alterations to the nervous and respiratory systems (Fowler 1977).

Arsenic has been classified as a human carcinogen by both International Agency for Research on Cancer (IARC) (Group 1) and EPA (Category A), based on observations of increased lung cancer mortality in high dose, occupationally exposed populations and on observations of increased skin cancer incidence in several Asian populations consuming drinking water with high arsenic concentrations (EPA 1995a; IARC 1983). Paradoxically, no laboratory animal studies with arsenic have produced cancer. Several investigators have postulated that arsenic is a threshold human carcinogen, because at low doses, it appears to be detoxified efficiently by conversion to dimethylarsenic acid (Thompson 1993). At doses high enough to saturate this metabolic conversion capacity, arsenic would not be detoxified, and would then become carcinogenic.

Arsenic is readily absorbed by all routes. The primary metabolic processes following arsenic exposure involve redox reactions that interconvert $As^{3+}$ and $As^{5+}$, and methylate the inorganic forms for excretion (ATSDR 1991a). $As^{3+}$ is conjugated with sulfhydryl compounds and excreted in the urine. The major urinary metabolites of arsenic include dimethylarsenic acid and methylarsenic acid (Challenger 1945).

**Benzene**

Benzene has been classified as a known human carcinogen (Category A) by the EPA, based on several occupational epidemiology studies showing an increased incidence of nonlymphocytic leukemia associated with high workplace exposures (EPA 1995a). Supporting evidence comes from rodent studies in which benzene induced tumors in

multiple species at multiple sites when administered either by inhalation or by gavage (EPA 1995a). When administered by gavage, tumors induced by benzene included leukemias/lymphomas in both sexes of rats (Maltoni et al. 1983) and in both sexes of mice (NTP 19 86a). When administered via inhalation, however, benzene induced a marginal increase in the incidence of hematopoietic neoplasms in male C57B1 mice, but no increases in any tumors in male AKR or CD-1 mice similarly exposed (Snyder et al. 1981). Additionally, male Sprague-Dawley rats exposed to a similar dosing regime did not develop tumors (Snyder et al. 1981). In another rat experiment by Maltoni et al. (1983), male and female rats developed tumors of the liver and of the Zymbal's gland but not of the hematopoietic system.

Case reports and epidemiologic studies of workers have established a causal relationship between high dose exposure to benzene and acute myeloid leukemia (AML). AML is a fatal condition, and onset is often rapid; it is characterized by diminished production of normal erythrocytes, granulocytes, and platelets, which leads to death by anemia, infection, or hemorrhage. While some studies have implicated other types of leukemia and possibly lymphoma with exposure to high concentrations of benzene, the evidence is strongest and most consistent for AML and its variants (Goldstein 1988).

A cohort study of white male workers occupationally exposed to benzene in two rubber manufacturing facilities (Infante et al. 1977) showed a significant excess of leukemia, either myelogenous or monocytic, yielding 10-fold increase in relative risk from the two types leukemia combined. The average benzene exposure for workers was estimated at 100 ppm. Benzene appeared to be the only major industrial chemical present that is known to be associated with blood disorders; thus, the possibility that leukemia was associated with exposure to other chemicals in the workplace was minimized.

Human case studies have shown that benzene inhalation exposure is fatal at concentrations of 20,000 ppm for short durations (Flurry 1928). An inhalation $LC_{50}$ value for rats is 13,700 ppm for a 4-hour exposure (Drew and Fouts 1974). Lethality in animals has been ascribed to ventricular fibrillation due to increased release of adrenaline (Nahum and Hoff 1934). Animal lethality data indicate that benzene is of low toxicity following acute oral exposure. The oral $LD_{50}$ for rats ranges from 930-5600 mg/kg (O'Bryan and Ross 1988).

The major systemic effect of high-dose, chronic exposure to benzene is hematotoxicity. Benzene exerts its toxic effects in the bone marrow, producing deficiencies of blood cells such as pancytopenia (significant decreases in all major types of blood cells: erythrocytes, leukocytes and platelets) and aplastic anemia (which can progress to acute nonlymphocytic leukemia). Deficiencies in various types of blood cells lead to other disorders such as hemorrhagic conditions from a lack of platelets, susceptibility to infection from lack of leukocytes, and increased cardiac output from lack of erythrocytes.

**Benzo(a)anthracene**

Reports of traditional subchronic or chronic systemic toxicity of benzo(a)anthracene by any route have not been found (ATSDR 1990). A few research studies have explored some limited pathological systemic endpoints in animals exposed either by ingestion or injection (ATSDR 1990); however, the findings of these investigations are inadequate to assess the risks of this chemical for exposed humans.

The carcinogenicity of benzo(a)anthracene has been investigated by two routes of exposure (skin contact and ingestion). No data exist on its carcinogenicity by inhalation. Benzo(a)anthracene is currently assigned an EPA carcinogen classification of Category D.

The evidence for potential carcinogenicity of PAH, including benzo(a)anthracene, comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Although interpretation of some of these data is complicated by the use of different solvents in different tests, the following PAH induced skin tumors following intermediate or long-term dermal exposure: benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene (Wynder and Hoffmann 1959a, 1959b; Hoffmann and Wynder 1966; Bingham and Falk 1969; Hecht et al. 1974; Habs et al. 1980; LaVoie et al. 1982).

Based on the findings of these skin painting studies, the relative carcinogenic potencies (in relation to benzo(a)pyrene) are as follows: benzo(a)pyrene > dibenzo(a,h)anthracene > benzo(b)fluoranthene > benzo(a)anthracene > dibenzo(k)fluoranthene > indeno(1,2,3-cd)pyrene > chrysene. The range of carcinogenic potencies of these PAH spans several orders of magnitude.

The carcinogenicity of ingested benzo(a)anthracene has been investigated in one study. Bock and King (1959) reported on the findings of animal gavage studies of benzo(a)anthracene to determine its carcinogenicity. However, the findings are inconclusive because of methodological limitations.

**Benzo(a)pyrene**

There are no data on subchronic and chronic systemic toxicity of benzo(a)pyrene by any route (ATSDR 1990). A few research studies have explored some systemic pathological endpoints in animals exposed either by ingestion or inhalation (Nousiainen et al. 1984; Robinson et al. 1975; Thyssen et al. 1981); however, the findings of these investigations are judged inadequate to assess the risks of this chemical for exposed humans.

The carcinogenicity of benzo(a)pyrene has been investigated by skin contact, ingestion, and inhalation. Epidemiologic studies have demonstrated increased mortality due to lung cancer in humans exposed via inhalation to coke-oven emissions (Lloyd 1971; Mazumdar

et al. 1975; Redmond et al. 1976), roofing tar emissions (Hammond et al. 1976), and cigarette smoke (McLure and MacMahon 1980). Reports of skin tumors among individuals exposed to mixtures containing PAH have also been documented (e.g., Purde and Etlin 1980). Each of these mixtures contained a number of PAH including benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)anthracene, and dibenzo(a,h)anthracene, as well as other potentially carcinogenic chemicals including nitrosamines, coal tar pitch, and creosote. Evaluating the contribution of any individual PAH to the total carcinogenicity of these mixtures in humans is not possible, because of the complexity of the mixtures and the presence of other carcinogens. Epidemiologic evidence in humans regarding the potential carcinogenicity of benzo(a)pyrene alone is thus inadequate. Benzo(a)pyrene is currently assigned an EPA carcinogen classification of Category B2.

Experimental studies in laboratory animals have shown that repeated administration of benzo(a)pyrene by any route is associated with an increased incidence of tumors. It is tumorigenic in animals via dietary administration, gavage, inhalation, intratracheal instillation, and dermal and subcutaneous applications (EPA 1995a). Mice administered daily dietary doses of up to 1,000 ppm benzo(a)pyrene for 38 to 238 days exhibited an increased incidence of stomach tumors (Rigdon and Neal 1966). Benzo(a)pyrene induces skin tumors in mice at the point of contact with repeated dermal application (Shubik and della Porta 1957). An inhalation study by Thyssen et al. (1981) showed that repeated exposure to benzo(a)pyrene particles induced respiratory tract tumors in Syrian golden hamsters. Benzo(a)pyrene is mutagenic in the Ames assay and in prokaryote and mammalian cell culture tests for DNA damage (EPA 1995a), providing supporting data for its possible mechanism of action as an initiator of tumorigenesis.

Benzo(a)pyrene appears to be a developmental and reproductive toxicant when administered at high doses by ingestion to pregnant mice and rats, although results are inconsistent among studies. In addition, the findings may be of questionable relevance to humans, since the doses administered appear to have induced maternal toxicity (MacKenzie and Angevine 1981; Shevaleva 1978; Rigdon and Neal 1965). Systemic toxicity of benzo(a)pyrene has been characterized as minimal (ATSDR 1990).

Among the carcinogenic PAH, benzo(a)pyrene has been the most widely studied, and is considered to be the most potent. Therefore, benzo(a)pyrene was chosen to represent the other carcinogenic PAH: benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

**Benzo(b)fluoranthene**

Information on subchronic and chronic systemic toxicity of benzo(b)fluoranthene by any route has not been located (ATSDR 1990). No toxicity studies examining the developmental and reproductive effects of benzo(b)fluoranthene have been reported. There are no human data that specifically link exposure to benzo(b)fluoranthene to human

cancers; however, it is a component of mixtures that have been associated with human cancer (IARC 1983). There are sufficient data on the carcinogenic effects of benzo(b)fluoranthene on experimental animals to classify it as an animal carcinogen.

The carcinogenicity of benzo(b)fluoranthene has been investigated by dermal application, intraperitoneal or subcutaneous injection, and lung implantation, but not by inhalation or ingestion. A dose-response relationship for benzo(b)fluoranthene carcinogenicity has been demonstrated over an order-of-magnitude dose range in Swiss mice receiving topical doses (three times per week) throughout their lifetime (Wynder and Hoffmann 1959b). The tumor initiating activity of benzo(b)fluoranthene on mouse skin has been demonstrated using a standard initiation/promotion protocol with promoting agent 12-*O*-tetradecanonyl-phorbol-13-acetone (LaVoie et al. 1982). Increases in the number of animals with tumors and tumors per animal appeared to be dose-related. A lifetime lung implant study using Osborne-Mendel rats produced tumors (epidermoid carcinomas and pleomorphic sarcomas) in the lung and thorax that showed a statistically significant dose-response relationship (Deutsch-Wenzel et al. 1983). Studies of intraperitoneal injection into CD-1 mice (LaVoie et al. 1987) and subcutaneous injection into XVIInc/Z mice (Lacassagne et al. 1963) also support the evidence that benzo(b)fluoranthene is an animal carcinogen.

**Benzo(k)fluoranthene**

Reports of subchronic and chronic systemic toxicity of benzo(k)fluoranthene by any route have not been conducted (ATSDR 1990).

The carcinogenicity of benzo(k)fluoranthene has been investigated by skin contact, but not by ingestion or inhalation. The evidence for potential carcinogenicity of PAH other than benzo(a)pyrene comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Although interpretation of some of these data is complicated by the use of different solvents in different tests, the following PAH induced skin tumors after intermediate or long-term dermal exposure: benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene (Habs et al. 1980; Wynder and Hoffmann 1959a, 1959b; Bingham and Falk 1969; Hecht et al. 1974; Hoffmann and Wynder 1966; LaVoie et al. 1982).

Benzo(k)fluoranthene is currently assigned an EPA human carcinogen classification of Category B2.

**Benzo(g,h,i)perylene**

The subchronic or chronic systemic toxicity of benzo(g,h,i)perylene has not been studied by any route (ATSDR 1990). Consequently, pyrene, a structurally similar noncarcinogenic PAH that has been studied more extensively, was used as a surrogate representative for the systemic toxicity of benzo(g,h,i)perylene for all routes. Most animal data indicate that

systemic oral toxicity of noncarcinogenic PAH such as benzo(g,h,i)perylene is mild, and appears to involve mainly reversible enzyme and/or organ weight changes (ATSDR 1990).

The carcinogenicity of benzo(g,h,i)perylene has been investigated by skin contact, but not by ingestion or inhalation. Benzo(g,h,i)perylene was tested for complete carcinogenic activity and initiating activity in mouse skin painting assays, and produced no tumors in either type of assay (Wynder and Hoffmann 1959a, 1959b; Hoffmann and Wynder 1966; Müller 1968; Van Duuren et al. 1973). Furthermore, when injected subcutaneously, benzo(g,h,i)perylene induced no tumors (Müller 1968). It also tested negative as a possible cocarcinogen with benzo(a)pyrene (Van Duuren et al. 1973; Van Duuren and Goldschmidt 1976).

Benzo(g,h,i)perylene is currently assigned an EPA carcinogen classification of Category D.

**Beryllium**

Toxic effects resulting from subchronic or chronic oral administration of beryllium to laboratory animals have not been widely studied. Respiratory effects (altered morphology and biochemical parameters) have been observed following administration of beryllium in food to rats (Goel et al. 1980), while the only observed effects of lifetime administration of beryllium in drinking water to rats were changes in body weight gain (Schroeder and Mitchener 1975a,b). Data on the teratogenicity or reproductive effects of beryllium are limited, but beryllium has been reported to produce embryolethality and terata in chick embryos (Puzanova et al. 1978).

The lung is the primary target organ for beryllium toxicity via inhalation. For both humans and animals, the manifestations of subchronic or chronic beryllium intoxication are similar: lung fibrosis ("chronic berylliosis") and pneumonitis, and some reports of cellular proliferation, macrophage infiltration, and inflammation (ATSDR 1987). Frank effect levels (FELs) for lung toxicity in a variety of laboratory species were 0.04 $mg/m^3$ beryllium following subchronic or chronic exposure durations (ATSDR 1987).

Beryllium has been classified by the EPA as a probable human carcinogen (Category B2) based on inadequate human evidence but sufficient animal carcinogenicity evidence (EPA 1995a). Beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injection (EPA 1995a).

**Bis(2-Chloroethyl)Ether**

The EPA weight-of-evidence classification for human carcinogenic potential of this compound is Category B2 — probable human carcinogen (EPA 1995a). Liver tumors were detected in mice given bis(2-chloroethyl)ether for 560 days.

**Bis(2-Chloroisopropyl)Ether**

A 2-year dietary study in mice (EPA 1995a) found that the critical effect was decreased hemoglobin. The EPA weight-of-evidence classification for the human carcinogenic potential of this chemical is Category C — possible human carcinogen (EPA 1995a). Development of liver and lung tumors occurred in a 2-year gavage study in mice.

**2-Butanone (Methyl ethyl ketone)**

Weanling FDRL-Wistar stock rats (30/sex/group) were given 2-butanol (a metabolic intermediate of 2-butanone) in drinking water at 0, 0.3, 1.0, or 3.0 percent solutions and a standard laboratory ration *ad libitum* (Cox et al. 1975). Over several generations in this developmental feeding study, the critical effect was determined to be decreased fetal birth weight.

The EPA weight-of-evidence classification for the carcinogenicity of 2-butanone is Category D — not classifiable as to human carcinogenicity (EPA 1995a).

**Butyltin**

Some organotin compounds act on immature lymphoblasts in the outer cortex of thymus. The thymus is considered as the privileged site of T-lymphocyte generation. The mechanism of toxicity includes interference with cell proliferation. The consequences of toxicity can be a decrease in thymic output of newly generated T-lymphocytes (i.e., generation of a new T-cell repertoire), or induction of autoimmune symptoms by the creation of unwanted repertoire. This latter phenomenan may be applicable to cyclosporin that under specified conditions can induce so-called syngeneic graft-vs-host disease (Schuurman et al. 1992).

Two organotin compounds, tri-n-butyltin acetate (TBTA) and triphenyltin acetate (TPTA), that have antifungal potentials were evaluated for acute mammalian toxicity in rats. The median lethal doses were 297.54 mg TBTA/kg and 402.38 mg TPTA/kg. Both compounds produced significant central nervous system and respiratory depressions at single doses of 200 mg TBTA/kg or 300 mg TPTA/kg. The histopathological findings due to TBTA included pulmonary, hepatic and renal congestion, brain hemorrhages, and destruction of the intestinal mucosa. TPTA produced brain congestion, and hepatic and pulmonary petechial and generalized hemorrhages (Attahiru et al. 1991).

The in vivo induction of hepatotoxicity, as evaluated by the activity of ornithine carbamyl transferase in serum, was investigated in mice administered orally with the following three butyltin compounds: tributyltin chloride (TBTC), dibutyltin dichloride (DBTC) and monobutyltin trichloride (MBTC). The minimal concentrations of TBTC and DBTC that caused hepatotoxicity at 24 hours after oral administration were 180 $\mu$mol and 60 $\mu$mol/kg, respectively, while MBTC did not induce liver injury even at 7,000 $\mu$mol/kg. The study

concluded that non-hepatotoxicity of MBTC may be due either to low absorption through the digestive tract of mice or to the low levels of Sn in liver; however, the level of Sn in liver was not associated with the induction of hepatotoxicity by TBTC and DBTC (Ueno et al. 1994).

Pregnant rats were given di-n-butyltin dichloride (DBT) by gastric intubation at a dose of 0, 2.5, 5.0, 7.5 or 10.0 mg/kg on days 7-15 of pregnancy. Maternal toxicity occurred in the 7.5 and 10.0 mg/kg groups as evidenced by a significant increase in maternal death and decrease in food consumption and body weight gain. The incidence of fetuses with malformations was roughly proportional to the dose of DBT, and was significantly increased in the 5.0, 7.5 and 10.0 mg/kg groups. Cleft jaw, ankyloglossia, defects of the mandible, fusion of the ribs and deformity of the vertebral column were predominantly found. It is concluded that DBT produced teratogenic effects in the absence of maternal toxicity (Ema et al. 1991).

Butyltin trichloride (BT), dibutyltin dichloride (DBT) and tributyltin chloride (TBT) were compared for their developmental toxicity including teratogenic potential following administration during the susceptible period for the teratogenesis of DBT. Pregnant rats were given either BT at a dose of 1000, 1500 or 2000 mg/kg, DBT at a dose of 10 or 15 mg/kg or TBT at a dose of 40 or 80 mg/kg by gastric intubation on days 7 and 8 of pregnancy. Although maternal toxicity occurred, as evidenced by a significantly increased maternal lethality at 1,500 and 2,000 mg/kg and decreased maternal weight gain at 1,000 and 1,500 mg/kg, no significant increase in the incidences of postimplantation loss and malformed fetuses were observed after treatment with BT. Treatment with DBT resulted in a significantly lower maternal weight gain, lower fetal weight and higher postimplantation embryolethality. A significantly and markedly increased incidence of fetuses with malformations, such as exencephaly, cleft jaw, cleft lip, ankyloglossia, club foot, deformity of the vertebral column in the cervical and thoracic regions and of the ribs and ano- or microphthalmia, was observed in both groups treated with DBT. While treatment with TBT at 40 and 80 mg/kg caused a significantly decreased maternal weight gain and increased postimplantation embryolethality, no significantly increased incidence of malformed fetuses occurred. It could be concluded that BT, DBT and TBT are different in the susceptibility and spectrum of developmental toxicity (Ema et al. 1995).

Dibutyltin dichloride (DBT), tributyltin chloride (TrBT), and tetrabutyltin (TeBT) were compared for their developmental toxicity and teratogenic potential following administration during the susceptible period for teratogenesis of TrBT. Pregnant rats were given either DBT or TrBT at a dose of 165 or 330 mumol/kg or TrBT at a dose of 330, 660, 1,320, 2,640 or 5,280 mumol/kg on days 13-15 of pregnancy. No significantly increased incidences of postimplantation loss or of fetuses with malformations were found following treatment with DBT. Treatment with TrBT at 165 and 330 mumol/kg resulted in a significant decrease in the maternal weight gain. A significant decrease in the fetal weight was found at 330 mumol/kg. A significantly and markedly increased incidence of fetuses with cleft palate was noted in both groups treated with TrBT. Treatment with

TeBT caused a significantly decreased maternal body weight gain at doses of 660 mumol/kg and above. A significantly increased incidence of fetuses with cleft palate was observed at a dose of 5280 mumol/kg. It could be concluded that there is a difference in the manifestation and degree of developmental toxicity between DBT, TrBT and TeBT (Ema et al. 1996).

**Cadmium**

Ingestion of cadmium results in nausea, vomiting, and abdominal pain. Inhalation of cadmium fumes may result in an acute chemical pneumonitis and pulmonary edema (Goyer 1986).

The critical effects associated with chronic ingestion of cadmium are proteinuria adrenal damage in humans.

The EPA weight-of-evidence of cadmium is Category B1—probable human carcinogen. The inhalation of cadmium has been shown to produce respiratory tract cancers in humans and various tumors in rats and mice following inhalation and injection exposures. No positive cancer studies of ingested cadmium suitable for quantitation are available (EPA 1995a).

**Carbazole**

No background information regarding carbazole toxicity was readily available. Liver tumors were observed in mice fed carbazole in their diet for 96-weeks (Tsuda et al. 1982).

**Chlorobenzene**

Beagle dogs received chlorobenzene orally by capsule at doses of 27.25, 54.5, or 272.5 mg/kg-day for 5 days/week for 13 weeks. The LOAEL was 54.5 mg/kg-day and the critical effects observed were histopathological changes in the liver as well as changes in the blood chemistry.

Rats were exposed to chlorobenzene at doses of 75 ppm for 7 hours/day, 5 days/week for 120 days. The critical effects observed were liver and kidney effects.

The EPA weight-of-evidence classification for the carcinogenicity of this compound is Category D—not classifiable as to human carcinogenicity (EPA 1995a).

**Chloroform**

Chloroform is classified as a probable human carcinogen (Category B2), based on increased incidence of several tumor types in rats and three strains of mice, but inadequate human data

(EPA 1995a). The majority of tests for genotoxicity of chloroform have been negative (EPA 1995a).

Adverse effects resulting from chloroform ingestion have been widely studied. Effects of subchronic and chronic exposure to chloroform range from mortality through various systemic (respiratory, cardiovascular, gastrointestinal, hematological, musculoskeletal, hepatic, and renal systems), immunological, neurological, developmental, reproductive, and carcinogenic effects (ATSDR 1993). Typical animal LOAELs and NOAELs for these varied systems range from 30 to 600 mg/kg-day chloroform for subchronic and chronic exposure durations (ATSDR 1993). Cancer in laboratory animals is reported from various studies to occur with ingestion of approximately 60 to 200 mg/kg-day chloroform for 78 to 180 weeks (ATSDR 1993).

Chloroform was first recognized for its ability to depress central nervous system function, hence its use as a general anesthetic (Simpson 1847). Much as with oral exposure, inhalation exposure to chloroform may bring about death, systemic effects (respiratory, gastrointestinal, hematological, hepatic, renal), neurological effects, and cancer. Human and laboratory animal LOAELs and NOAELs for systemic or neurological toxicity occur largely in the range of 10 to 100 ppm exposures (ATSDR 1993).

Neither ATSDR (1993) nor EPA (1995a) have reviewed, in their toxicological assessments of chloroform, studies relating subchronic or chronic dermal exposure to chloroform with adverse health effects in rodents or humans. Acute exposure NOAELs for hepatic, dermal, or renal effects in rabbits are observed with topical application of solutions containing 1000 to 4000 mg chloroform per kilogram body weight (ATSDR 1993).

**Chromium**

Chromium is a metal that is found in varying oxidative states ranging from chromium(-II) to chromium(+VI). $Cr^{3+}$ is the most commonly occurring natural form of the metal. $Cr^{6+}$, which originates from anthropogenic sources, is of greatest toxicological significance.

Other than localized preneoplastic histopathological changes in the lung, chromium does not appear to induce systemic toxicity. A 1-year drinking-water study in rats (MacKenzie et al. 1958) showed no systemic effects related to chromium exposure. Similarly, no toxicologically significant effects were observed in a 4-year study with dogs (Anwar et al. 1961), or in a group of humans who drank water for three years from a private well containing chromium concentrations of 1 mg/L (EPA 1995a).

Hexavalent chromium ($Cr^{6+}$) is classified as a human carcinogen by the EPA (Category A), based on the demonstration in epidemiologic studies of an increase in the incidence of lung cancer in chromium-exposed workers (EPA 1995a). There are a sufficient number of these studies to establish a dose-response relationship between chromium exposure and human lung cancer. However, these findings may be confounded by the smoking habits of

workers. In calculating the dose-response relationship, it was assumed by both the author of the studies (Mancuso 1975) and EPA (1995a) that the smoking rate among workers was similar to that of white males in the general U.S. population. However, several other epidemiologic studies on the distribution of smoking among human population groups suggest that the smoking rate may be higher among industrial workers than in the general population (EPA 1995a). Chromium workers are exposed to both trivalent and hexavalent chromium; however, only hexavalent chromium has been found to be carcinogenic in animal studies and only hexavalent chromium is considered to be a human carcinogen (EPA 1995a). When assessing carcinogenicity among workers, it has been assumed that the ratio of trivalent to hexavalent chromium is 6:1 (EPA 1995a).

Animal carcinogenicity studies with $Cr^{6+}$ have supported the human evidence of carcinogenicity, producing the following tumors types: intramuscular injection site tumors in rats and mice; intrapleural implant site tumors for various hexavalent compounds in rats; intrabronchial implantation site tumors for various hexavalent compounds in rats; and subcutaneous injection site sarcomas in rats (EPA 1995a).

**Chrysene**

Studies investigating the subchronic or chronic systemic toxicity of chrysene by any route have not been conducted (ATSDR 1990).

The evidence for potential carcinogenicity of chrysene and other PAH comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Although interpretation of some of these data is complicated by the use of different solvents in different tests, of six PAH studied, the potency of chrysene following intermediate- or long-term dermal exposure was least (Habs et al. 1980; Wynder and Hoffmann 1959a, 1959b; Bingham and Falk 1969; Hecht et al. 1974; Hoffmann and Wynder 1966; LaVoie et al. 1982).

Studies investigating the carcinogenicity of either ingested or inhaled chrysene have not been conducted.

Chrysene is currently assigned an EPA carcinogen classification of Category B2.

**Copper**

Copper is a ubiquitous, nutritionally-essential trace element required for hemoglobin synthesis and for varied oxidative enzymes; copper is used in various industrial processes.

Because of its role as a nutritionally essential element, copper is subject to homeostatic mechanisms that attempt to maintain a physiologically balanced supply of the nutrient. Thus, altered copper status can create problems of both deficiency or excess. Copper deficiency is primarily a topic for nutritionists, and only copper excess (toxicity) will be

considered here. An additional consideration is the chemical speciation of the nutrient. Generally, the element must be in a biologically-available form (e.g., a soluble salt) to exert toxic effects; insoluble forms usually preclude any significant absorption into an organism.

As a dietary requirement, oral exposure to copper has been well-studied in animals and humans. Mortality, as well as toxic effects in a variety of organ systems (cardiovascular, hematological, musculoskeletal, hepatic, renal, neurological, developmental, and reproductive) have been associated with excess ingestion of copper (ATSDR 1989a).

Inhalation toxicity of copper and its salts is largely unstudied (Calabrese and Kenyon 1991). Tertiary references cited in Calabrese and Kenyon (1991) indicate lung morphological changes following inhalation exposures to copper: rabbits exhibited a 50 percent increase in the volume density of alveolar type II cells but with no change in lung lysozyme levels following exposure to 0.6 $mg/m^3$ $CuCl_2$ for 6 hours per day, 5 days per week, for 4 to 6 weeks, while guinea pigs exposed thrice daily for 6.5 months to an atmosphere saturated with Bordeaux mixture (lime and 1.5 percent $CuSO_4$ in solution) developed micronodular lesions and small histiocytic granulomas. Similar pathological lesions have been observed in vineyard workers exposed to Bordeaux mixture, but the lesions may not be solely attributable to copper.

Information on copper's carcinogenic effect on humans is lacking, due to an absence of human carcinogenicity data, inadequate evidence of carcinogenicity in animals, and equivocal mutagenicity data (EPA 1995a). Copper is currently assigned an EPA carcinogen classification of Category D.

**4,4′-DDE**

4,4′-DDE is classified as a Category B2 carcinogen on the basis of increased incidence of liver tumors including carcinomas in two strains of mice and in hamsters and of thyroid tumors in female rats exposed to DDE by diet (EPA 1995a).

As reported by EPA (1995a), human epidemiological data are not available for DDE. Evidence for the carcinogenicity in humans of DDT, a structural analog, is based on autopsy studies relating tissue levels of DDT to cancer incidence. These studies have yielded conflicting results.

NCI (1978b) administered DDE in feed at TWA doses of 148 and 261 ppm to 50 B6C3F1 mice/sex/dose for 78 weeks. After an additional 15 weeks, a dose-dependent and statistically significant increase in incidence of hepatocellular carcinomas was observed in males and females in comparison with controls. Increased weight loss and mortality was observed in females. Tomatis et al. (1974) administered 250 ppm DDE in feed for lifetime (130 weeks) to 60 CF-1 mice/sex. A statistically significant increase in incidence of hepatomas was observed in both males and females in comparison with controls. In

females, 98 percent of the 55 surviving exposed animals developed hepatomas, compared to 1 percent of the surviving controls. Rossi et al. (1983) administered DDE in feed for 128 weeks to 40-46 Syrian Golden hamsters/sex/dose at doses of 500 and 1,000 ppm. After 76 weeks, a statistically significant increase in incidence of neoplastic nodules of the liver were observed in both sexes in comparison with vehicle-treated controls.

NCI (1978b) also fed DDE at TWA doses of 437 and 839 ppm for males and 242 and 462 ppm for females for 78 weeks to 50 Osborne-Mendel rats/sex/ dose, with an additional 35-week observation period. A dose-dependent trend in incidence of thyroid tumors was observed in females which was statistically significant by the Cochran Armitage trend test after adjustment for survival. However, the Fischer exact test was not statistically significant.

**Dibenzo(a,h)anthracene**

Reports of the subchronic or chronic systemic toxicity of dibenzo(a,h)anthracene by any route have not been found (ATSDR 1990). A few research studies have explored some systemic pathological endpoints in a few animals exposed either by ingestion or injection (ATSDR 1990); however, the findings of these investigations are judged inadequate to assess the risks of dibenzo(a,h)anthracene for exposed humans.

The evidence for potential carcinogenicity of dibenzo(a,h)anthracene and other PAH comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Although interpretation of some of these data is complicated by the use of different solvents in different tests, the following PAH induced skin tumors following intermediate or long-term dermal exposure: benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene (Wynder and Hoffmann 1959a, 1959b; Hoffmann and Wynder 1966; Bingham and Falk 1969; Hecht et al. 1974; Habs et al. 1980; LaVoie et al. 1982).

The carcinogenicity of ingested dibenzo(a,h)anthracene has been investigated in one study. Berenblum and Haran (1955) reported on the findings of an animal gavage study of dibenzo(a,h)anthracene to determine its carcinogenicity; however, the findings are inconclusive because of methodological limitations.

No studies investigating the carcinogenicity of inhaled dibenzo(a,h)anthracene have been conducted. Dibenzo(a,h)anthracene is currently assigned an EPA carcinogen classification of Category B2 based on no human data and sufficient data from animal bioassays.

**Dibenzofuran**

The EPA (1995a) weight-of-evidence classification for the carcinogenicity of dibenzofuran is Category D — not classifiable as to human carcinogenicity based on no human or animal

data for dibenzofuran alone. Systemic toxicity of dibenzofuran is similar to that associated with dioxins (HSDB 1995).

**1,4-Dichlorobenzene**

Rats were exposed to 1,4-dichlorobenzene at a concentration of 75 ppm for 5 hours/day, 5 days/week, for 76 weeks. The critical effects observed were liver and kidney changes.

The EPA weight-of-evidence classification for the carcinogenicity of this compound is Category C — a possible human carcinogen — based on a 103-week oral gavage study in mice, in which 1,4-dichlorobenzene produced liver tumors.

**1,2-Dichloroethane**

The EPA weight-of-evidence classification for the carcinogenicity of this compound is Category B2 — probable human carcinogen (EPA 1995a). 1,2-Dichloroethane has been shown to produce several tumor types in rats and mice treated by gavage and lung papillomas in mice after topical application.

**1,2-Dichloroethene (Total)**

The toxicity of mixed *cis*- and *trans*-isomers of 1,2-dichloroethene has been approximated by analogy using a 2-year drinking water study (Quast et al. 1983) in which 1,1-dichloroethene was administered to rats in drinking water (EPA 1994b).

The EPA weight-of-evidence classification for the carcinogenicity of 1,2-dichloroethene is Category D (EPA 1995a).

**1,2-Dichloropropane**

A chronic inhalation study was conducted with rats, mice and rabbits (Nitschke et al. 1988) in which male and female F344 rats and B6C3F1 mice (10/group) were exposed to 0, 15, 50, or 150 ppm dichloropropane (0, 69.3, 231, or 693 mg/m$^3$) for 6 hours/day, 5 days/week for 13 weeks. The observed critical effect was nasal mucosa hyperplasia in rats (EPA 1995a).

The EPA weight-of-evidence classification for the carcinogenicity of this compound is Category B2 — probable human carcinogen (EPA 1994b). Liver tumors were observed in mice administered 1,2-dichloropropane by gavage (NTP 1986b).

**Dioxins/Furans (2,3,7,8-TCDD)**

Effects following dioxin exposure via the oral route have been well-studied in animals, and to a lesser extent in humans. With a variety of relevant experimental durations (i.e., subchronic or chronic; from >14 days to >1 year), adverse effects from dioxin were expressed predominantly as decreased longevity, as well as reproductive, immunological, and hepatic effects (ATSDR 1989b).

Dioxin (2,3,7,8-TCDD) is a probable human carcinogen (Category B2), based on observations of increased soft tissue sarcoma and lymphomas in populations exposed primarily via contact with herbicides contaminated with 2,3,7,8-TCDD. EPA (1988b) summarized the epidemiological data as providing limited evidence that exposure to phenoxyacetic acid herbicides and/or chlorophenols is causally related to the risks of soft tissue sarcoma, but none of the data sufficed to implicate 2,3,7,8-TCDD alone. Animal carcinogenicity studies were related to dermal exposure, and indicated skin tumors resulted from application to female Swiss mice. Mixed results were obtained regarding the promoter-like potential of dioxin.

**Ethylbenzene**

Owing to its intrinsic volatility, effects of oral ingestion of ethylbenzene do not receive the degree of study that inhalation administration does. A rat 182-day oral bioassay (Wolf et al. 1956) was the most definitive study. In this study ethylbenzene was given to rats 5 days/week at doses of 13.6, 136, 408, or 680 mg/kg-day in olive oil gavage. There were 10 albino female rats/dose group and 20 controls. Observed responses included growth, mortality, appearance and behavior, hematologic findings, terminal concentration of urea nitrogen in the blood, final average organ and body weights, histopathologic findings, and bone marrow counts.

EPA considers ethylbenzene to be unclassifiable as a human carcinogen (Category D) based on inadequate data (EPA 1995a).

**Fluoranthene**

One study of the subchronic toxicity of fluoranthene has been reported (EPA 1989e). Administration of fluoranthene by gavage to mice for 13 weeks resulted in increased salivation, mild nephropathy, increased liver enzyme levels, and increased liver weights accompanied by pigmentation indicative of microscopic lesions, at high doses. Most animal data indicate that, if systemic oral toxicity of noncarcinogenic PAH occurs at all, it is usually mild and appears to involve mainly reversible enzyme and/or organ weight changes (ATSDR 1990).

In a series of dermal exposure experiments, various PAH were applied topically to the backs of mice repeatedly over time for the observation of tumor response. Fluoranthene

did not exhibit any carcinogenic activity with repeated topical administration to mice (Hoffmann et al. 1972).

Fluoranthene was mutagenic when tested *in vitro* with human lymphoblasts in the presence of exogenous metabolic activation and negative without exogenous metabolic activation (Barfknecht et al. 1982; Crespi et al. 1985). Fluoranthene induced sister chromatid exchanges in Chinese hamster ovary cells, but only with metabolic activation (Palitti et al. 1986).

The carcinogenicity of fluoranthene has not been classified (Category D) based on no human data and inadequate data from animal bioassays (EPA 1995a).

**Fluorene**

One subchronic toxicity study of fluorene has been reported (EPA 1989f). The administration of fluorene via gavage to mice for 13 weeks resulted in changes in hematological parameters which included decreased red blood cell count, packed cell volume, and hemoglobin concentration at high doses. Increased liver and spleen weights accompanied by increased amounts of hemosiderin in the spleen and in the Kupffer cells of the liver were also observed. Most animal data on PAH have indicated that if systemic oral toxicity of noncarcinogenic PAH occurs at all, it is usually mild and appears mainly to involve reversible enzyme and/or organ weight changes (ATSDR 1990).

In a series of dermal exposure experiments, various PAH were applied topically to the backs of mice repeatedly over time to observe tumor response. Studies of the carcinogenicity or cocarcinogenicity of fluorene, using mouse skin painting assays, were either not positive or were inconclusive (Kennaway 1924; Reigel et al. 1951; LaVoie et al. 1979, 1981). Fluorene also did not induce tumors when administered via subcutaneous injection (Shear 1938) or in the diet (Wilson et al. 1947).

In genotoxicity testing, fluorene did not produce positive results in either reverse or forward mutation *Salmonella typhimurium* assays (EPA 1995a). Negative results were also reported for DNA damage assays using *Salmonella typhimurium*, *Escherichia coli*, and primary hepatocyte cultures (Mamber et al. 1983; Sina et al. 1983; Nakamura et al. 1987). Fluorene produced positive results in a DNA damage assay in mouse lymphoma cells in the presence and absence of hepatic homogenates (Garberg et al. 1988).

The carcinogenicity of fluorene has not been classified (Category D) based on no human data and inadequate data from animal bioassays (EPA 1995a).

**Indeno(1,2,3-cd)pyrene**

Studies investigating the subchronic or chronic systemic toxicity of indeno(1,2,3-cd)pyrene by skin contact, ingestion, or inhalation have not been conducted (ATSDR 1990).

The evidence for potential carcinogenicity of indeno(1,2,3-cd)pyrene and other PAH comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Although interpretation of some of these data is complicated by the use of different solvents in different tests, the following PAH induced skin tumors following intermediate or long-term dermal exposure: benzo(a)anthracene, dibenzo(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and chrysene (Wynder and Hoffmann 1959a, 1959b; Hoffmann and Wynder 1966; Bingham and Falk 1969; Hecht et al. 1974; Habs et al. 1980; LaVoie et al. 1982). Anthracene, fluoranthene, fluorene, phenanthrene, and pyrene did not induce skin tumors with repeated dermal application.

Indeno(1,2,3-cd)pyrene is currently assigned an EPA carcinogen classification of Category B2 based on no human data and sufficient data from animal bioassays (EPA 1995a).

**Lead**

The predominant systems affected by chronic lead inhalation or ingestion by humans are the hematological, neurological, cardiovascular, and renal systems (ATSDR 1993). The basis for lead toxicity is its ability to bind to ligating groups in physiologically critical biomolecules, which may then disrupt their function by competing with essential metal ions for binding sites, inhibiting enzyme activity, and altering ion transport (Calabrese and Kenyon 1991). Toxic hematological effects include inhibition of several enzymes involved in heme synthesis, with resultant depression of hemoglobin synthesis and anemia. The primary cardiovascular effect is elevation of blood pressure, a dose-dependent effect which also lacks any apparent threshold (Harlan 1988). Neurological effects typically manifest themselves as neurobehavioral effects and alterations of the peripheral nervous system. Consequences can include weakness in the limbs (Zimmerman-Tansella et al. 1983), fatigue (Hänninen et al. 1979; Baker et al. 1979), loss of memory function (Hänninen et al. 1979), significant impairment in learning capacity (Wang et al. 1989; Rummo et al. 1979; Ernhart et al. 1981), limb tremors (Baker et al. 1979), and encephalopathy at higher blood levels (Rummo et al. 1979). High blood lead levels have also been correlated with nephropathy, gastrointestinal effects, and electrocardiographic abnormalities (ATSDR 1993). The existence of neurological impairments from serum levels of lead below 10 $\mu$g/dL is currently being debated in the scientific community. Because infants and young children appear to be particularly sensitive to the neurologic effects of lead, no threshold dose has been established for either oral or inhalation exposure.

Exposure to environmental lead levels which translate to relatively low blood lead levels has been shown to have adverse effects on several physiological parameters. These include the alteration of several of the enzymes involved in the synthesis of the heme moiety, an essential component of substances like hemoglobin (the oxygen transporter in red blood cells), cytochrome P-450s (major xenobiotic detoxification mechanisms), and respiratory cytochromes (a major source of metabolic energy reserves). In addition, neurological effects on behavior, memory, learning capacity, and emotion have been established.

Increases in blood pressure in the middle-aged have also been observed. These effects manifest themselves at all measured blood lead levels, with no known threshold in humans. However, animal studies have been performed to evaluate the toxic endpoints of low level lead exposure, and doses at which there are no or minimal apparent effects have been achieved.

Lead at very high doses has been shown to cause some tumors in animals (Azar et al. 1973; Koller et al. 1985; Van Esch and Kroes 1969). However, epidemiological studies, despite large exposures among workers, have failed to indicate that lead may cause cancer in humans (Kang et al. 1980; Cooper et al. 1985; Selevan et al. 1985; Baker et al. 1980b). EPA has classified lead as a Category B2 carcinogen, due to sufficient evidence from animal bioassays (renal tumors in rats ingesting lead for a lifetime) but inadequate evidence in humans (EPA 1995a); the data are considered inadequate to develop a carcinogenic slope factor for lead. Lead appears to be more potent as a systemic toxicant to the hemopoietic and neurological systems than as a cancer-causing agent.

**Manganese**

Ingestion is one of the primary routes of exposure to inorganic manganese, although it is not absorbed appreciably across the intestinal walls (probably less than 5 percent). CNS effects are the typical effects observed following ingestion and inhalation exposures. Discrepancies in the extent of absorption or bioavailability of manganese in variable carrier media has prompted the development of separate oral RfDs for manganese, one in food and one in water.

EPA considers the potential carcinogenicity of manganese to be unclassifiable (Category D), based on an absence of human carcinogenicity data, inadequate evidence of carcinogenicity in animals, and inadequate genotoxicity data (EPA 1995a).

**Mercury**

Ingestion is one of the primary routes of exposure to mercury, but elemental mercury is only very poorly absorbed from the gastrointestinal tract (probably less than 0.01 percent) (Hammond and Beliles 1980). While CNS effects are the typical target organ effects observed following inhalation exposures, renal effects are the primary target of ingested inorganic mercury. In chronic exposures, nephrotoxicity is typically manifest as proteinuria; in severe cases, the nephrotic syndrome is observed, with subsequent edema and hypoproteinemia (Hammond and Beliles 1980).

The major toxic effects of inhaled mercury are primarily neurological. In acute exposure scenarios, clinical signs include paresthesia, ataxia, dysarthria, and deafness (Berlin 1979). Chronic exposure typically involves exposure to both mercury vapor and divalent mercury. Toxic symptoms include renal damage with nephrotic syndrome as well as increased

salivation, inflammatory changes of the gums and the appearance of black lines along the gums (Skerfving and Vostal 1972).

EPA considers the potential carcinogenicity of mercury to be unclassifiable (Category D), based on an absence of human carcinogenicity data, inadequate evidence of carcinogenicity in animals, and inadequate genotoxicity data (EPA 1995a).

**Methylene Chloride**

In a 2-year study by the National Coffee Association (NCA 1982), groups of 85 F344 rats per sex per dose received approximately 5, 50, 125, or 250 mg/kg-day of methylene chloride in drinking water. Many effects were monitored. Treatment related histological alterations of the liver were evident at nominal doses of 50 mg/kg-day or higher. The observed critical effect was liver toxicity (EPA 1995a).

In a chronic inhalation study (NCA 1982), rats were exposed intermittently to methylene chloride in air for 2 years. The observed critical effect was liver toxicity (EPA 1994b).

The EPA weight-of-evidence classification for methylene chloride carcinogenicity is Category B2 — probable human carcinogen (EPA 1995a). Methylene chloride has been shown to induce increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, and increased incidence of benign mammary tumors in both sexes of rats, salivary gland carcinomas in male rats and leukemia in female rats.

**2-Methylphenol**

In a 90-day oral subchronic neurotoxicity study (EPA 1987), rats were gavaged daily with 0, 50, 175, 450 or 600 mg/kg-day 2-methylphenol. Doses greater than 450 mg/kg-day produced significant neurological events, such as increased salivation, urination, tremors, lacrimation, palpebral closure, and rapid respiration (EPA 1995a).

The EPA weight-of-evidence classification for the carcinogenicity of 2-methylphenol is Category C — possible human carcinogen based on increased incidence of skin papillomas in mice in an initiation-promotion study (EPA 1995a).

**4-Methylphenol**

4-Methylphenol (*p*-cresol) was administered by gavage to pregnant New Zealand white rabbits (CMA 1988). The rabbits were given 5 mg/kg-day 4-methylphenol on gestation days 6–18. The critical effect was maternal death (EPA 1994b).

The EPA weight-of-evidence classification for the carcinogenicity of 4-methylphenol is Category C — possible human carcinogen based on increased incidence of skin papillomas

in mice in an initiation-promotion study (EPA 1995a). A quantitative estimate of carcinogenic risk from oral or inhalation exposure is not available (EPA 1995a).

**Naphthalene**

Several studies have been reported on the subchronic and chronic toxicity of naphthalene. At high inhalation and oral doses, naphthalene can produce injury. Cataracts were diagnosed in 8 of 29 chemical plant workers occupationally exposed to high doses of naphthalene for 5 years (Ghetti and Mariani 1956). In addition, skin contact with naphthalene can result in irritation or severe dermatitis in sensitized humans (Manahan 1989).

Naphthalene ingestion has resulted in abdominal pain, nausea, vomiting, diarrhea, urine darkening, bladder irritation, jaundice, anemia, and hyperthermia (Gerarde 1960). Daily oral administration of 1 g/kg to rabbits produced degenerative changes in the lens of the eye; within 2 weeks the whole lens became cataractous (Potts 1986). A review of the literature on cataract formation in rodents and rabbits resulting from naphthalene administration demonstrates that different strains of rats, mice, and rabbits show differences in the metabolic pathways for naphthalene and that only some strains are susceptible to cataract formation from naphthalene ingested at high doses (Van Heyningen and Pirie 1976). Hemolytic anemia was observed in dogs given oral doses of 3 to 9 g of naphthalene (Zuelzer and Apt 1949), and the effect was reversible within 50 days after cessation of exposure.

The inhalation of high acute doses of naphthalene by humans has caused headache, confusion, eye irritation, nausea, profuse perspiration with vomiting, optic neuritis, hematuria, and edema (Gerarde 1960). In a 2-year study (NTP 1992), chronic exposure of mice to naphthalene at airborne concentrations of 10 or 30 ppm resulted in chronic inflammation of the lung and nose, metaplasia of the olfactory epithelium, and hyperplasia of the respiratory epithelium. In this study, lung adenomas were statistically significantly greater in females in the highest dose group than in controls.

EPA considers the potential carcinogenicity of naphthalene to be unclassifiable (Category D), based on an absence of human carcinogenicity data and inadequate evidence of carcinogenicity in animals (EPA 1995a).

**Phenanthrene**

Reports of subchronic and chronic systemic toxicity of phenanthrene by any route have not been reported (ATSDR 1990). Consequently, pyrene, a structurally similar noncarcinogenic PAH that has been studied more extensively, was used as a surrogate representative for the systemic toxicity of phenanthrene for all routes. Most animal data indicate that systemic oral toxicity of noncarcinogenic PAH such as phenanthrene is mild,

and appears to involve mainly reversible enzyme and/or organ weight changes (ATSDR 1990).

A rat gavage study (IARC 1983) did not provide adequate evidence on the carcinogenicity of phenanthrene by ingestion. Dermal application and injection studies revealed no carcinogenic effects of phenanthrene, although the dermal studies were inadequate. Skin tumor initiation/promotion assays showed phenanthrene to be ineffective as an initiator.

Phenanthrene is currently assigned an EPA carcinogen classification of Category D based on no human data and inadequate animal data (EPA 1995a).

**Polychlorinated Biphenyls (PCB)**

The carcinogenicity of PCB is classified by both EPA and IARC as a probable human carcinogen (EPA Category B2, IARC Category 2), based on sufficient animal data and inadequate human data (EPA 1995a; IARC 1987a). Although a fair amount of human epidemiological data exist, no one study is adequate for purposes of carcinogenic classification. Thus, the slope factor is based on an oral feeding study in rats. However, WHO (IPCS 1993) has concluded that the complication of PCDF co-contamination of PCB mixtures limits any conclusion about purely PCB tumor promotion.

A retrospective mortality study (Bertazzi et al. 1982, 1987) involved 2,100 capacitor manufacturing workers studied for the 1946 to 1982 time frame. They were exposed to Aroclor-1254, Pyralene-1436 (54 percent chlorine), and Pyralene-3010/3011 (42 percent chlorine). Workplace air measurements showed Aroclor-1254 levels at 5200–6800 $\mu g/m^3$ in 1954 and Pyralene-3010 at 48–275 $\mu g/m^3$ in 1977. Surface and hand wipe samples reflected considerable exposure potential via the dermal and direct ingestion pathways. There was a statistically significant increase in total (male and female) cancer deaths (26 observed versus 12.9 expected), and in gastrointestinal cancer deaths in males (6 observed versus 2.2 expected), and hematological cancer deaths in females (4 observed versus 1.1 expected).

Two other retrospective mortality studies (Brown and Jones 1981; Brown 1987) looked at a total of 2588 capacitor manufacturing workers in two plants. Exposures were to Aroclors-1254, -1242, and -1016. Total mortality (n = 295) was less than expected (n = 318), and cancer mortality (n = 62) was also less versus the expected (n = 80). However, cancer deaths of the liver, gall bladder, and biliary tract were higher than expected (5 observed vs. 1.9 expected). Although statistical significance was not achieved due to the low number of deaths, the higher liver and biliary tract cancers were seen in the plant with the higher PCB air concentrations (630–850 $\mu g/m^3$ versus 24–393 $\mu g/m^3$).

Nagasaki et al. (1972) found that mice fed 500 ppm (15–25 mg/kg body weight) of Aroclor-1260/Kaneclor-500 (54 percent chlorinated) resulted in hepatocellular adenomas and/or carcinomas, but that mice fed Kaneclor 400 and Kaneclor 300 (42 percent

chlorinated) did not develop any tumors. Kimbrough et al. (1972) observed bladder cancers in rats (n = 2) fed 100 ppm of Aroclor-1260 for 8 months. Kimbrough et al. (1975) reported the development of hepatocellular carcinomas in female rats fed 100 $\mu$g/g body weight for 21 months.

Allen and Norback (1973) reported the induction of hyperplasia and dysplasia of the gastrointestinal tract in male and female rhesus monkeys fed 300 ppm Aroclor-1248 for 3 months. Although the short-term nature of this experiment did not allow for an evaluation of the carcinogenic potential of PCB, it was believed that the increased cellularity, abnormal dysplastic growth pattern, and invasion of adjacent tissue region were strongly suggestive of an eventual neoplastic transformation.

Norback and Weltman (1985) conducted the most complete study to date. Rats were fed 100 $\mu$g/g body weight of Aroclor-1260 for 16 months, followed by 50 $\mu$g/gm body weight for an additional 8 months. In the PCB-exposed group, 95 percent of the female rats and 15 percent of the males developed hepatocellular neoplasms. The liver tumors were not aggressive (i.e., not metastatic), since mortality was not effected. This study serves as the basis for the EPA's classification of PCB as Category B2 carcinogens. The major weakness in this study is the lack of any characterization about the presence or absence of any PCDF co-contamination.

IARC (1987a) established that the oral feeding studies in animals are sufficient to conclude that PCB exposure results in benign and malignant liver neoplasms in mice and rats. However, WHO (IPCS 1993) reaches a different conclusion. The conclusion reached by the International Programme on Chemical Safety (IPCS) is that the potential for humans liver cancers cannot be reliably predicted from the available animal data. It was believed that, while the role of PCB as tumor promoter in animals was substantially evident, the complication of PCDF co-contamination remains a major limitation to any conclusion about PCB tumor promotion.

Numerous occupational exposure studies have evaluated chronic workplace exposures to PCB. Ouw et al. (1976) studied 34 workers who were exposed for periods from 1 month to 23 years to pure Aroclor-1242 at air time-weighted-average (TWA) concentrations of 0.32- 2.22 mg/m$^3$. Clinical symptoms included dermal burning around the eyes, face and skin, rashes, chloracne, and a persistent body odor. A positive correlation was found between blood serum PCB levels and the reporting of dermatological problems. Interestingly, no dermatological problems were found in workers with blood serum PCB levels below 200 ppb. This latter fact is supported by the work of Baker et al. (1980a) who evaluated PCB-contaminated municipal sludge in landfarming. Although serum triglyceride levels were positively correlated with serum PCB levels, no dermatological symptoms were observed at the highest exposed group (mean blood serum PCB = 75 ppb). However, Maroni et al. (1981) found that, out of a worker group of 80, 16 had test results indicating liver problems. Of that group that had demonstrable liver dysfunction, 20 percent had blood serum PCB levels below 200 ppb (131 ppb, 152 ppb, 180 ppb). Thus, it

would appear that for a 42-percent chlorine PCB exposure, the threshold for liver and skin symptoms lies between 100 and 200 ppb PCB in blood.

The acute toxicity of PCB is fairly low, especially in terrestrial organisms. The adverse effects of PCB varies with the percentage composition of the specific isomers, their stereochemical orientation, the presence of impurities (e.g., PCDFs), the animal species involved, and the route of exposure. In animals, the $LD_{50}$s increase with increasing chlorination. The young are more sensitive than adults, a factor that has not been adequately addressed in many of the toxicity tests. In rats, the $LD_{50}$s range from 3980 mg/kg for Aroclor-1221 up to 10,000–11,000 mg/kg for Aroclor-1260 (Fishbein 1974). A typical $LD_{50}$ for the young of a species might range from 1,300 to 2,500 mg/kg versus 4,000 to 11,000 mg/kg for an adult. There is also considerable variation within and between species, with the rhesus monkey and guinea pig being very sensitive, the cynomolgus monkey and rabbit next, followed by the rat. In general, rats and fish are less sensitive to the lower chlorinated PCB, while birds tend to be less sensitive to the higher chlorinated PCB (Hansen 1987). It is important to point out that lethality has been observed in animals which have accumulated high residues of PCB and then subjected to stressful conditions. Thus, the high $LD_{50}$s may well underestimate the acute toxicity of PCB under conditions of stress.

**Pyrene**

Studies investigating the subchronic or chronic systemic toxicity of pyrene by skin contact or inhalation have not been conducted (ATSDR 1990).

A single subchronic toxicity study of pyrene has been reported. The administration of daily gavage doses of pyrene to rats over 13 weeks resulted in decreased kidney weights and minimal or mild kidney lesions (EPA 1989f). Most animal data indicate that systemic oral toxicity of noncarcinogenic PAH, such as pyrene, is mild and appears mainly to involve reversible enzyme and/or organ weight changes (ATSDR 1990).

The evidence for potential carcinogenicity of some PAH, including pyrene, comes from a series of dermal exposure experiments in which various PAH were applied topically to the backs of mice repeatedly over time and the tumor response observed. Pyrene did not induce skin tumors with repeated dermal application (ATSDR 1990). No studies on pyrene's potential to induce cancer by inhalation or ingestion have been conducted. The carcinogenicity of pyrene is classified as Category D, based on no human data and inadequate data from animal bioassays (EPA 1995a).

**1,1,2,2-Tetrachloroethane**

1,1,2,2-Tetrachloroethane is classified as Category C, possible human carcinogen, based on incidence of hepatocellular carcinomas in mice and lack of human carcinogenicity data.

In a bioassay undertaken by NCI (1978c) 50 each male and female Osborne-Mendel rats and B6C3F1 mice were gavaged with technical grade (90 percent pure) 1,1,2,2,-tetrachloroethane in corn oil, 5 days/week. Treatment was over 78 weeks, followed by observation periods of 32 weeks for the rats and 12 weeks for the mice. The high and low average doses (incorporating varying dosage levels throughout the treatment period) were, respectively, 108 and 62 mg/kg-day for male rats, 76 and 43 mg/kg-day for female rats, and 282 and 142 mg/kg-day for mice of both sexes. Control groups consisted of 20 animals/sex and species. Vehicle controls received corn oil at the same rate as the high-dose animals; untreated controls were not intubated. Ten of the high-dose female rats died within the first 5 weeks of the study, but the association between increased dosage and elevated mortality was not statistically significant for male rats. Significantly increased mortality was also evident in the high-dose mice of both sexes. No statistically significant incidence of neoplasms was observed in rats. A highly significant dose-related increase in the incidence of hepatocellular carcinomas was observed in both male and female mice.

**Thallium**

Thallium is one of the more toxic metals and can cause neural, hepatic and renal injury. It may also cause deafness and loss of vision. In some cases, deaths in humans have been reported as a result of long-term thallium intake. These cases are caused by the contamination of food or the use of thallium as a depilatory.

Administration of 0.20 mg thallium/kg-day for 90 days in rats produced increased SGOT levels and serum LDH levels and alopecia.

The EPA weight-of-evidence cancer classification of thallium is Category D (EPA 1995a).

**Toluene**

Foo et al. (1990) conducted a cross-sectional study involving 30 female workers exposed to toluene emissions from glue at an electronic assembly plant. Toluene levels from personal sample monitoring were reported as an 8-hour TWA. Neither historical exposure values, nor concurrent exposures to other solvents, were documented. Workers in the exposed and control groups were matched on demographic and ethnic variables and on the use of medications; all were nonsmokers and none used alcohol. TWA toluene levels for exposed workers were 88 ppm (332 mg/m$^3$), whereas those for control workers were 13 ppm (49 mg/m$^3$). Both these values are averages of the personal sampling monitors for each group. A battery of eight neurobehavioral tests administered to all exposed and control workers before the workers reported for duty indicated that exposed workers performed poorly on 6 of 8 tests, as compared with control group workers. Differences in performance between the two groups were statistically significant. Irritation effects were not evaluated in this study, nor were clinical signs or symptoms. This study has several limitations, notably small sample sizes, insufficient chemical exposure data, and the lack of a zero exposure group; however, its findings have been supported by a short-term clinical study by

Echeverria et al. (1989), who used exposure levels, above and below 88 ppm (332 mg/m$^3$) for exposure durations of 3–7 hours over 142 days and achieved similar results.

A subchronic gavage study was conducted with rats (NTP 1990): groups of animals were administered toluene in corn oil via gavage at dose levels of 0, 312, 625, 1250, 2500, or 5000 mg/kg-day for 5 days per week for 13 weeks. All animals in the highest dose group died within the first week. No neurotoxic effects of biological significance were observed in animals receiving doses of 1,250 or less mg/kg-day. Organ weight changes occurred in the liver, kidney, brain, and urinary bladder in animals receiving 1,250 or more mg/kg-day; however, consistent histopathological changes were evident for the liver, kidney, and urinary bladder in the highest surviving dose groups (2,500 mg/kg-day), and in the brain at the middle and highest surviving dose groups (1,250 mg/kg-day and 2500 mg/kg-day). A similar study conducted by NTP (1990), with mice being exposed to the same gavage dose, resulted in severe symptoms of neurotoxicity in the two highest dose groups and early death for all animals in the highest dose groups. No other significant changes were reported for any treated groups in the mouse study.

Toluene has been classified by the EPA as a Category D carcinogen (i.e., not classifiable as to human carcinogenicity) based on inadequate data (EPA 1995a).

**1,1,2-Trichloroethane**

In studies by White et al. (1985) and Sanders et al. (1985), mice of both sexes were exposed to 1,1,2-trichloroethane (1,1,2-TCA) in drinking water for 90 days. Concentrations provided were 0, 20, 200, or 2,000 mg/L, which resulted in intakes of 0, 4.4, 46, and 305 mg/kg-day for males and 0, 3.9, 44, and 384 mg/kg-day for females. Clinical chemistry indications of adverse effects on the liver occurred in both sexes at 2000 mg/L. Effects on the erythrocytes occurred only in females and depressed humoral immune status occurred in both sexes at 200 and 2,000 mg/L.

In a bioassay conducted by NCI (1978d) technical grade (92.7 percent pure) 1,1,2-TCA was administered by gavage in corn oil to Osborne-Mendel rats and B6C3F1 mice: (50/species/sex/dose) for each of 2 doses and 20 animals/species/sex for each of 2 control groups. Administration was 5 times/week for 78 weeks during which time doses for rats were increased from 70 and 30 mg/kg-day to 100 and 50 mg/kg-day and doses for mice were increased from 300 and 150 mg/kg-day to 400 and 200 mg/kg-day. By two statistical tests, treatment of mice was found to be associated with increased incidence of hepatocellular carcinomas. A dose-related increase in pheochromocytomas was also confirmed in female mice. Tumors found in treated but not control rats included adrenal cortical carcinomas; transitional-cell carcinomas of kidney; renal tubular adenomas; and hemangiosarcomas of spleen, pancreas, abdomen and subcutaneous tissue. However, there was no statistically significant increase in tumor incidence in rats as a function of treatment.

The EPA weight-of-evidence classification for the carcinogenicity of 1,1,2-trichloroethane is Category C — possible human carcinogen. The basis for the classification was hepatocellular carcinomas and pheochromocytomas in one strain of mice (EPA 1995a). Carcinogenicity was not shown in rats.

**Trichloroethene**

Effects of oral exposure to trichloroethene are well studied, with multiple studies reporting mortality, systemic effects (hematological, hepatic, renal), developmental, reproductive, neurological, and carcinogenic effects after subchronic and chronic administration of trichloroethene (ATSDR 1991b). No results, however, are listed from human studies.

As a volatile organic solvent, the more common experimental protocols employ inhalation exposures to trichloroethene. Overexposure to trichloroethene is first manifested as central nervous system depression. Other effects can also be observed in the respiratory, cardiovascular, hematological, hepatic, and renal organ systems (ATSDR 1991b).

Several epidemiologic studies have failed to find evidence of an association between trichloroethene and cancer, although each study has been found wanting in some area (Calabrese and Kenyon (1991), citing EPA (1985c)). Results from laboratory animal carcinogenicity bioassays can be conflicting, with differences in the administered chemical, exposure protocols, animal strains, and other factors contributing to the inconsistencies. Trichloroethene had been classified as a probable human carcinogen (Category B2), but this classification has been removed as of July of 1992 (EPA 1995a).

**Vinyl Chloride**

Vinyl chloride is classified as a known human carcinogen by both IARC (1987b) and EPA (1985a,b), inducing liver hemangiosarcoma, a rare form of tumor of the hepatic vascular system, in workers occupationally exposed via inhalation to high airborne concentrations (Monson et al. 1974; Byren et al. 1976; Infante 1981; Nakamura 1983; Heldaas et al. 1984; Spirtas et al. 1983). Further, vinyl chloride consistently induces liver hemangiosarcomas, liver carcinomas, and lung hemangiosarcomas in rats and mice when administered via inhalation or ingestion (Maltoni et al. 1980, 1981; Lee et al. 1977, 1978; Hong et al. 1981; Feron et al. 1981).

Vinyl chloride exposure has been associated with several systemic effects in both humans and animals. In humans occupationally exposed via inhalation to high doses of vinyl chloride, the following symptoms or diseases have been observed: neurotoxicity, respiratory toxicity, immunological disorders including Raynaud's Syndrome (an autoimmune disease), hypertension, acroosteolysis and scleroderma (conditions involving bone and skin lesions in fingers and toes) and gastrointestinal disturbances (including hepatotoxicity) have been reported (EPA 1985a,b). Several epidemiologic studies suggest

that there is an association between vinyl chloride exposure and reproductive or developmental toxicity, but these data are not conclusive (EPA 1985a).

### Zinc

Because of its role as a nutritionally-essential element, zinc is subject to homeostatic mechanisms that attempt to maintain a physiologically-balanced supply of the nutrient. As a dietary requirement, oral exposure to zinc has been well-studied in animals and humans. With a variety of experimental durations (from >14 days to >1 year), adverse effects from zinc excess include mortality, and gastrointestinal, hematological, musculoskeletal, hepatic, renal, immunological, and developmental changes (ATSDR 1992).

No studies have been reviewed by EPA (1995a) or ATSDR (1992) which relate zinc exposure via inhalation or dermal routes for durations >14 days to adverse health effects.

ATSDR (1992) did not report any human studies indicating in vivo genotoxic effects, but did note increased chromosomal aberrations in bone marrow cells of mice when exposed by inhalation (citing Voroshilin et al. 1978) or orally (Deknudt 1982; Deknudt and Gerber 1979). Dominant lethal assays in mouse, however, produced negative results (Vilkina et al. 1978). As summarized by EPA (1995a), *in vitro* tests are equivocal.

Zinc is currently assigned an EPA carcinogen classification of Category D, based on an absence of human carcinogenicity data and inadequate evidence of carcinogenicity in animals (EPA 1995a).

## 6.3 DOSE-RESPONSE ASSESSMENT

The purpose of this section is to establish the toxic potency concentrations that will be used, along with the results of the exposure assessment in Section 6.4, to estimate the risks for each of the chemicals of concern. Dose-response assessment is the determination of a chemical's concentration at which toxicity does or does not occur, based on the quantitative relationship between increasing a chemical's dose and the resulting increase in an adverse toxic response. Based on a chemical's ability to cause cancer or adverse health effects other than cancer (established in Section 6.2), two types of toxicity values are established:

- Slope factors (SFs) for the carcinogenic effects of a chemical. When available in IRIS (EPA 1995a) or the *Health Effects Assessment Summary Tables* (HEAST, EPA 1994b), EPA-verified SFs were used in this assessment.

- Oral reference doses and inhalation reference concentrations for a chemical's adverse health effects other than cancer were obtained from the above sources. Following EPA guidance (EPA 1989a), RfDs and RfCs developed for the evaluation of subchronic exposures were used to evaluate health effects associated with exposure durations of up to 7 years; while RfDs and RfCs

developed for the evaluation of chronic exposures were used to evaluate health effects associated with exposure durations of more than 7 years. In instances where separate subchronic RfDs or RfCs were unavailable, the chronic values were used as a basis for subchronic exposures. Subchronic RfDs and RfCs were also used as bases for chronic exposures when chronic RfDs or RfCs were not available.

A complete listing of available SFs and RfDs (oral, inhalation, and dermal) for all COCs is presented in Table 6-17.

When no toxicity values were available for certain COCs, health hazards associated with these chemicals were evaluated in a qualitative manner. Toxicity values were not available for benzotriazole and chlorinated benzotriazole.

Toxicity values have not been established for lead. Risks associated with exposures to lead are discussed qualitatively in the context of the EPA OSWER Directive #9355.4-12 (EPA 1994d) and Rhode Island guidance on allowable concentrations of lead in the environment (RIDoH 1994) in Section 6.5.2.4.

Dermal absorption of inorganics across the skin was assumed to be negligible (EPA 1989b). Therefore, dermal intake of onsite or offshore media inorganic COCs was assumed to be negligible, and dermal uptake and risks from soil/sediment were addressed for organic compounds only.

### 6.3.1 Establishing Toxicity Values for Health Effects Other than Cancer (Systemic Toxicity) for the Chemicals of Concern

For the selected COCs, the approach used to identify the toxicity values for noncarcinogenic health effects involved the following steps:

- Determining if an EPA-verified oral RfD or inhalation RfC exists. RfDs, RfCs, and the no-observed-adverse-effects-levels (NOAELs) on which they are based, are found in EPA's *Integrated Risk Information System* (IRIS) database (EPA 1995a).

- Examining HEAST (EPA 1994b) and other sources, such as the Superfund Technical Support Center (EPA 1995c) and the EPA Region III RBCs document (EPA 1995b), for RfDs and RfCs not found in IRIS.

- Assigning oral RfDs as surrogates for inhalation RfDs for COCs without inhalation RfDs, based on the general assumptions that (1) the toxicity is systemic (i.e., manifests at a site or sites away from the locus of entry), and

(2) absorption via the different routes of entry (e.g., oral, inhalation) is similar.[5]

- Since RfDs for the dermal route of exposure were not available for any COC, oral RfDs were adjusted to an absorbed basis for use as dermal RfDs by applying an oral absorption fraction for each COC, according to the methodology in Appendix A of EPA (1989a).

### 6.3.2 Establishing Toxicity Values for the Carcinogenic Effects of the COCs

For the selected COCs, the approach used to identify SFs involved the following steps:

- Determining if an EPA-verified oral SF or inhalation SF exists in EPA's IRIS database (EPA 1995a).

- Examining HEAST (EPA 1994b) and other sources, such as the Superfund Technical Support Center (EPA 1995c) and the EPA Region III RBCs document (EPA 1995b) for SFs not found in IRIS.

- Assigning oral SFs as surrogates for inhalation SFs for COCs without inhalation SFs, based on the general assumptions that: (1) the toxicity is systemic (i.e., manifests at a site or sites away from the locus of entry), and (2) absorption via the different routes of entry (e.g., oral, inhalation) is similar.[5]

- Since SFs for the dermal route of exposure were not available for any COC, oral SFs were adjusted to an absorbed basis for use as dermal SFs by applying an oral absorption fraction for each COC, according to the methodology in Appendix A of EPA (1989a).

Among the PAH (all detected in offshore media samples), seven have the ability to elicit cancer: benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h,)anthracene, indeno(1,2,3-cd)pyrene, and chrysene. Benzo(a)pyrene is the most potent carcinogen among the PAH.

An oral slope factor of 7.3 $(mg/kg\text{-}day)^{-1}$ for benzo(a)pyrene has been estimated by EPA (1993b). For each of the other six carcinogenic PAH, no adequate human or animal data exist to directly estimate a SF. EPA Region I methodology involves the utilization of the SF for benzo(a)pyrene for the other carcinogenic PAH, along with a conversion of the estimated

[5] The impact of these assumptions is that the route of entry is rendered of secondary importance to the manifestation of toxicity. Assumption of similar absorbtion via the different routes of entry allows route-to-route extrapolation in cases where route-specific absorption information is unavailable. Assignment of oral toxicity values to inhalation exposures was not done in cases where these assumptions were known not to hold true (e.g., copper and chromium).

intakes of each carcinogenic PAH to an "equivalent" intake of benzo(a)pyrene according to the following table (EPA 1994a):

| Compound Relative Potency Value | |
|---|---|
| Benzo(a)anthracene | 0.1 |
| Benzo(b)fluoranthene | 0.1 |
| Benzo(k)fluoranthene | 0.01 |
| Benzo(a)pyrene | 1.0 |
| Chrysene | 0.001 |
| Dibenzo(a,h)anthracene | 1.0 |
| Indeno(1,2,3-cd)pyrene | 0.1 |

It is inappropriate to use oral slope factors to evaluate cancer risks associated with dermal exposure to carcinogens such as benzo(a)pyrene, which cause skin cancer through a direct action at the point of application (EPA 1993b). Therefore, since dermal slope factors for PAH are not available, risks associated with dermal exposure to carcinogenic PAH were not evaluated in this risk assessment. Cancer risks associated with dermal exposures to PAH are discussed qualitatively in Section 6.5.3.3.

Since inhalation SFs for PAH are not available and use of benzo(a)pyrene relative potency values is not technically appropriate for the evaluation of inhalation exposures (Personal communication, Dr. Rita Schoeny, EPA), risks associated with inhalation of carcinogenic PAH were not quantified in this assessment but are discussed qualitatively in Section 6.5.3.3.

In the light of EPA's recently proposed guidelines for evaluating cancer risks for PCB, the cancer risks associated with PCB are estimated using (1) the existing cancer slope value of 7.7 per mg/kg-day; and (2) the proposed upper-end slope value of 2 per mg/kg-day. The upper bound value is chosen not only to set exposure standards to protect public health but also to regard exposure through food chain (e.g., ingestion of shellfish), which contains bioaccumulated PCB, as highest risk (EPA 1996). All PCB detected were in offshore media samples.

### 6.3.3 Toxicity Values for COCs at NCBC Davisville

#### Acenaphthene

EPA (1995a) has established an oral RfD for acenaphthene based on a NOAEL of 175 mg/kg-day from a 90-day subchronic toxicity study in CD-1 mice (EPA 1989d). The results of this study indicated no treatment-related effects on survival, clinical signs, body weight changes, total food intake, or ophthalmological alterations. However, increased liver weight

changes accompanied by microscopic alterations (cellular hypertrophy) were noted in animals given higher doses of acenaphthene (350 and 700 mg/kg-day). For chronic exposure to humans, an uncertainty factor of 3000 has been applied to the NOAEL, which includes 10 for interspecies extrapolation, 10 for intraspecies variability, 10 for the use of a subchronic study for chronic NOAEL derivation, and 3 for lack of reproductive/developmental toxicity data and lack of toxicity data in a second species. Therefore, the oral chronic RfD for acenaphthene in humans is estimated to be 0.06 mg/kg-day. For subchronic human exposure, the uncertainty factor of 300 includes 10 for interspecies differences, 10 for intraspecies variability, and 3 for lack of adequate data on reproductive/developmental toxicity and in a second species. Therefore, the oral subchronic RfD for acenaphthene in humans is estimated to be 0.6 mg/kg-day (EPA 1995a). Oral RfDs were used as bases for inhalation RfDs without further adjustment.

**Acetone**

The chronic oral RfD for acetone is 0.1 mg/kg-day (EPA 1995a) and is based on a subchronic oral study in rats. Acetone was administered by gavage for 90 days to groups of albino rats at doses of 0, 100, 500, or 2,500 mg/kg-day. The LOAEL was 500 mg/kg-day and the critical effects were increased liver and kidney weights and nephrotoxicity. An uncertainty factor of 1,000 was applied to the NOEL of 100 mg/kg-day to obtain the RfD. The uncertainty factor was used to account for inter- and intraspecies variability and the use of subchronic data. The subchronic oral RfD for acetone is 1 mg/kg-day (EPA 1994b) and is based on the same gavage study. Chronic and subchronic oral RfDs were used as surrogates for inhalation RfDs without further adjustment.

**Aldrin**

EPA (1995a) reports a chronic oral RfD for aldrin of $3 \times 10^{-5}$ mg/kg-day. This RfD is calculated from a LOAEL of 0.5 ppm in the diet (0.025 mg/kg/day) observed in a chronic rat feeding study (Fitzhugh et al. 1964). An uncertainty factor of 1,000 was applied to account for the uncertainty of extrapolation from animals to humans, the uncertainty in the range of human sensitivities, and because the RfD is based on a LOAEL rather than a NOAEL. The chronic oral RfD was used as a basis for the subchronic oral RfDs and inhalation RfDs without further adjustment.

EPA (1995a) has estimated an oral slope factor (SF) of 17 $(mg/kg\text{-}day)^{-1}$ by applying the linearized multistage procedure, extra risk model to incidence of liver carcinomas observed in C3H mice (Davis 1965), and male B6C3F1 mice (NCI 1978a) which were fed aldrin in the diet. A geometric mean SF of 17 $(mg/kg\text{-}day)^{-1}$ was calculated from the three slope factors derived from the three data sets since all three SFs were similar. The inhalation SF is based on the same data used to estimate the oral SF (EPA 1995a).

**Aluminum**

The available systemic toxicity data on aluminum have been evaluated and found to be inadequate for quantitative risk assessment (EPA 1995a). The value for the chronic oral RfD (1 mg/kg-day) was obtained from the EPA Environmental Criteria Assessment Office, Cincinnati, Ohio, and may be subject to change or revision. The chronic oral RfD was used as a basis for the subchronic oral RfD and inhalation RfDs without further adjustment.

EPA (1995a) has not established a SF for aluminum.

**Anthracene**

The subchronic NOAEL for anthracene in animals is considered to be the highest dose tested (1,000 mg/kg-day). No pathological, clinical chemistry, or hematological alterations were observed resulting from the treatment of anthracene in this study. For subchronic human exposures, an uncertainty factor of 300 includes 10 for interspecies variability, 10 for intraspecies variability, and 3 for lack of reproductive/developmental toxicity and adequate second-species data. The subchronic oral RfD for anthracene in humans is estimated to be 3 mg/kg-day (EPA 1994b). For chronic human exposures, an uncertainty factor of 3,000 includes 10 for interspecies variability, 10 for intraspecies variability, 10 for the use of a subchronic study for chronic NOAEL derivation, and 3 for lack of reproductive/developmental toxicity and adequate second-species data. Therefore, the chronic oral RfD for anthracene in humans is estimated to be 0.3 mg/kg-day (EPA 1995a). Chronic and subchronic oral RfDs were used as bases for inhalation RfDs without further adjustment.

**Antimony**

EPA (1995a) has established an oral reference dose (RfD) of $4 \times 10^4$ mg/kg-day for antimony compounds. Fifty male and fifty female rats were administered 5 ppm potassium antimony tartrate (5 mg/L) in drinking water over their lifetime (Schroeder et al. 1970). During the course of the study, growth rates were not altered but both male and female rats exhibited significantly shortened life spans, surviving 106 and 107 days, respectively, less than control males and females. Nonfasting blood glucose levels were decreased in treated males and cholesterol levels were altered in both sexes. A decrease in mean heart weight for males was also noted. No increase in tumor incidence associated with treatment was observed. Since there was only one dose group, a NOAEL could not be determined. The LOAEL was 5 ppm or 0.35 mg/kg-day. An uncertainty factor of 1,000 (10 for interspecies conversion, 10 for intraspecies sensitivity, and 10 for the use of a LOAEL) was used. The chronic oral RfD was used as the basis of the subchronic oral RfD and the chronic and subchronic inhalation RfDs without further adjustment.

EPA (1995a) has not established a SF for antimony.

**Arsenic**

Data by Tseng (1977) and Tseng et al. (1968) from a population epidemiology study in Taiwan were used to derive a chronic oral RfD of $3\times10^{-4}$ mg/kg-day (EPA 1995a). The critical effects were considered to be hyperpigmentation, keratosis, and possible vascular complications. Since hyperpigmentation and keratosis of the skin are lesions that potentially may progress to skin neoplasms, this toxic endpoint is considered to be appropriate for RfD derivation. The NOAEL is derived by multiplying the average concentration in drinking water by 4.5 L/day (because of the hot climate, typical daily drinking estimates are approximately doubled for this study population), adding in the contribution of arsenic in food, and dividing exposure by average body weight for Taiwanese adults (Abernathy et al. 1989). The EPA-derived chronic oral RfD incorporates an additional uncertainty factor of 3 for the lack of data concerning the potential toxicity of arsenic. The chronic oral RfD for arsenic was used as a basis for the subchronic oral RfD without further adjustment.

EPA has not derived an inhalation RfC for arsenic (EPA 1995a). For this assessment, the oral RfD was used as a the basis for the chronic and subchronic inhalation RfDs without further adjustment.

Considerable scientific controversy has surrounded the derivation of an estimated SF for arsenic by ingestion, principally drinking water. Based on a study in Taiwan (Tseng 1977; Tseng et al. 1968), EPA has developed a unit risk for drinking water of $5\times10^{-5}$ $(\mu g/L)^{-1}$ which is equivalent to an ingestion SF from food of $2.5\times10^{-5}$ $(\mu g/person/day)^{-1}$, or $1.8\times10^{-3}$ $(\mu g/kg\text{-}day)^{-1}$) (EPA 1995a). This estimate was used to generate an oral slope factor of 1.8 $(mg/kg\text{-}day)^{-1}$. The SF for ingestion was adopted in this risk assessment for skin contact, as a default condition. The inhalation SF is based on the geometric means of several occupational epidemiologic studies in which workers exposed to high concentrations of airborne arsenic had significantly increased lung cancer incidences. The inhalation SF is $4.3\times10^{-3}$ $(\mu g/m^3)^{-1}$ [equal to 15 $(mg/kg\text{-}day)^{-1}$)] (EPA 1995a).

**Benzene**

The epidemiologic and experimental data are currently insufficient to develop toxicity values for health effects other than cancer (EPA 1995a). However, human studies show that adverse hematologic effects do not occur at concentrations of 10 ppm or less (Collins et al. 1991; Hancock et al. 1984) in occupationally exposed workers. In animals, adverse hematologic effects begin to appear at 10–100 ppm (e.g., Seidel et al. 1989; Cronkite et al. 1985, 1989).

EPA (1995a) has developed oral and inhalation SFs for benzene, based primarily on the results of several epidemiologic studies. For oral exposures, the SF was estimated as $2.9\times10^{-2}$ $(mg/kg\text{-}day)^{-1}$; when applied to drinking water, this unit risk is expressed as $8.3\times10^{-7}$ $(\mu g/L)^{-1}$, assuming human daily water intake of 2 L/day. EPA's inhalation unit risk was estimated as $8.3\times10^{-6}$ $(\mu g/m^3)^{-1}$, assuming an inhalation rate of 20 $m^3$/day, which corresponds to an inhalation slope factor of $2.9\times10^{-2}$ (mg/kg-day).

**Benzo(a)anthracene**

Insufficient data are available to derive a SF for benzo(a)anthracene. Based on EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a surrogate because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for benzo(a)anthracene to cause cancer (see Section 6.3.2).

**Benzo(a)pyrene**

No toxicity values for health effects other than cancer have been derived for benzo(a)pyrene.

Carcinogenic PAH appear to exert their effects mainly at the point of contact (dermal application results in skin tumors), or portal of entry (ingestion results mainly in forestomach tumors; inhalation results in respiratory tract tumors and tumors of the upper digestive tract—presumably due to mucociliary particle clearance and involuntary ingestion of particles). Tumors distant from the point of application have also been observed. Among the PAH, benzo(a)pyrene (BaP) has the ability to elicit cancer, and it is the most potent carcinogen.

For ingestion of and dermal contact with BaP, a SF of 7.3 $(mg/kg\text{-}day)^{-1}$ was estimated by EPA (1995b). This SF is the geometric mean of several slopes (ranging from 4.5 to 11.7 $(mg/kg\text{-}day)^{-1}$) from the studies of Neal and Rigdon (1967) and Brune et al. (1981).

Few studies have evaluated the carcinogenic effects of inhalation exposure to BaP. Rats exposed chronically to combustion gases of a coal-burning furnace enriched with BaP developed lung tumors; however, these gases contained other PAH, as well as other potentially carcinogenic compounds, so that a direct association between BaP exposure and lung tumors cannot be made (Heinrich et al. 1986). Therefore, no inhalation SF is available.

**Benzo(b)fluoranthene**

No toxicity values for health effects other than cancer have been derived for benzo(b)fluoranthene.

Insufficient data are available to derive a SF for benzo(b)fluoranthene. Based on EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a surrogate because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for benzo(b)fluoranthene to cause cancer (see Section 6.3.2).

**Benzo(k)fluoranthene**

No toxicity values for health effects other than cancer have been derived for benzo(k)fluoranthene.

Insufficient data are available to derive a SF for benzo(k)fluoranthene. Based on EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a surrogate because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for benzo(k)fluoranthene to cause cancer (see Section 6.3.2).

**Benzo(g,h,i)perylene**

Insufficient data are available to derive an oral or inhalation RfDs for benzo(g,h,i)perylene. The chronic oral RfD of 0.03 mg/kg-day derived for pyrene was used as a basis for the oral subchronic RfD and subchronic and chronic inhalation RfDs for benzo(g,h,i)perylene because the toxicity of pyrene, a structurally similar noncarcinogenic PAH, was considered to be representative of the toxicity of benzo(g,h,i)perylene.

EPA (1995a) has not established SFs for benzo(g,h,i)perylene.

**Beryllium**

EPA (1995a) has established a chronic oral RfD for soluble beryllium salts of 0.005 mg/kg-day, based on a rat chronic oral bioassay (Schroeder and Mitchener 1975a). This RfD for beryllium is based on the NOAEL obtained from that study (5 ppm in drinking water, converted to 0.54 mg/kg-day based on default exposure assumptions for drinking water ingestion rate and body weight of rats) and by applying an aggregate uncertainty factor of 100. The uncertainty factor accounts for interspecies extrapolation and for the protection of sensitive humans. The chronic oral RfD was used as the basis for the subchronic oral RfD and the subchronic and chronic inhalation RfDs without further adjustment.

EPA (1995a) has calculated an oral SF for beryllium of 4.3 $(mg/kg\text{-}day)^{-1}$. The slope factor calculation was based on the appearance of gross tumors at various sites in Long-Evans male rats administered beryllium in the drinking water (Schroeder and Mitchener 1975a). As noted by EPA (1995a), however, the estimate is derived from a study which did not show a significant increase in tumorigenic response, and was limited by use of only one non-zero dose group, the occurrence of high mortality and unspecified type and site of the tumors, it was used as the basis of the quantitative estimate because exposure occurred via the most relevant route. Oral risk estimates derived by extrapolation from studies in other species/strains for the intravenous and inhalation routes (also highly uncertain) are within an order of magnitude.

EPA (1995a) has calculated an inhalation unit-risk concentration of $2.4 \times 10^{-3}$ $(\mu g/m^3)^{-1}$, corresponding to an SF of 8.4 $(mg/kg\text{-}day)^{-1}$. The basis for this value lies in data from occupationally-exposed humans, despite recognized insufficiencies in the underlying study,

such as: confounding variables in the epidemiology; uncertainty in estimates of exposure levels and duration; overall poor quality of animal studies used (conducted at single dose levels or lacking control groups).

**bis(2-Chloroethyl)ether**

No toxicity values for health effects other than cancer from exposure to bis(2-chloroethyl)ether are available.

The oral SF for bis(2-chloroethyl)ether) has been established as 1.1 $(mg/kg\text{-}day)^{-1}$ (EPA 1994b) based on a chronic oral gavage followed by dietary study in mice. Liver tumors were detected in mice given bis(2-chloroethyl)ether for 560 days. An inhalation SF of 1.1 $(mg/kg\text{-}day)^{-1}$ was also established based on route-to-route extrapolation of the oral data (EPA 1994b).

**bis(2-Chloroisopropyl)ether**

No chronic oral or inhalation RfDs are available for bis(2-chloroisopropyl)ether (EPA 1995a). A subchronic oral RfD of $4\times10^{-2}$ mg/kg-day has been established based on a two year dietary study in mice (EPA 1994b). The critical effect was decreased hemoglobin and the uncertainty factor was 1,000. This subchronic oral RfD was used as the basis for the subchronic inhalation RfD without further adjustment. For the purposes of this risk assessment, the subchronic oral RfDs was used as a basis for chronic and subchronic inhalation RfDs without further adjustment.

The EPA weight-of-evidence classification for the human carcinogenic potential of bis(2-chloroispropyl)ether is C—possible human carcinogen (EPA 1994b). The oral SF has been established as $7\times10^{-2}$ $(mg/kg\text{-}day)^{-1}$ (EPA 1994b) based on the development of liver and lung tumors in a 2-year gavage study in mice. Based on route-to-route extrapolation of these oral data, an inhalation SF of $3.5\times10^{-2}$ $(mg/kg\text{-}day)^{-1}$ has been established (EPA 1994b).

**2-Butanone (Methyl ethyl ketone)**

The chronic oral RfD for 2-butanone, 0.6 mg/kg-day (EPA 1995a), is based on a multi-generation developmental feeding study in rats. The LOAEL was 3,122 mg/kg-day and the critical effect observed was decreased fetal birth weight. The NOAEL was 1,771 mg/kg-day. An uncertainty factor of 3,000 was applied to the NOAEL to obtain the RfD. The subchronic oral RfD for 2-butanone, 0.2 mg/kg-day (EPA 1994b), is based on the same feeding study in rats, with an applied uncertainty factor of 1,000.

The chronic inhalation RfD for 2-butanone, 0.29 mg/kg-day (EPA 1995a), is based on a developmental inhalation study in mice. The LOAEL was 8,906 $mg/m^3$ and the critical effect was decreased fetal birth weight. The NOAEL was 2,978 $mg/m^3$. An uncertainty factor of 1,000 and a modifying factor of 3 were applied to the NOAEL to obtain the RfD. The

subchronic inhalation RfD for 2-butanone is also 0.29 mg/kg-day, based on the study and uncertainty factors cited above (EPA 1994b).

**Cadmium**

EPA (1995a) has established oral RfDs of 0.0005 mg/kg-day for cadmium in drinking water and 0.001 mg/kg-day for cadmium in food. For both exposure media, the critical effect was significant proteinuria in human subjects chronically-exposed to cadmium. Both reference doses were also based on an aggregate uncertainty factor of 10, to account for intrahuman variability to the toxicity of this chemical in the absence of specific data on sensitive individuals. The RfD is based on the highest level of cadmium in the human renal cortex not associated with significant proteinuria, with modeled exposures adjusted to allow for absorption differences arising from differing cadmium sources (EPA 1995a). Inhalation RfDs are pending verification (EPA 1995a), so the more conservative RfDs, i.e., the oral RfDs for cadmium in water, were used for inhalation exposures. Chronic RfDs were used as surrogates for subchronic RfDs without further adjustment.

EPA (1995a) has calculated an inhalation unit risk concentration (risk per unit concentration of cadmium in the air) of $1.8 \times 10^{-3}$ $(\mu g/m^3)^{-1}$ [equivalent to 6.3 $(mg/kg\text{-}day)^{-1}$]. The critical study for this derivation considered mortality from lung, tracheal, and bronchial carcinogenicity in occupationally-exposed white male humans (Thun et al. 1985).

**Carbazole**

EPA (1994b) lists an oral slope factor for carbazole of $2 \times 10^{-2}$ $(mg/kg\text{-}day)^{-1}$ for liver tumors seen in a 96-week mouse study (Tsuda et al. 1982). No other information regarding carbazole toxicity was available.

**Chromium**

Hexavalent chromium appears to exhibit no significant adverse systemic toxicity via ingestion. A one-year drinking water study in rats showed no evidence of toxicity over the duration of the study (MacKenzie et al. 1958). The NOAEL for hexavalent chromium in the MacKenzie et al. (1958) study was calculated to be 2.4 mg/kg-day. EPA used an uncertainty factor of 500 (10 for interspecies extrapolation, 10 for intraspecies variability, and 5 for a less than lifetime study), yielding a value of 0.005 mg/kg-day for hexavalent chromium compounds (EPA 1995a). The subchronic oral RfD for hexavalent chromium is 0.02 mg/kg-day (EPA 1994b), based on the 1-year drinking water study in rats (MacKenzie et al. 1958) and applying an uncertainty factor of 100.

EPA has no chronic or subchronic RfC for hexavalent chromium (EPA 1995a). Epidemiologic studies of occupational inhalation exposure to hexavalent chromium indicate adverse respiratory effects ranging from irritation of the nasal mucosa to perforation of the septum, depending on exposure concentration. A study by Lindberg and Hedenstierna (1983) showed

evidence of respiratory effects at occupational exposure levels of 2 $\mu g/m^3$ of hexavalent chromium. No adverse effects were observed at 1 $\mu g/m^3$ (0.14 $\mu g$/kg-day). The chronic and subchronic oral RfDs were used as bases for the chronic and subchronic inhalation RfDs without further adjustment.

EPA (1995a) considers hexavalent chromium to be a known human carcinogen (Category A). Trivalent chromium is an essential nutrient (NRC 1989), and only hexavalent chromium seems to have the ability to cause cancer in humans. The ratio of trivalent chromium to hexavalent chromium in occupational environments is considered to be 6:1 (Mancuso 1975). Unit risks from various studies range from 0.035 to 0.13 $(\mu g/m^3)^{-1}$ (Langard et al. 1980; Axelsson et al. 1980; Pokrovskaya and Shabynina 1973). These studies assume that the smoking habits of chromate workers are similar to those of the general white male population and thus may overestimate risk because the proportion of smokers is typically higher for industrial workers than for the general population. Alternatively, the assumption of a 6:1 ratio between trivalent chromium and hexavalent chromium may underestimate risk, if this ratio is incorrect. Using Mancuso's data, EPA's inhalation unit risk for cancer is $1.2 \times 10^{-2}$ $(\mu g/m^3)^{-1}$ [equal to 42 $(mg/kg\text{-}day)^{-1}$] (EPA 1995a).

**Chrysene**

No toxicity values for health effects other than cancer have been derived for chrysene.

Insufficient data are available to derive a SF for chrysene. Following EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a basis because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for chrysene to cause cancer (see Section 6.3.2).

**Chlorobenzene**

The chronic oral RfD for chlorobenzene, $2 \times 10^{-2}$ mg/kg-day (EPA 1995a), is based on a 13-week dog study. Beagle dogs received chlorobenzene orally by capsule at doses of 27.25, 54.5, or 272.5 mg/kg-day for 5 days/week for 13 weeks. The LOAEL was 54.5 mg/kg-day and the critical effects observed were histopathological changes in the liver, as well as changes in the blood chemistry. An uncertainty factor of 1,000 was applied to the NOAEL of 19 mg/kg-day to obtain the RfD. A subchronic oral RfD has not been established (EPA 1994b) and for the purpose of this risk assessment the chronic oral RfD was used.

The chronic inhalation RfD for chlorobenzene, $5.7 \times 10^{-3}$ mg/kg-day (EPA 1995a), is based on a rat study. Rats were exposed to chlorobenzene at doses of 75 ppm for 7 hours/day, 5 days/week for 120 days. An uncertainty factor of 10,000 was applied to obtain the RfD. The critical effects observed were liver and kidney changes. For the purposes of this risk assessment, the chronic inhalation RfD was used as a basis for the subchronic RfD without further adjustment.

## Chloroform

EPA has established an oral RfD of 0.01 mg chloroform ingested per kilogram body weight per day, based on formation of fatty cysts in the liver of chronically-exposed dogs (Heywood et al. 1979). This RfD is based upon a LOAEL of 15 mg/kg-day, adjusted to 12.9 mg/kg-day to reflect a 7-day per week dosing schedule, and an aggregate uncertainty factor of 1000. The uncertainty factor incorporates use of a LOAEL, interspecies conversion, and human sensitivity (10-fold each).

EPA has calculated an oral slope factor (a plausible upper-bound estimate of the probability of a carcinogenic response per unit intake of the chemical over a lifetime) of 0.0061 $(mg/kg\text{-}day)^{-1}$. The slope factor calculation was based on kidney tumors in male Osborne-Mendel rats administered chloroform via drinking water (Jorgenson et al. 1982).

EPA has calculated an inhalation unit risk concentration (risk per unit concentration of chloroform in the air) of $2.3\times10^{-5}$ $(\mu g/m^3)^{-1}$. The critical study (NCI 1976) for this derivation reported hepatocellular carcinoma in female B6C3F1 mice administered chloroform by gavage. Risk estimates derived from male rat kidney tumor data (0.024) (NCI 1976) and studies by Roe et al. (1979) (0.1) are generally supportive of the risk estimate.

## Copper

Subchronic and chronic oral RfDs for copper are both reported as $3.7\times10^{-2}$ mg/kg-day, which is derived from the current drinking water standard for copper of 1.3 mg/L (EPA 1995a). The oral RfD is based on a single dose of 5.3 mg copper which resulted in local gastrointestinal tract irritation in humans. The oral RfD was not used as a basis for an inhalation RfD because it is based on gastrointestinal irritation. No inhalation RfDs or RfCs were assigned.

No SFs for copper were available.

## 4,4′-DDE

EPA (1995a) has estimated an oral SF for DDE of $3.4\times10^{-1}$ $(mg/kg\text{-}day)^{-1}$ by applying the linearized multistage model to the tumor incidence data observed in three studies involving mice or hamsters: NCI (1978b), Tomatis et al. (1974), and Rossi et al. (1983). The oral quantitative estimate is a geometric mean of six slope factors computed from cited incidence data by gender. For comparison, the geometric mean obtained using the slope factors from the mouse studies alone is $7.8\times10^{-1}$ (mg/kg-day), which is within a factor of 2 of that derived from the mouse and hamster studies combined. In addition, the SF for DDE was within a factor of 2 of the SFs for liver tumors for three structurally similar compounds: DDT—$3.4\times10^{-1}$ $(mg/kg\text{-}day)^{-1}$; DDD—$2.4\times10^{-1}$ $(mg/kg\text{-}day)^{-1}$; and Dicofol—$4.4\times10^{-1}$ $(mg/kg\text{-}day)^{-1}$. The oral SF was used as a basis for the inhalation SF without further adjustment.

No toxicity values for health effects other than cancer have been derived for DDE.

**Dibenzo(a,h)anthracene**

No toxicity values for health effects other than cancer have been derived for dibenzo(a,h)anthracene.

Insufficient data are available to derive a SF for dibenzo(a,h)anthracene. Following EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a surrogate because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for dibenzo(a,h)anthracene to cause cancer (see Section 6.3.2).

**Dibenzofuran**

The chronic oral RfD for dibenzofuran is estimated to be $4 \times 10^{-3}$ mg/kg-day (EPA 1995b). The chronic oral RfD was used as the basis for the chronic inhalation and subchronic oral and inhalation RfDs without further adjustment.

No SFs are available for dibenzofuran.

**1,4-Dichlorobenzene**

An oral RfD for 1,4-dichlorobenzene is not available. The chronic inhalation RfD for 1,4-dichlorobenzene has been established as 0.23 mg/kg-day based on an inhalation reference concentration of 0.8 mg/m$^3$ (EPA 1995a). The chronic inhalation RfD is based upon an inhalation study in rats. Rats were exposed to 1,4-dichlorobenzene at a concentration of 75 ppm for 5 hours/day, 5 days/week, for 76 weeks. The critical effects observed were liver and kidney changes. An uncertainty factor of 100 was applied to obtain the chronic inhalation RfD. The subchronic inhalation RfC is 2.5 mg/m$^3$ [equivalent to 0.7 mg/kg-day] (EPA 1994b).

The oral SF for 1,4-dichlorobenzene is $2.4 \times 10^{-2}$ (mg/kg-day)$^{-1}$ (EPA 1995a). In a 103-week oral gavage study in mice, 1,4-dichlorobenzene produced liver tumors. An inhalation slope factor of 1,4-dichlorobenzene is not available (EPA 1995a).

**1,2-Dichloroethane**

No RfDs are available for 1,2-dichloroethane.

1,2-Dichloroethane has been shown to produce several tumor types in rats and mice treated by gavage and lung papillomas in mice after topical application. An oral slope factor of $9.1 \times 10^{-2}$ (mg/kg-day)$^{-1}$ and an inhalation unit risk of $2.6 \times 10^{-5}$ ($\mu$g/m$^3$)$^{-1}$ have been established (EPA 1995a). The inhalation unit risk is equivalent to an inhalation SF of $9.1 \times 10^{2}$.

**1,2-Dichloroethene (Total)**

The toxicity of mixed *cis*- and *trans*-isomers of 1,2-dichloroethene has been approximated by analogy using a 2-year drinking water study in which 1,1-dichloroethene was administered to rats (Quast et al. 1983). The chronic oral RfD for mixed isomers of 1,2-dichloroethene is $9\times10^{-3}$ mg/kg-day (EPA 1994b). The LOAEL was 50 ppm, and the critical effect observed was liver lesions. An uncertainty factor of 1,000 was applied to obtain the RfD. The subchronic oral RfD is also $9\times10^{-3}$ mg/kg-day (EPA 1994b), based on the chronic oral RfD. In the absence of inhalation RfDs, the oral RfDs were used as bases for inhalation RfDs without further adjustment.

No SFs are available for 1,2-dichloroethene.

**1,2-Dichloropropane**

Chronic and subchronic oral RfDs are not available for this compound. A chronic inhalation RfD of $1.1\times10^{-3}$ mg/kg-day has been established based on an inhalation reference concentration of $4\times10^{-3}$ mg/m$^3$ (EPA 1995a). The chronic inhalation RfD is based on a rat study in which critical effect was nasal mucosa hyperplasia; an uncertainty factor of 300 was applied. The subchronic inhalation RfD, $3.7\times10^{-3}$ mg/kg-day, is based on a RfC $1.3\times10^{-2}$ mg/m$^3$ (EPA 1994b). The critical effect was the same and an uncertainty factor of 100 was applied.

The oral slope factor for 1,2-dichloropropane, $6.8\times10^{-2}$ (mg/kg-day)$^{-1}$, is based on a mouse gavage study (EPA 1995a). Liver tumors were induced following 1,2-dichloropropane administration. An inhalation SF is not available at this time. The oral SF was used as a basis for the inhalation SF.

**Dioxins (2,3,7,8-TCDD)/Furans**

With a variety of relevant experimental durations (i.e., subchronic or chronic; from >14 days to >1 year), adverse effects from dioxin were expressed predominantly as decreased longevity, as well as reproductive, immunological, and hepatic effects. In general, for exposures of 15 days to 1 year, most of the animal NOAELs for these effects occur at ingestion of dioxin ranging from approximately 0.001 (longevity and liver effects) to 0.01 $\mu$g/kg-day (immunotoxicity), with no human NOAELS. Animal LOAELs ranged from 0.001 $\mu$g/kg-day (reproductive, liver effects) to 0.01 $\mu$g/kg-day (immunotoxicity), with no human LOAELs. For exposures of 1 year or longer, only an animal NOAEL of 0.001 $\mu$g/kg-day for liver toxicity was observed, with no human NOAELs or LOAELs.

There are no established oral or inhalation RfDs for dioxin (2,3,7,8-TCDD) or its isomers.

EPA has proposed an oral SF for 2,3,7,8-TCDD of $1.5\times10^{5}$ (mg/kg-day)$^{-1}$. An interim approach for extrapolating 2,3,7,8-TCDD toxicity values for use with various isomers

exhibiting fractional toxicities relative to 2,3,7,8-TCDD (i.e., use of toxicity equivalence factors) has been developed (EPA 1994f). The critical study involved oral exposure of rats to dioxin in the diet for approximately 2 years, and yielded respiratory tumors and liver tumors (EPA 1994b).

EPA (1994b) has proposed an inhalation SF of $1.5 \times 10^5$ (mg/kg-day)$^{-1}$. The toxicity equivalence factor approach has also been proposed for use with inhalation exposures. The critical study was the same as that used for the oral SF.

**Ethylbenzene**

EPA (1995a) has established a chronic oral RfD for ethylbenzene of 0.1 mg/kg-day based on renal and hepatic toxicity in rat subchronic oral bioassays (Wolf et al. 1956). This RfD is based upon a NOEL of 136 mg/kg-day, adjusted to 97.1 mg/kg-day to convert from a 5-day per week to 7-day per week dosing schedule, and by applying an aggregate uncertainty factor of 1,000. The uncertainty factor accounts for intra- and inter-species extrapolation (10-fold each) and for extrapolation of a subchronic effect level to a chronic effect level (10-fold). The chronic oral RfD was used as a basis for the subchronic oral RfD without further adjustment.

Ethylbenzene has been shown to be a reproductive toxicant via subchronic or chronic inhalation exposures to laboratory animals. EPA (1995a) has established a chronic inhalation RfC for ethylbenzene of 1 mg/m$^3$, based on developmental toxicity in rats and rabbits (Andrew et al. 1981; Hardin et al. 1981). This chronic inhalation RfC is equivalent to a chronic inhalation RfD of 0.29 mg/kg-day. The chronic inhalation RfD is based upon an adjusted human-equivalent-concentration NOAEL of 434 mg/m$^3$ and the application of an aggregate uncertainty factor of 300. The uncertainty factor accounts for human sensitivity (10-fold), the absence of multigenerational reproductive and chronic studies (10-fold), for interspecies conversion (3-fold). The chronic inhalation RfD was used as the basis for the subchronic inhalation RfD without adjustment.

No SFs for ethylbenzene are available.

**Fluoranthene**

Based on increased SGPT levels, kidney and liver pathology, and clinical and hematological changes seen in mice dosed with fluoranthene via gavage, the LOAEL is considered to be 250 mg/kg-day, and the corresponding NOAEL is 125 mg/kg-day (EPA 1989e). An uncertainty factor of 3,000 reflects 10 for interspecies conversion, 10 for intraspecies variability, 10 for use of a subchronic study for chronic human NOAEL derivation, and 3 for suspected reproductive toxicity based on observations of reproductive toxicity of benzo(a)pyrene in animal studies. The chronic oral RfD for fluoranthene is 0.04 mg/kg-day (EPA 1995a). For subchronic exposure, the uncertainty factor of 300 includes 10 for interspecies variability, 10 for intraspecies variability, and 3 for suspected reproductive toxicity based on the reproductive toxicity of benzo(a)pyrene in animal studies. The subchronic oral RfD for fluoranthene is

estimated to be 0.4 mg/kg-day (EPA 1994b). Chronic and subchronic oral RfDs were used as bases for chronic and subchronic inhalation RfD without further adjustment because fluoranthene is toxic at organs distant from the portal of entry and the systemic dose is expected to govern its toxic potency.

No SFs for fluoranthene are available.

**Fluorene**

EPA (1995a) has established an oral RfD of 0.04 mg/kg-day for fluorene based on a subchronic toxicity study performed in CD-1 mice (EPA 1989f). Based on hematological effects from this study, the LOAEL was considered to be 250 mg/kg-day and the NOAEL, 125 mg/kg-day. An uncertainty factor of 3,000, reflecting 10 for interspecies variability, 10 for intraspecies variability, 10 for use of a subchronic study for chronic human NOAEL derivation, and 3 for suspected reproductive toxicity based on observations of reproductive toxicity of fluorene in animal studies was used (EPA 1995a). For subchronic exposure, the uncertainty factor of 300 includes 10 for interspecies variability, 10 for intraspecies variability, and 3 for suspected reproductive toxicity based on the reproductive toxicity of BaP in animal studies. The subchronic oral RfD for fluorene is estimated to be 0.4 mg/kg-day (EPA 1994b). Chronic and subchronic oral RfDs were used as bases for chronic and subchronic inhalation RfDs without further adjustment.

No SFs for fluorene are available.

**Indeno(1,2,3-cd)pyrene**

No RfDs for indeno(1,2,3-cd)pyrene are available.

Insufficient data are available to derive a SF for indeno(1,2,3-cd)pyrene. Based on EPA Region I guidance (EPA 1994a), the oral SF for benzo(a)pyrene was used as a surrogate because the cancer potency of benzo(a)pyrene was considered to be representative of the potential for indeno(1,2,3-cd)pyrene to cause cancer (see Section 6.3.2).

**Lead**

Chronic and subchronic RfDs for lead have not been derived by EPA (1995a). Some health effects of lead may occur at blood lead concentrations so low as to be essentially without a biological threshold. This is the basis for EPA's decision not to derive an RfD for lead. EPA considers an RfD for inorganic lead to be inappropriate (EPA 1995a). An RfC for lead has not been determined by EPA.

Cancer slope factors for lead have not been determined by EPA (1995a).

**Manganese**

Two separate oral RfDs have been proposed by EPA, one based on ingestion of manganese in water and the other based on the ingestion of manganese in food. Exposure to manganese is associated with effects on the central nervous system. The Food and Nutrition Board of the National Research Council (NRC 1989) determined an "adequate and safe" intake of manganese to be 2–5 mg/day for adults. This level was chosen because it includes an "extra margin of safety" from the level of 10 mg/day, which the NRC considered to be safe for an occasional intake. Based on this information, an oral RfD of 0.005 mg/kg-day for manganese in water has been established (EPA 1995a). The oral RfD for manganese in foods is 0.001 mg/kg-day (EPA 1995a). EPA (1994b) cross-assigned chronic oral RfDs to subchronic exposures. The water-based oral RfDs (the lower of the water- and food-based oral RfDs) were used as bases for the chronic and subchronic inhalation RfDs without adjustment.

Cancer slope factors for manganese are not available.

**Mercury**

The chronic oral RfD for mercury is $3\times10^{-4}$ mg/kg-day (EPA 1995a) based on prevention of renal damage, the critical effect. An aggregate uncertainty factor of 1,000 was applied. The subchronic oral RfD for mercury is also $3\times10^{-4}$ mg/kg-day (EPA 1994b).

The chronic inhalation RfD for mercury is $3\times10^{-4}$ mg/m$^3$ ($8.6\times10^{-5}$ mg/kg-day ) (EPA 1995a), and is based on several occupation studies. Neurotoxicity was the critical effect following inhalation exposure by humans. An uncertainty factor of 30 was applied to obtain the RfD. The subchronic inhalation RfD, based on the chronic inhalation RfD, is also $8.6\times10^{-5}$ mg/kg-day (EPA 1994b).

Cancer slope factors for mercury are not available.

**Methylene chloride**

The chronic oral RfD for methylene chloride, $6\times10^{-2}$ mg/kg-day (EPA 1995a), is based on a drinking water bioassay in rats (NCA 1982, 1983). Rats were given methylene chloride at doses of 5, 50, 125, or 250 mg/kg-day in drinking water for 2 years. The critical effect was liver toxicity. The LOAELs were 52.58 and 58.32 mg/kg-day for males and females, respectively. The NOAELs were 5.85 and 6.47 mg/kg-day for males and females, respectively. An uncertainty factor of 100, which accounted for inter- and intra-species variability, was applied to these NOAELs to obtain the RfD. The subchronic oral RfD, based on the chronic oral RfD, is also $6\times10^{-2}$ mg/kg-day (EPA 1994b).

The chronic inhalation RfD for methylene chloride is 0.86 mg/kg-day (3 mg/m$^3$) (EPA 1995a). This value is based upon a chronic inhalation study in rats. Rats were exposed intermittently to methylene chloride in air for 2 years. The NOAEL was 694.8 mg/m$^3$, and an uncertainty

factor of 100 was applied to obtain the RfD. The subchronic inhalation RfD, based on the chronic inhalation RfD, is also 0.86 mg/kg-day (EPA 1994b).

Methylene chloride has been shown to induce increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, and increased incidence of benign mammary tumors in both sexes of rats, salivary gland carcinomas in male rats and leukemia in female rats. An oral SF of $7.5 \times 10^{-3}$ (mg/kg-day)$^{-1}$ (EPA 1995a), calculated as the arithmetic mean of SF derived from an inhalation mouse study and an oral/drinking water study in mice, has been established. An inhalation SF of $1.6 \times 10^{-3}$ (mg/kg-day)$^{-1}$ has been established, based upon the induction of adenomas and carcinomas (liver and lung) in mice following inhalation exposure (EPA 1995a).

**2-Methylphenol**

The chronic oral RfD for 2-methylphenol is $5 \times 10^{-2}$ mg/kg-day (EPA 1995a), and is based on a 90-day oral subchronic neurotoxicity study in rats (EPA 1987). The rats were gavaged daily with 0, 50, 175, 450 or 600 mg/kg-day 2-methylphenol. Doses greater than 450 mg/kg-day produced significant neurological events. The NOAEL for systemic toxicity was 50 mg/kg-day in rats (EPA 1995a). An uncertainty factor of 1,000 was applied to account for interspecies and intraspecies variability and for uncertainty in extrapolation of subchronic data to chronic effects. The subchronic oral RfD for 2-methylphenol, $5 \times 10^{-1}$ mg/kg-day (EPA 1994b), is based on the same EPA study (EPA 1987) and was derived using an uncertainty factor of 100. Inhalation RfDs are not available (EPA 1994b), so oral RfDs have been cross-assigned to inhalation exposures without further adjustment.

Although The EPA weight-of-evidence classification for the carcinogenicity of this compound is Category C, possible human carcinogen, based on increased incidence of skin papillomas in mice in an initiation-promotion study, a quantitative estimate of carcinogenic risk from oral or inhalation exposure is not available (EPA 1995a).

**4-Methylphenol**

The chronic oral RfD for 4-methylphenol, $5 \times 10^{-3}$ mg/kg-day (EPA 1994b), is based on a gavage study done in pregnant rabbits. The rabbits were given 5 mg/kg-day 4-methylphenol on gestation days 6–18. The critical effect was maternal death. An uncertainty factor of 1,000 was applied to obtain the RfD. The subchronic oral RfD for 4-methylphenol is $5 \times 10^{-2}$ mg/kg-day (EPA 1994b), and was estimated using an uncertainty factor of 100. Oral RfDs were used as bases for inhalation RfDs without further adjustment.

Although 4-methylphenol is a Category C carcinogen, a quantitative estimate of carcinogenic potency from oral or inhalation exposure is not available (EPA 1995a).

**Naphthalene**

Chronic and subchronic oral RfDs for naphthalene are both $4 \times 10^{-2}$ mg/kg-day (EPA 1995c). The RfD was based on a subchronic study by NTP (1980) in which rats were administered naphthalene by gavage five days/week for 13 weeks. A NOAEL of 50 mg/kg-day was identified, converted to an equivalent dose of 36 mg/kg-day, and the RfD was calculated using an uncertainty factor of 1,000 to account for intra- and inter-species variability and for the use of a subchronic study. These oral values were withdrawn in the November supplement of the 1992 HEAST (EPA 1995c). Oral RfDs were used as bases for inhalation RfDs without further adjustment.

Naphthalene has been tested in studies capable of detecting the ability to cause cancer; however, all but one study showed no such evidence. In the 2-year NTP study of chronic toxicity and carcinogenicity (NTP 1992), a statistically elevated incidence of lung alveolar/bronchiolar adenomas at the high dose level was observed in female mice at the highest dose tested. This study provides weak, possibly questionable, evidence of carcinogenicity, because (a) only one sex showed the tumorigenic effect; (b) only one tumor type (benign) was observed; (c) no dose-response existed since the tumors were present only in the group receiving the highest dose; and (d) the strain of mice used in the study typically exhibits high spontaneous rates of lung adenomas. These data are unlikely to prove adequate for the estimation of a SF according to EPA cancer risk assessment guidelines (EPA 1986c).

**Phenanthrene**

Insufficient data exist to derive RfDs or RfCs for phenanthrene. Toxicity values for pyrene, a structurally similar noncarcinogenic PAH, were used in this risk assessment.

**Polychlorinated Biphenyls (PCB)**

EPA Region III (EPA 1995b) lists a chronic oral RfD of $2 \times 10^{-5}$ for Aroclor-1254. This chronic oral RfD was used for Aroclors-1242, -1254, and -1260 in this assessment. The chronic oral RfD was used as a basis for the subchronic oral RfD and chronic and subchronic inhalation RfDs without further adjustment.

The most recent oral SF for PCB, 7.7 $(\text{mg/kg-day})^{-1}$, is based on an oral feeding study in rats (Norback and Weltman 1985) (EPA 1995b). This value was used to evaluate cancer risks for all Aroclor mixtures. It should be noted that EPA has withdrawn the SF from IRIS, and considerable controversy still exists as to whether the available data is sufficient to classify PCB as carcinogenic (IARC 1987a), or are insufficient to support such a classification (IPCS 1993). The oral SF was used as a basis for the inhalation SF for all Aroclor mixtures.

EPA recently proposed to update the cancer dose-response assessment for PCB and analyzed how information on toxicity, disposition, and environmental processes could be considered together to evaluate health risks from PCB mixtures in the environment. The EPA's

assessment considers all cancer studies to develop a range of dose-response slopes, then uses information on environmental processes to provide guidance on choosing an appropriate slope for representative classes of environmental mixtures and different exposure pathways. The cancer potency of PCB mixtures is described by two ranges of estimates. Upper bound slopes span a range of 0.3-2 per mg/kg-day average lifetime exposure to PCB. Central estimates of these slopes span a range of 0.1-0.9 per mg/kg-day (EPA 1996).

**Pyrene**

Mice given pyrene by gavage for 13 weeks exhibited only mild nephropathy characterized by minimal or mild kidney lesions and a reduction in kidney weights (EPA 1989f). Based on these findings and using uncertainty factors whose product is 3,000, EPA (1995a) calculated a chronic oral RfD of 0.03 mg/kg-day. The subchronic RfD for pyrene is 0.3 mg/kg-day (EPA 1994b). Since pyrene is toxic at organs distant from the portal of entry, the systemic dose is expected to govern its toxic potency. Therefore, the oral RfDs were used as bases for inhalation RfDs.

For other noncarcinogenic PAH, data for health effects other than cancer are either absent or inadequate for dose-response assessment. Therefore, toxicity values for pyrene were used as surrogates for these COCs: benzo(g,h,i)perylene and phenanthrene.

**1,1,2,2-Tetrachloroethane**

In a bioassay undertaken by NCI (1978c), Osborne-Mendel rats and B6C3F1 mice were gavaged with 1,1,2,2,-tetrachloroethane. Treatment was over 78 weeks, followed by observation periods of 32 weeks for the rats and 12 weeks for the mice. The high and low average doses (incorporating varying dosage levels throughout the treatment period) were, respectively, 108 and 62 mg/kg-day for male rats, 76 and 43 mg/kg-day for female rats, and 282 and 142 mg/kg-day for mice of both sexes. Control groups consisted of 20 animals/sex and species. Significantly increased mortality and incidence of hepatocellular carcinomas were evident in the high-dose mice of both sexes. The oral SF was estimated to be $2 \times 10^{-1}$ $(mg/kg\text{-}day)^{-1}$, based on the observed increased incidence of hepatocellular carcinomas in mice (EPA 1995a).

The inhalation SF for 1,1,2,2-tetrachloroethane is $2 \times 10^{-1}$ $(mg/kg\text{-}day)^{-1}$ (EPA 1995a). The inhalation SF was calculated from the oral exposure data (EPA 1995a).

**Thallium**

The chronic oral RfD for thallium carbonate, $8 \times 10^{-5}$ mg/kg-day (EPA 1995a), is based on a gavage study in rats. Administration of 0.20 mg/kg-day thallium for 90 days in rats produced increased SGOT levels and serum LDH levels and alopecia. An uncertainty factor of 3,000 was used to obtain this RfD. A subchronic oral RfD of $8 \times 10^{-4}$ (EPA 1994b) was established

using an uncertainty factor of 300. Oral RfDs were used as bases for inhalation RfDs without further adjustment.

**Toluene**

Toluene-induced neurotoxicity has been documented in humans exposed to high, but not low, concentrations. The EPA chronic oral RfD for toluene is 0.2 mg/kg-day (EPA 1995a), based on a 13-week rat gavage study in which an increase in liver and kidney organ weights was reported as the most sensitive index of toxicity (NTP 1990). An aggregate uncertainty factor of 1,000 was applied to account for inter- and intra-species extrapolations, for subchronic to chronic extrapolation and for limited reproductive and developmental toxicity data. The subchronic oral RfD for toluene is 2 mg/kg-day (EPA 1994b).

EPA (1995a) has developed an inhalation RfC for toluene of 0.4 mg/m$^3$, based on the neurological effects observed in an occupational epidemiologic study (Foo et al. 1990), with application of an uncertainty factor of 300 (10 for intraspecies variability, 10 for the use of a LOAEL, and 3 for database deficiencies in characterizing adequately the neurotoxicity and respiratory irritation of toluene in animal studies). The RfC was used to develop a chronic inhalation RfD of $1.1 \times 10^{-1}$. The subchronic inhalation RfD for toluene is 0.3 mg/kg-day (EPA 1995c), based on an inhalation study involving male rats that inhaled up to 1,500 ppm toluene 6 hr/d, 5 d/wk for 6 months (Ladefoged 1991).

**1,1,2-Trichloroethane**

White et al. (1985) and Sanders et al. (1985) were used to derive the chronic oral RfD for 1,1,2-trichloroethane. Mice of both sexes were exposed to 1,1,2-trichloroethane in drinking water for 90 days. Concentrations provided were 0, 20, 200, or 2,000 mg/L, which resulted in intakes of 0, 4.4, 46, and 305 mg/kg-day for males and 0, 3.9, 44, and 384 mg/kg-day for females. Clinical chemistry indications of adverse effects on the liver occurred in both sexes at 2,000 mg/L. Effects on the erythrocytes occurred only in females and depressed humoral immune status occurred in both sexes at 200 and 2000 mg/L. The concentration of 20 mg/L, corresponding to 3.9 mg/kg-day for female rats (White et al. 1985; Sanders et al. 1985), is the NOAEL at which significant adverse effects were not observed and is chosen as the basis for the derivation of a chronic oral RfD of $4 \times 10^{-3}$ mg/kg-day (EPA 1995a). Uncertainty factors of 10 each were used for interspecies and intraspecies variability, and a factor of 10 for extrapolation to lifetime exposure from an intermediate exposure duration. The subchronic oral RfD for 1,1,2-trichloroethane is $4 \times 10^{-2}$ mg/kg-day (EPA 1994b). Oral RfDs were used as bases for inhalation RfDs without further adjustment.

In a bioassay conducted by NCI (1978d) 1,1,2-trichloroethane was administered to Osborne-Mendel rats and B6C3F1 mice for 78 weeks. Treatment of mice was found to be associated with increased incidence of hepatocellular carcinomas. The oral SF for 1,1,2-trichloroethane is $5.7 \times 10^{-2}$ (mg/kg-day)$^{-1}$, and the inhalation SF is $5.7 \times 10^{-2}$ (mg/kg-day)$^{-1}$ (EPA 1995a), based on the oral exposure data.

**Trichloroethene**

EPA's Science Advisory Board has recommended that trichloroethene be classified on the Category C–B2 continuum. However, EPA has yet to adopt a final position on the weight of evidence classification for trichloroethene (EPA 1995c). An oral SF of $1.1 \times 10^{-2}$ $(mg/kg\text{-}day)^{-1}$, the value that was withdrawn from IRIS, and an inhalation SF of $6 \times 10^{3}$ $(mg/kg\text{-}day)^{-1}$ were used in this HHRA based on consultation with the Superfund Technical Support Center.

Animal LOAELs and NOAELs for trichloroethene toxicity typically range from 10 to 1,000 mg/kg-day, although a single rat NOAEL for renal effects is stated to occur at 50 mg/kg-day (Maltoni et al. 1986). From an assortment of subchronic and chronic inhalation exposure studies, laboratory animal LOAELs and NOAELs typically range from 100 to 2000 ppm (ATSDR 1991b). A single study assessing respiratory, cardiovascular, hepatic and renal effects in rats reported a NOAEL of 35 ppm following 90 days of continuous exposure to trichloroethene (Prendergast et al. 1967). EPA Region III lists a chronic oral RfD for trichloroethene of $6 \times 10^{-3}$ mg/kg-day (EPA 1995b). This chronic oral RfD was used as a basis for subchronic oral and chronic and subchronic inhalation RfDs without further adjustment.

**Vinyl Chloride**

RfDs are not available for vinyl chloride.

The oral SF for vinyl chloride is 1.9 $(mg/kg\text{-}day)^{-1}$, based on an increased incidence of liver and lung tumors in rats (EPA 1994b). The inhalation SF for vinyl chloride is 0.3 $(mg/kg\text{-}day)^{-1}$, based on an increased in liver tumors in rats exposed intermittently to vinyl chloride for one year (EPA 1994b).

**Zinc**

EPA (1995a) has established a chronic oral RfD for zinc of 0.3 mg/kg-day, based on a decrease in erythrocytic superoxide dismutase content in adult human females after 10 weeks of exposure (Yadrick et al. 1989). This RfD is based upon a dietary supplement LOAEL dosage of approximately 60 mg/kg, converted to 1 mg/kg-day, and by applying an aggregate uncertainty factor of 3. The uncertainty factor accounts for the use of a minimal LOAEL from a moderate-duration study of the most sensitive humans and consideration of a substance that is an essential dietary nutrient. The chronic oral RfD was used as a basis for the chronic inhalation RfD. SFs are not available for zinc.

## 6.4 ASSESSMENT OF HUMAN EXPOSURE

The purpose of an exposure assessment is to determine the populations that may potentially be exposed to onsite or selected offshore media-related chemicals, the pathways by which exposure may occur, and the magnitude, frequency, and duration of these potential human

exposures. This exposure assessment focuses on the contaminants of concern present at in onsite and selected offshore media. The exposure assessment involved a five-step analytical sequence:

(1) **Identification of populations of interest.** Five populations were identified based on their future potential for onsite exposures: Future construction workers, future commercial/industrial workers, the children of commercial/industrial workers in an onsite day care facility, hypothetical residents consuming ground water, and consumers of locally caught shellfish.

(2) **Formulation of conceptual site model.** Exposure pathway identification involves the development of a "conceptual site model" that includes primary and secondary sources of contamination (e.g., soil), their release mechanisms (e.g., infiltration), and exposure pathways (e.g., ingestion of soil). Exposure scenarios were developed to demonstrate the interrelationship between contaminated environmental media, the chemicals (from among those selected in Section 6.2) that are in the environmental media, the populations of interest and their activities leading to exposures to the chemicals, and the specific routes by which chemicals in the various media may enter the body.

(3) **Estimation of exposure point concentrations.** EPCs of COCs were estimated based on environmental sampling data where available, and with the use of models (e.g., COC concentrations in air).

(4) **Identification of the values to be assigned to each exposure parameter in each exposure scenario.** Identification of appropriate values for exposure parameters involved determining such factors as ingestion rates, inhalation rates, body weights, exposure times, frequencies, and durations, rates of absorption of chemicals into the body; and skin surface area. Many of these and other factors are scenario-specific and were selected primarily in accordance with existing EPA guidance.

(5) **Quantification of exposures.** The exposure is the amount of each chemical (expressed as the amount of chemical per unit of body weight per day, or "mg/kg-day") that an individual takes in, according to each identified (chemical-specific, medium-specific, activity-specific, route-specific) exposure scenario.

The results of the exposure assessment are pathway-specific intakes into the body for exposures to COCs in onsite and selected offshore media. The results of the exposure assessment are combined in Section 6.5 with the results of the dose-response assessment to estimate human risk for both cancer and noncancer health effects.

### 6.4.1 Potential Receptor Populations

This assessment is limited to onsite exposures at Site 07 and exposures to selected offshore media. The *Comprehensive Reuse Plan for the Davisville Naval Construction Battalion Center* drafted by the Base Reuse Committee and adopted by the Town of North Kingston and the State of Rhode Island specifies that Calf Pasture Point may be used for conservation and recreational purposes in the future. Remediation and construction at the site would involve construction workers. Following any remediation activities, Site 07 will become a conservation area with the potential for limited recreational development. Site 07 is northeast of the Allen Harbor Landfill, which is also slated to be conserved with a limited potential for recreational development. Recreational development at the site, which would attract recreational users to the site, is likely to be limited to construction of showering and sanitary facilities and a snack bar. Here, potential human receptors, adults and children, who bathe or swim in the Entrance Channel are also assumed to be a receptor of concern. In addition, shellfish (offshore media) are found in Allen Harbor, presenting the opportunity for local residents to catch and consume them. Finally, hypothetical residents have been assumed to consume deep and bedrock ground water even though residential development of the site is not part of the future reuse plan and is therefore extremely unlikely.

In this HHRA, future remediation/construction workers, future recreational users (future land-based recreational users (children aged 2–18), future water-based recreational users (adults and children)), consumers of locally caught shellfish, and hypothetical residents were identified as the populations with the potential for exposure to contaminants of concern at Site 07 (onsite media) and to selected offshore media. Anticipated future activities and practices of the identified populations were characterized in order to assess the likelihood and extent of their exposure.

### 6.4.2 Exposure Pathways

An exposure pathway describes a characteristic mechanism by which a population or individual can be exposed to chemicals present at a site. An exposure pathway consists of the following four components:

- A source and mechanism of chemical release to the environment;
- An environmental transport medium for the released chemical;
- A point of potential human contact with the contaminated medium; and
- A human exposure route at the point of exposure.

All four components must exist for an exposure pathway to be complete and for exposure to occur. Incomplete exposure pathways do not result in actual human exposure, and are not included in the exposure assessment and resulting risk characterization.

In this investigation, exposure pathways considered were those which represent plausible, complete pathways of potential exposure to chemicals of concern present in or originating from

soil, ground water, and air at Site 07 (onsite media) and intertidal zone sediment and shellfish (selected offshore media). In some cases, exposure pathways which are not necessarily plausible (e.g., use of the ground water as a source of water for residential consumption or recreational showering) were included in order to assure completeness of the baseline risk assessment. Inclusion of these less plausible pathways does not indicate that the ground water at Site 07 is believed likely to be used in the manner indicated in the exposure scenarios.

#### 6.4.2.1 Chemical Release Source

As illustrated in the Conceptual Site Model (Figure 6-2), the COCs at Site 07 and adjacent selected offshore media, if adsorbed onto soil particulates, may be released into the air as a result of disturbance of affected soils (e.g., by wind erosion or by excavation and construction activities). The amount of soil particulate released to the air is dependent on the soil particulate particle size, the physical properties of the soil, and the level of activity on the soil. Ground water at the interface between the landfill and the harbor also represents a potential chemical release source into harbor waters and sediment. Shellfish may accumulate COCs from sediments and surface water.

#### 6.4.2.2 Environmental Transport Media

As illustrated in the Conceptual Site Model (Figure 6-1), soil, ground water, and air were identified as the environmental transport media for the release of chemicals present at Site 07 (onsite media) and/or sediment, surface water, and shellfish for the selected offshore media.

#### 6.4.2.3 Exposure Points

An exposure point is defined as a location of potential contact between a receptor population and a chemical constituent. The objective of determining exposure points is to identify where receptor populations may be potentially exposed to chemical constituents contained within environmental transport media. In this investigation, potential exposure points included soil (both surface and subsurface), ground water, and air. In addition, sediment and shellfish obtained from the harbor are considered selected offshore media exposure points in this assessment.

#### 6.4.2.4 Human Exposure Routes

An exposure route is defined as the mechanism by which a chemical constituent comes in contact with a receptor population. The following human exposure routes were identified for Site 07 (onsite media) and selected offshore media:

*Exposures via Soil (onsite media)*

- Incidental ingestion of soil
- Dermal contact with soil

*Exposures via Sediment (offshore media)*

- Incidental ingestion of sediment
- Dermal contact with sediment

*Exposures via Surface Water (offshore media)*

- Incidental ingestion of surface water
- Dermal contact with surface water

*Exposures via Ground Water (onsite media)*

- Incidental ingestion of ground water
- Consumption of ground water
- Inhalation of volatiles from ground water while showering
- Dermal contact with ground water while showering

*Exposures via Air (onsite media)*

- Inhalation of suspended soil particulates during excavation
- Inhalation of volatiles from soil during excavation

*Exposure via Shellfish* (offshore media)

- Ingestion of shellfish taken from Allen Harbor adjacent to Site 07

#### 6.4.2.5 Human Exposure Pathways

The exposure pathways considered to represent plausible, pathways of potential exposure to chemical constituents in onsite media (soil, ground water, or air) or offshore media (shellfish and sediment in the intertidal zone) are summarized below. Based on evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the shellfish and intertidal sediment (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling and analyses conducted to date by the Navy have identified no related unacceptable risk. However,

the HHRA results for potential exposure to both onsite media and offshore media are presented. Consistent with EPA Region I guidance (EPA 1989b, 1994a), two values for each exposure parameter were selected for use in characterizing potential exposures: one value to represent a "central tendency" or "average exposure" (AE) and another value for the high-end or "reasonable maximum exposure" (RME) that is intended to represent a reasonable worst-case exposure. Evaluation of both the AE and RME provides an indication of the potential range of exposures possible at a site. Assumed values for exposure parameters were obtained from a variety of EPA guidance and reference documents. Descriptions of values used for exposure parameters, as well as algorithms for calculating (lifetime) average daily intakes, may be found in Table 6-18. Descriptions of values used for exposure parameters, as well as algorithms for calculating (lifetime) average daily doses, may be found in Tables M-1 through M-17 in Appendix M.

**Future Construction Workers**

Since Site 07 has not yet undergone remediation, the following assumptions for the construction worker scenario were based on previous experience with site remediation and an evaluation of possible remediation activities at Site 07 consistent with the Base Reuse Plan. Under this scenario, it was assumed that hypothetical construction workers will directly contact surface and subsurface soils during excavation. It was assumed that remediation/construction workers might incidentally ingest ground water from the shallow aquifer while excavating.

For this HHRA, it was assumed that any remediation/construction will be accomplished in one calendar year. Excavation was assumed to take 30 calendar days (one month), and other work preceding was assumed to require an additional 60 calendar days, or two months. Thus, for the average case in this risk assessment, the exposure period of interest was assumed to be three months (13 weeks). The maximum case, allowing for delays, was conservatively assumed to take four months (17 weeks). Since workers are likely to be onsite for 5 days/week, 8 hours/day, the following values were used for exposure frequency: excavation duration—20 days/year, average case exposure duration—65 days/year, and reasonable maximum case exposure duration—85 days/year.

Although dress is likely to be consistent with Level D requirements (i.e., coveralls, boots, and gloves), to produce a conservatively prudent estimate of exposure, workers are assumed to have exposed hands and forearms under average exposure conditions, whereas reasonable maximum exposure conditions could include exposed hands, arms and face. Contact with ground water in excavation trenches was assumed to occur only during excavation activities. Additional information on selected values for exposure parameters (e.g., soil ingestion, exposure duration) for future construction workers is located in Table 6-18 and Tables M-1 through M-5 in Appendix M.

Based on the above analysis, the following three exposure pathways were identified as being complete for future remediation/construction workers:

- *Incidental ingestion of surface and subsurface soils;*
- *Dermal contact with surface and subsurface soils; and*
- *Incidental ingestion of shallow ground water while performing excavations.*

Inhalation pathway exposures are not complete because no COCs in air were identified.

**Future Recreational Users**

Site 07 will become a conservation area with a limited potential for recreational development. The receptor population for recreational exposures consists of children between the ages of 2 and 18. Recreational users can reasonably be expected to come into contact with surface soils while playing or participating in games and sports on the site, so exposures to surface soil were evaluated in this investigation. Sediment located along the landfill-harbor interface may be contacted by recreational users when walking along the harbor or when swimming. Swimming in the Entrance Channel also presents an opportunity for exposure to surface water. Finally, if recreational facilities—such as changing rooms and showers for swimmers—are built on the site, showering would present an opportunity for exposure to COCs in ground water if the deep aquifer were used as the source of shower water.

Because the magnitude of potential exposures to environmental media changes with age, values for exposure parameters used to evaluate potential exposures for recreational users were age-weighted values derived from age-specific values obtained from EPA reference documents. In assessing potential future exposures at a recreational facility, best professional judgment was necessarily used to select values for some parameters regarding exposure frequency, duration and time. Recreational users were assumed to visit the site either 1 or 4 times per week during the 9 warmer months of the year, for a total exposure frequency of 36 or 144 days/year. Year-round exposures were not assumed because of the cold winters in New England. Recreational users were assumed to be exposed to marine sediment only when swimming, with the surfaces of the feet and hands coming into contact with sediment.

In order to estimate exposures resulting from inhalation of volatile contaminants while showering, EPA Region I utilizes a "dose-equivalent" approach in which the dose via inhalation is assumed to be equal to that received from ingesting 2 liters of water (EPA 1994c). Additional information on selected exposure parameters (e.g., sediment ingestion rate, exposure duration) for future recreational users is located in Table 6-18 and Tables M-6 through M-11 in Appendix M.

The receptor population for water-based recreational exposures consists of swimmers and waders, including both adults and children. Future water-based recreational adults and children were assumed to weigh 70 kg and 15 kg, respectively. The adult exposure duration was assumed to be 30 years for reasonable maximum exposure and 9 years for average

exposure. The child exposure duration was assumed to be 4 years (ages 2 to 6) for reasonable maximum exposure and 2 years for average exposure.

In assessing potential future exposures at a recreational facility, best professional judgment was used to select values for some parameters regarding exposure frequency, duration and time. For exposures related to swimming, the receptors were assumed to swim one or three times per week during the three summer months only, for a total exposure frequency of 13 or 39 days/year. All exposure pathways for recreational users were assumed to be associated with swimming or wading. Whole body surface area data were used in estimating dermal exposure to COPC in surface water while swimming (Adults: 20,000 $cm^2$ for AE and 23,000 $cm^2$ for RME; Children: 8,660 $cm^2$ for AE and 10,660 $cm^2$ for RME). Incidental ingestion of surface water for both children and adults was assumed to be 25 mL/hour for average exposure and 50 mL/hour for reasonable maximum exposure. Additional information on selected values for exposure parameters for future water-based recreational users is located in Table 6-18 and Tables M-12 through M-15 in Appendix M.

Based on the above analysis, the following six exposure pathways were identified as being complete for future recreational users of Site 07 and the adjacent offshore media (sediment and surface water in the adjacent Allen Harbor and Entrance Channel):

- *Incidental ingestion of surface soil;*
- *Dermal contact with surface soil;*
- *Incidental ingestion of sediment;*
- *Dermal contact with sediment;*
- *Dermal contact with deep and bedrock ground water while showering;*
- *Inhalation of volatiles from deep and bedrock ground water while showering;*
- *Incidental ingestion of surface water; and*
- *Dermal contact with surface water.*

**Consumers of Locally Caught Shellfish**

Site 07 will become a conservation and recreational area. Although currently prohibited, it is possible that local residents will come to fish for shellfish in areas that have been impacted by contaminants in Allen Harbor. The receptor population for consumption of locally caught shellfish includes local resident adults and children. Because the likelihood and magnitude of potential exposures to environmental media changes with age, values for body weight used in this investigation were age-weighted values derived from default values—15 kg for children under age 6 and 70 kg for adults—obtained from EPA Region I reference documents (EPA 1994a).

Values for exposure parameters associated with shellfish ingestion rate, exposure frequency and duration were obtained from EPA Region I guidance (EPA 1994a). In the absence of relevant site-specific data, for the purposes of this assessment, it was conservatively assumed that local residents would catch and consume only shellfish obtained from Allen Harbor.

Additional information on selected values for exposure parameters for consumers of locally caught shellfish is located in Table 6-18 and Table M-16 in Appendix M.

**Hypothetical Future Residents**

The Base Reuse Plan for NCBC Davisville Site 07 does not include residential development. Nevertheless, potential exposure to hypothetical residents consuming onsite ground water as a source of drinking water was evaluated as a conservatively prudent measure. Exposure parameters used for this pathway were default assumptions for residential consumption of drinking water. Additional information on selected values for exposure parameters for hypothetical residential consumption of ground water is located in Table 6-18 and Table M-17 in Appendix M.

### 6.4.3 Estimating Exposure Point Concentrations

To assess human health risks, the concentration levels of the COCs in each medium were determined. Sampling data for onsite media (soil and ground water) and offshore media (surface water, sediment, and shellfish) were evaluated for use in this HHRA. The methods used to estimate exposure point concentrations for each of these media are described below.

In calculating exposure point concentrations, a value of one-half the detection limit was used for samples in which analytes were reported as being below the sample quantitation limit (SQL) (i.e., a nondetect). For a given chemical, any single sample which had an unusually high SQL was examined for its impact on the representative exposure point concentration in accordance with guidance (EPA 1989a). If the use of the high nondetect value caused the estimated exposure point concentration to exceed the maximum detected value, this high nondetect was eliminated from the analysis. For purposes of reporting the data in a summary format, the frequency of detection (i.e., the number of detected values versus the total number of samples) was not altered when a high nondetect value was removed for statistical purposes. However, the detection limits reported in the summary tables represent only the detection limits for the samples retained for actual calculation of exposure point concentrations.

#### 6.4.3.1 Soil Exposure Point Concentrations

Both surface (0–2 ft) and subsurface (2–10 ft) soil samples were collected at NCBC Site 07 and analyzed. For the purposes of this HHRA, all 38 soil samples collected at depths up to 10 ft during previous Phases of this RI were combined and defined as "total soil." This aggregation was performed because, as described above, the construction workers are likely to come into contact with both surface and subsurface soils while excavating on the site. Recreational users were assumed to come into contact with surface soil only.

Reported data concentrations were used to determine the 95th percentile upper confidence limit on the mean (95 UCLM) for COCs in total soil, according to the methodology given in EPA (1992b). Following EPA (1992b, 1994a) guidance, exposure point concentrations in soil were

estimated as the 95 UCLM for purposes of estimating both average and reasonable maximum exposures. In cases where the 95 UCLM exceeded the maximum detected concentration, the mean concentration was used to estimate average exposures and the maximum detected concentration was used to estimate reasonable maximum exposures.

For COCs in soil, 95 UCLMs were estimated using the equation given below, which assumes a lognormal distribution of the environmental data (EPA 1992b). The first step in this process is transforming the data by taking the natural logarithm of the data set. Next, the following equation was used with the transformed data set:

$$95\ UCLM = e^{(\bar{x} + 0.5s^2 + sH/\sqrt{n-1})}$$

where

| | | |
|---|---|---|
| *95 UCLM* | = | 95th percentile upper confidence limit on the mean |
| $e$ | = | Constant (base of the natural logarithm; equal to 2.718) |
| $\bar{x}$ | = | Mean of the transformed data |
| $s$ | = | Standard deviation of the transformed data |
| $H$ | = | H-Statistic |
| $n$ | = | Number of samples in the data set. |

Estimated exposure point concentrations for COCs in total soil (i.e., both surface and subsurface soil) and surface soil are listed in Tables 6-19 and 6-20. The same exposure point concentrations were used for both average and reasonable maximum exposure estimates for soils because the 95 UCLM did not exceed the maximum detected value for the COCs.

#### 6.4.3.2 Sediment Exposure Point Concentrations

Estimated exposure point concentrations of contaminants in sediment (offshore media in the adjacent Allen Harbor and Entrance Channel) were calculated as the average and maximum detected concentrations. This approach, rather than use of the 95 UCLM, was dictated by EPA Region I policy (EPA 1992b) because fewer than 10 samples were available. Estimated exposure point concentrations for COCs in sediment are summarized in Table 6-21.

#### 6.4.3.3 Ground Water Exposure Point Concentrations

To estimate reasonable maximum exposures to contaminants in ground water, EPA Region I guidance (EPA 1994a) requires use of the maximum detected concentration of each COC. If more than one round of sampling data are available from individual wells, then the reported data from these separate rounds are averaged. The highest concentration—whether it was a single detect from a well sampled only once or an average across multiple rounds in a single well—was used to estimate the reasonable maximum exposure. At Site 07, two samples were

taken in Shallow Ground Water Wells 2, 3, 4, 5, 6, 7, 8, and two samples were taken in Deep Ground Water Wells 3, 5, 9, 10, 11, 12, 13. Thus, in these wells, the reported concentrations from all rounds of sampling were averaged and compared with the single detects from the other wells in order to determine the maximum concentration for use in estimating the RME. For estimation of average exposures, EPA Region I guidance requires use of the average plume concentration for each COC.

For each COC in ground water, nondetect results were eliminated from the analysis if the use of the high nondetect value caused the average to exceed the maximum detected value. For purposes of reporting the data in a summary format, the frequency of detection (i.e., the number of detected values versus the total number of samples) was not altered when a high nondetect value was removed for statistical purposes. However, the detection limits reported in the summary tables represent only the detection limits for the samples retained for actual calculation of average concentrations. Estimated exposure point concentrations for COCs in shallow, deep and bedrock ground water are included in Tables 6-22, 6-23a and 6-23b, respectively.

### 6.4.3.4 Surface Water Exposure Point Concentrations

Two different sets of exposure point concentrations in surface water (offshore media) were used. Under the first scenario, the predicted surface water concentrations at the Entrance Channel for the four VOCs based upon the measurements taken at the shallow ground water Well 21S were assumed to be the exposure point concentrations. The modeling as explained in Section 5.8.4 resulted in the following estimated surface water concentrations in the Entrance Channel resulting from site shallow ground-water transport : 1,1,2,2- Tetrachloroethane: 0.5 $\mu$g/L; 1,1,2-Trichloroethane: 0.1 $\mu$g/L; 1,2-Dichloroethene: 0.9 $\mu$g/L; and Trichloroethene: 1.0 $\mu$g/L.

Under the second scenario, the detected concentrations in one sample taken from the Well 21S were conservatively assumed to be the exposure point concentrations in the surface water. This sample was taken at 12.5-14.25 ft below the surface water and 15 ft below the ground surface. The following concentrations detected in the shallow ground water at Well 21S were used as the exposure point concentrations in the surface water of the Entrance Channel: 1,1,2,2-Tetrachloroethane: 310 $\mu$g/L; 1,1,2-Trichloroethane: 41 $\mu$g/L; 1,2-Dichloroethene: 540 $\mu$g/L; and Trichloroethene: 590 $\mu$g/L.

### 6.4.3.5 Shellfish Exposure Point Concentrations

Exposure point concentrations in shellfish (offshore media in the adjacent Allen Harbor and Entrance Channel) were calculated in sediment, as the average and maximum detected concentration (refer to Section 6.4.3.2 above) because fewer than 10 samples were available. Estimated exposure point concentrations for COCs in shellfish are summarized in Table 6-24.

### 6.4.4 Estimating Intakes for Contaminants of Concern at Site 07

The last step in the exposure assessment was the estimation of intake and resulting dose for each of the pathways considered in the assessment. The extent of potential intake received through the various pathways is dependent on an individual's location and behavior. It is not possible to predict accurately the level of exposure for specific individuals due to uncertainty in future activity patterns and incomplete knowledge of certain exposure variables (e.g., frequency of visiting the recreational area). Therefore, it was necessary to make a series of prudent simplifying assumptions about potential exposure that are believed to yield a conservatively high estimate of potential human exposures.

In an exposure assessment, it is generally necessary to provide at least two different measures of intake, depending on the nature of the effect being evaluated. When evaluating longer-term (i.e., subchronic and chronic) exposures to noncarcinogenic chemicals, intakes are averaged over the period of exposure (i.e., the averaging time, AT) (EPA 1989a). This measure of intake is referred to as the average daily intake (ADI). For carcinogens, intakes are averaged over an entire lifetime and are referred to as the chronic daily intake (CDI) (EPA 1989a).

The generic equation to calculate intakes is given below:

$$(C)ADI = \frac{C \times IF \times EF \times ED \times RAF}{BW \times AT}$$

where

| | | |
|---|---|---|
| *(C)ADI* | = | (chronic daily intake or average daily intake (mg/kg-day) |
| *C* | = | Concentration in a specific medium (mg/L or mg/kg) |
| *IF* | = | Intake factor[6] |
| *EF* | = | Exposure frequency (days/year) |
| *ED* | = | Exposure duration (years) |
| *RAF* | = | Relative absorption factor (unitless) |
| *BW* | = | Body weight (kg) |
| *AT* | = | Averaging time (days). |

Table 6-18 summarizes the values assumed for all exposure parameters and the rationale supporting the selection of each value. The exposure parameters and equations utilized to estimate the intakes of COCs in the various media corresponding to all exposure scenarios and

[6] The intake factor is the product of all intake variables that, when multiplied by the concentration of the chemical of potential concern in a specific medium, results in an estimate of the chemical intake in mg/kg-day for that population and exposure pathway. Intake factors may include ingestion rate, inhalation rate, body surface area exposed to soil or water, dermal permeability constants, and soil adherence factors.

pathways developed for Site 07 are presented in detail in Tables M-1 through M-17 in Appendix M.

The adult populations modeled in this assessment are typically represented by using default values for the average male adult for purposes of exposure assessment (EPA 1994a, 1990, 1989a). For children, age-weighted average values for several exposure parameters were derived from age-specific tabulated data taking into account the change in the ratio of the rate of contact with the contaminated medium and body weight. These parameters included body weight, exposed skin surface area, and soil ingestion rate.

Based on EPA guidance (EPA 1992b), the appropriate exposure parameters to use in estimating doses depend on the number of samples taken in the medium. For media in which more than 10 samples were taken, the estimated exposure point concentration (e.g., the 95 UCLM) is combined with average and reasonable maximum values for exposure parameters to obtain two estimates of intake.[7] For media in which fewer than 10 samples were taken, the average and maximum concentrations for each COC are combined with average values for exposure parameters to obtain two estimates of intake, respectively.

Table 6-25 illustrates how the above guidance was applied in calculating doses and intakes of COCs at Site 07. In media where some COCs were analyzed in fewer than 10 samples and some in more, the entire COC list was treated as dictated by the majority. Estimated intakes for all COCs via all pathways and scenarios are summarized in Tables 6-26 to 6-37.

### 6.4.5 Exposures to Lead

Since the health effects from exposure to lead were not quantified in this assessment, but instead were evaluated qualitatively, intakes of lead were not estimated. Rather, the range and representative concentrations of lead in soil were compared to the EPA screening level of 400 mg/kg for lead in residential soils (EPA 1994d) and the Rhode Island Department of Health (RIDoH) screening level for "lead-free" soil of 150 mg/kg (RIDoH 1994).

## 6.5 CHARACTERIZATION OF THE NATURE AND MAGNITUDE OF HUMAN HEALTH RISKS AT NCBC DAVISVILLE SITE 07 AND ADJACENT Offshore MEDIA

Risk characterization is the final step of the HHRA process. In this step, the toxicity values from Section 6.3 were combined with the estimated chemical intakes for the populations described in Section 6.4 to quantitatively estimate both carcinogenic risks and health risks other than cancer. Risks were estimated for the following four receptor populations:

[7] An exception to this is when the 95 UCLM exceeds the maximum, in which case the average COC concentration is combined with average values for exposure parameters and the maximum concentration is combined with reasonable maximum values for exposure parameters.

- *Future remediation/construction workers*
- *Future recreational users*
- *Consumers of locally caught shellfish*
- *Hypothetical future residents*

The methodologies used to estimate cancer risks and chronic and subchronic risks for health effects other than cancer are described further in the sections below.

### 6.5.1 Methodology for Quantitative Risk Estimation

#### 6.5.1.1 Hazard Index for Noncarcinogenic Effects

The likelihood that health effects other than cancer are associated with exposures to COCs at Site 07 and in adjacent offshore media was estimated by comparing average daily intakes (ADIs) with established RfDs. Chronic RfDs were used for exposure durations greater than 7 years (i.e., for future recreational users, consumers of locally caught shellfish, and hypothetical future residents); subchronic RfDs were used for exposure durations fewer than 7 years (i.e., for future remediation/ construction workers) (EPA 1989a). The resulting ratio, known as a hazard quotient (HQ), was derived as shown in the equation below:

$$HQ = \frac{ADI}{RfD}$$

where

| | | |
|---|---|---|
| *HQ* | = | Hazard Quotient; ratio of average daily intake level to acceptable daily intake level (unitless) |
| *ADI* | = | Estimated average daily intake (mg/kg-day) |
| *RfD* | = | Reference concentration (mg/kg-day) |

If the average daily dose exceeds the RfD, the HQ will exceed one and there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above one, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur. HQs are scaling factors rather than direct estimates of risk (EPA 1989a).

For consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual HQs are summed to provide an overall Hazard Index (HI). If the HI is found to be less than 1.0, then no adverse health effects are likely to be associated with exposures at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on toxic endpoint of concern (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). Only if an endpoint-specific HI is greater than 1.0 is there reason for concern about potential health effects for that endpoint.

#### 6.5.1.2 Risk for Carcinogenic Effects

Carcinogenic risk was estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. The numerical estimate of excess lifetime cancer risk was calculated by multiplying the lifetime average daily dose by the risk per unit dose (the slope factor), as shown in the following equation:

$$Risk = CDI \times SF$$

where

| | | |
|---|---|---|
| *Risk* | = | The unitless probability of an exposed individual developing cancer |
| *CDI* | = | Chronic daily intake (mg/kg-day) |
| *SF* | = | Cancer slope factor $(mg/kg\text{-}day)^{-1}$. |

Because the SF is the statistical 95th percent upper-bound confidence limit on the dose-response slope, this method provides a conservatively high upper-bound estimate of risk. The actual risk may be lower (40 CFR Part 300).

Cancer risks were estimated for future remediation/construction workers, future recreational users, shellfish consumers, and hypothetical future residents consuming ground water. The interpretation of the significance of the cancer risk estimate is based on the appropriate public policy. EPA, in the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300), states that:

> *... For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between $10^{-4}$ and $10^{-6}$.*

### 6.5.2 Risk Characterization

#### 6.5.2.1 Future Remediation/Construction Workers

Subchronic risks for cancer and health effects other than cancer were estimated for future remediation/construction workers. Risks were calculated for COCs when exposure pathways were assumed to be complete, as described in Section 6.4.

Estimated HIs for health effects other than cancer among remediation/construction workers at Site 07 are summarized by exposure pathway and COC under average and reasonable maximum exposure conditions in Tables 6-38 and 6-39, respectively. Estimated total HIs for remediation/construction workers were $5 \times 10^{-3}$ and $4 \times 10^{-2}$ under average and reasonable maximum exposure conditions, respectively. These HI values are less than 1.0; therefore, it is

expected that no adverse systemic health effects would be associated with exposures to COCs under the conditions specified in the remediation/construction exposure scenario.

Estimated cancer risks for remediation/construction workers are summarized by exposure pathway and COC for average and reasonable maximum exposures in Tables 6-40 and 6-41, respectively. Estimated total cancer risks for future remediation/construction workers at Site 07 were estimated to be $5.8 \times 10^{-8}$ and $1.1 \times 10^{-7}$, under average and reasonable maximum exposure conditions, respectively. The estimated carcinogenic risks for average and reasonable maximum exposure conditions are less than EPA's point-of-departure value of one in one million.

### 6.5.2.2 Future Recreational Users

Chronic risks for cancer and health effects other than cancer were estimated for future recreational users. Exposures and resulting risks were calculated for pathways assumed to be complete, as described in Section 6.4. In the calculation of risks via surface water exposure pathways, the scenario which resulted in more conservative estimates by using measured VOCs concentrations in shallow ground water at Well 21S as exposure point concentrations is included in the following discussions regarding to risks posed by surface water exposure pathways.

Estimated HIs for health effects other than cancer via all exposure pathways except exposures via surface water are summarized by exposure pathway and COC for average and reasonable maximum exposure conditions in Tables 6-42 and 6-43. The estimated HQs for health effects other than cancer via the Entrance Channel surface water exposure pathways are summarized in Tables N-1 and N-2 in Appendix N. Estimated total HIs for recreational users at Site 07 were 10 and 216 under average and reasonable maximum exposure conditions, respectively. Under average exposure conditions, inhalation of volatiles from deep and bedrock ground water accounted for the greatest portion of the risk and was associated with an HI of 5 and 4, respectively. Trichloroethene (HQ = 5 for deep ground-water inhalation; HQ = 4 for bedrock ground-water inhalation) contributed most significantly to the HI for inhalation of volatiles during showering. HQs for all other COCs were less than 0.2 in the case of deep ground-water inhalation exposures and less than 0.3 in the case of bedrock inhalation exposures. Because the total HI is greater than 1.0, the COCs were separated according to their specific target organ toxicity and organ-specific HIs were calculated. The critical effect for chloroform, 1,1,2-trichloroethane, tetrachloroethene, 1,1-dichloroethene, and 1,2-dichloroethene is the liver. Thus, target-organ HIs for these COCs are below 1.0, indicating that adverse health effects in the liver are not likely to be observed in exposed populations under average exposure conditions. The critical effect for trichloroethene is renal effects. Thus, the HI for the renal effects is greater than 1.0, indicating that adverse health effects may be observed in exposed populations under average exposure conditions.

Under reasonable maximum exposure conditions, inhalation of volatiles from deep and bedrock ground water accounted for the greatest portion of the risk and was associated with an HI of ,

161 and 36, respectively. In addition, dermal contact with deep and bedrock ground water was associated with an HI of 15 and 3, respectively. As documented, the estimated HIs for reasonable maximum exposure are considerably greater than 1.0. Trichloroethene (HQ = 146 for deep ground-water inhalation; HQ = 33 for bedrock ground-water inhalation) contributed most significantly to the HI for inhalation of volatiles during showering. Trichloroethene was also responsible for (HQ = 14 for dermal contact with deep ground water; HQ = 3 for dermal contact with bedrock ground water) most of the risk associated with dermal contact exposures. Because the total HI is greater than 1.0, the COCs were separated according to their specific target organ toxicity and organ-specific HIs were calculated. The critical effect for chloroform (HQ = 2 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), 1,1,2-trichloroethane (HQ = 5 and 0.7 for inhalation of volatiles from deep and bedrock ground water, respectively), tetrachloroethene (HQ = 2 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), 1,1-dichloroethene (HQ = 2.0 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), and 1,2-dichloroethene (HQ = 5 and 2 for inhalation of volatiles from deep and bedrock ground water, respectively) is the liver. Thus, the HI for the liver is greater than 1.0 in both cases, indicating that adverse health effects may be observed in exposed populations under reasonable maximum exposure conditions. The critical effect for trichloroethene is renal effects. The HI for the renal effects is also greater than 1.0, indicating that adverse health effects may be observed in exposed populations under reasonable maximum exposure conditions.

Estimated cancer risks for recreational users at Site 07 are summarized by exposure pathway and COC for average and reasonable maximum exposures in Tables 6-44 and 6-45. The estimated cancer risks via the Entrance Channel surface water exposure pathways are summarized by exposure pathway and COC for average and reasonable maximum exposures in Tables N-3 and N-4 in Appendix N. For future recreational users of the Entrance Channel, exposure pathway-specific HIs for incidental ingestion of and dermal contact with surface water are all less than one for adults and children, indicating that no adverse effects are likely to be expected due to exposure to COCs in surface water.

Total estimated cancer risks for future recreational users at Site 07 were estimated to be $2.0 \times 10^{-3}$ and $3.7 \times 10^{-2}$ under average and reasonable maximum exposure conditions, respectively. These estimated carcinogenic risks are greater than $10^{-4}$.

For both average and RME cases, dermal contact with deep and bedrock ground water and inhalation of volatiles from deep and bedrock ground water while showering contributed most significantly to the overall risk. For the average exposure, the COC associated with the greatest cancer risk was due to 1,1,2,2-tetrachloroethane and trichloroethene exposure via dermal contact with deep ground water while showering ($7.2 \times 10^{-5}$ and $4.8 \times 10^{-6}$) and from inhalation of volatiles from deep ground water while showering ($1.3 \times 10^{-3}$ and $3.9 \times 10^{-5}$). For bedrock ground-water exposures, the COC associated with the greatest cancer risk was also due to 1,1,2,2-tetrachloroethane and trichloroethene exposures via dermal contact with bedrock ground water while showering ($2.1 \times 10^{-5}$ and $3.7 \times 10^{-6}$) and from inhalation of volatiles from bedrock ground water while showering ($4 \times 10^{-4}$ and $3 \times 10^{-5}$).

For the reasonable maximum exposure, the COC associated with the greatest cancer risk was due to 1,1,2,2-tetrachloroethane, trichloroethene, and vinyl chloride exposures via dermal contact with deep ground water while showering ($1.7 \times 10^{-3}$, $1.8 \times 10^{-4}$, $2.1 \times 10^{-4}$) and from inhalation of volatiles from deep ground water while showering ($2.6 \times 10^{-2}$, $1.2 \times 10^{-3}$, $1.3 \times 10^{-3}$). For bedrock ground-water exposures, the COC associated with the greatest cancer risk was also due to 1,1,2,2- tetrachloroethane, trichloroethene, and vinyl chloride exposures via dermal contact with bedrock ground water while showering ($2.7 \times 10^{-4}$, $4.1 \times 10^{-5}$, and $2.1 \times 10^{-5}$) and from inhalation of volatiles from bedrock ground water while showering ($4.1 \times 10^{-3}$, $2.7 \times 10^{-4}$, and $1.3 \times 10^{-4}$).

For future recreational users of the Entrance Channel, total estimated cancer risks via dermal contact with surface water ranged from $1.6 \times 10^{-6}$ (average) to $2.6 \times 10^{-5}$ (RME) for adults and from $7.2 \times 10^{-7}$ (average) to $7.5 \times 10^{-6}$ (RME) for children. Incidental ingestion of surface water also contributed insignificantly to the total risk under the reasonable maximum exposure scenarios ($2.3 \times 10^{-6}$ for adults; $1.4 \times 10^{-6}$ for children). Exposure to 1,1,2,2-tetrachloroethane via dermal contact with surface water and ingestion of surface water contributed most significantly to overall cancer risk.

The cancer risks associated with incidental ingestion of surface soil were estimated to be $8 \times 10^{-8}$ and $7 \times 10^{-7}$ under average and reasonable maximum exposure conditions, respectively. For the average and reasonable maximum exposure, COC in soil associated with the total risk was arsenic.

The cancer risk associated with incidental ingestion of sediment (offshore media in the adjacent Allen Harbor and Entrance Channel) under average and reasonable maximum exposure conditions was $1 \times 10^{-7}$ and $2 \times 10^{-6}$, respectively, with arsenic as the only contributor to the total risk.

#### 6.5.2.3 Shellfish Consumers

Estimated HIs for health effects other than cancer among consumers of locally caught shellfish from the adjacent Allen Harbor and Entrance Channel (offshore media) are summarized by COC for average and reasonable maximum exposures in Table 6-46. Estimated total HIs for consumers of locally-caught shellfish at Site 07 were 7 and 176 under average and reasonable maximum exposure assumptions. The estimated HIs for average and reasonable maximum exposure consumers of shellfish are considerably greater than 1.0. Under average exposure conditions, adverse health effects could be associated with exposure to mercury (HQ = 6). Under RME conditions, adverse health effects could be associated with exposures to mercury (HQ = 147), zinc (HQ = 14), arsenic (HQ = 7), copper (HQ = 3), cadmium (HQ = 2), Aroclor-1254 (HQ = 2), and Aroclor-1260 (HQ = 1). Because the HQs for these COCs are each greater than 1.0 under the reasonable maximum scenario, it is possible that adverse health effects in several target organs will be observed in exposed populations. The COC/target organ pairs are as follows: mercury/kidney, zinc/blood, arsenic/skin, copper/GI tract and

CNS effects for susceptible people who have Wilson's disease, cadmium/kidney, and PCB/liver.

Estimated cancer risks for consumers of shellfish are summarized by COC for average and reasonable maximum exposures in Table 6-47. Estimated cancer risks for consumers of locally caught shellfish adjacent to Site 07 were estimated to be $2.4 \times 10^{-5}$ and $2 \times 10^{-3}$, under average and reasonable maximum exposure conditions, respectively. For the average exposure scenario, arsenic ($2 \times 10^{-5}$) and PCB ($4 \times 10^{-6}$) contributed most significantly to the overall cancer risk. For the reasonable maximum exposure scenario, arsenic ($2 \times 10^{-3}$), PCB ($3 \times 10^{-4}$), benzo(a)pyrene ($2 \times 10^{-5}$), benzofluoranthene ($1 \times 10^{-5}$), and dibenzo(a,h)anthracene ($4 \times 10^{-6}$) contributed most significantly to the overall risk. Because arsenic is responsible for the overall cancer risk and PCB contribution is insignificant, estimation of PCB risks using the proposed upper-end slope factor of 2 per mg/kg-day did not change the cancer risk results (see Table 6-47).

### 6.5.2.4 Hypothetical Future Residents

Estimated HIs for health effects other than cancer among hypothetical residents consuming ground water at Site 07 under average and reasonable maximum exposure conditions are summarized in Table 6-48. Estimated total HIs for hypothetical residential consumers of deep ground water at Site 07 were 58 and 615 under average and reasonable maximum exposure assumptions, respectively. Estimated total HIs for hypothetical residential consumers of bedrock ground water at Site 07 were 47 and 155 under average and reasonable maximum exposure assumptions, respectively. These HI values are significantly greater than 1.0. Therefore, it is anticipated that adverse effects could be associated with exposures to COCs under the conditions specified in the hypothetical residential exposure scenario. For the average exposure conditions, the COCs contributing most significantly to the HI were trichloroethene (HQ = 50 and 38 for deep and bedrock ground water, respectively), 1,2-dichloroethene (HQ = 2 and 3 for deep and bedrock ground water, respectively), manganese (HQ = 1 and 3 for deep and bedrock ground water), tetrachloroethene (HQ = 1 for deep ground water) and 1,1,2-trichloroethane (HQ = 1 and 2 for deep and bedrock ground water, respectively). For the reasonable maximum exposure conditions, the COCs contributing most significantly to the HI were trichloroethene (HQ = 548 and 123 for deep and bedrock ground water, respectively), 1,2-dichloroethene (HQ = 17 and 7 for deep and bedrock ground water), respectively), and 1,1,2-trichloroethane (HQ = 17 and 3 for deep and bedrock ground water, respectively). 1,1-Dichloroethene (HQ = 8 for deep ground water), tetrachloroethene (HQ = 7 for deep ground water), chloroform (HQ = 7 for deep ground water), manganese (HQ = 4 and 19 for deep and bedrock ground water, respectively), arsenic (HQ = 3 for deep ground water), aluminum (HQ = 4 for deep ground water), and thallium (HQ = 1 for deep ground water) also had an HQ above 1 for hypothetical future residents consuming deep ground water under reasonable maximum exposures. Therefore, it is possible that adverse health effects in several target organs will be observed in exposed populations. The COC/target organ pairs are as follows: 1,2-dichloroethene/liver, 1,1-dichloroethene/liver, tetrachloroethene/liver, chloroform/liver, 1,1,2-trichloroethane/liver, trichloroethene/kidney,

arsenic/skin neoplasms, aluminum/GI tract, manganese/CNS effects, and thallium/increased SGOT.

Estimated cancer risks for hypothetical residents consuming ground water under average and reasonable maximum exposures are summarized by COC in Table 6-49. Estimated total cancer risks for hypothetical residents consuming deep ground water as drinking water at Site 07 were estimated to be $8.6 \times 10^{-3}$ and $2.8 \times 10^{-1}$, under average and reasonable maximum exposure conditions, respectively. Estimated total cancer risks for hypothetical residents consuming bedrock ground water as drinking water at Site 07 were estimated to be $2.8 \times 10^{-3}$ and $4.0 \times 10^{-2}$, under average and reasonable maximum exposure conditions, respectively. These estimated carcinogenic risks are greater than $10^{-4}$. For the average deep ground-water exposure scenario, 1,1,2,2-tetrachloroethane ($7.8 \times 10^{-3}$), trichloroethene ($4.2 \times 10^{-4}$), tetrachloroethene ($7.5 \times 10^{-5}$), vinyl chloride ($7 \times 10^{-5}$), arsenic ($5.5 \times 10^{-5}$), beryllium ($3.1 \times 10^{-5}$), 1,1,2-trichloroethane ($3 \times 10^{-5}$), 1,1-dichloroethene ($2.4 \times 10^{-5}$), and 1,2-dichloroethane ($1.4 \times 10^{-5}$) contributed most significantly to the overall cancer risk. For the average bedrock ground-water exposure scenario, 1,1,2,2-tetrachloroethane ($2.3 \times 10^{-3}$), trichloroethene ($3.2 \times 10^{-4}$), vinyl chloride ($8 \times 10^{-5}$), 1,1,2-trichloroethane ($5.5 \times 10^{-5}$), 1,1-dichloroethene ($3.1 \times 10^{-5}$), and arsenic ($1.6 \times 10^{-5}$), contributed most significantly to the overall cancer risk.

For the reasonable maximum deep ground-water exposure scenario, 1,1,2,2-tetrachloroethane ($1.8 \times 10^{-1}$), vinyl chloride ($5.6 \times 10^{-2}$), 1,1-dichloroethene ($1.8 \times 10^{-2}$), trichloroethene ($1.5 \times 10^{-2}$), 1,2-dichloroethane ($2.7 \times 10^{-3}$), 1,1,2-trichloroethane ($1.7 \times 10^{-3}$), tetrachloroethene ($1.5 \times 10^{-3}$), benzene ($8.5 \times 10^{-4}$), arsenic ($5.7 \times 10^{-4}$), beryllium ($3.2 \times 10^{-4}$), and chloroform ($1.8 \times 10^{-4}$) contributed most significantly to the overall cancer risk. For the reasonable maximum bedrock ground-water exposure scenario, 1,1,2,2-tetrachloroethane ($2.8 \times 10^{-2}$), vinyl chloride ($5.6 \times 10^{-3}$), trichloroethene ($3.5 \times 10^{-3}$), 1,1-dichloroethene ($1.8 \times 10^{-3}$), 1,2-dichloroethane ($2.7 \times 10^{-4}$), 1,1,2-trichloroethane ($2.6 \times 10^{-4}$), tetrachloroethene ($1.5 \times 10^{-5}$), arsenic ($8.9 \times 10^{-5}$), and chloroform ($1.8 \times 10^{-5}$) contributed most significantly to the overall cancer risk.

#### 6.5.2.5 Risks Associated with Lead

According to the most recent EPA OSWER Directive #9355.4-12 (EPA 1994d), the EPA recommends a screening level for lead in soil for residential land use of 400 ppm. EPA has stated in the Directive that this is not a cleanup goal, but rather a tool which should be used to determine which sites or portions of sites require further study and to encourage voluntary cleanup. The Directive states that "[l]evels of contamination above the screening level would NOT automatically require a removal action, nor designate a site as 'contaminated'." The Rhode Island Department of Health considers soil to be "lead-free" for a residential scenario when the lead concentration is below 150 ppm (RIDoH 1994). Soil containing from 150 to 500 ppm lead is considered "lead-safe," and soil containing from 500 to 1,000 ppm lead is considered "lead-safe" if there is no exposed bare surface soil and only provided that the Environmental Lead Management Plan is fully implemented. Lead concentrations in soil

above 1,000 ppm are considered unacceptable and require lead hazard reduction in accordance with Rhode Island regulations (RIDoH 1994).

Lead was detected in all 26 soil samples collected at Site 07 for which lead data are reported at concentrations ranging from 1.5 to 8.6 mg/kg. The mean lead concentration in soil was 3.7 mg/kg, and the 95 UCLM concentration was 4.5 mg/kg. Thus, all detected concentrations of lead at Site 07 are significantly below the level at which RIDoH considers soil to be "lead-free." Consideration of the lead data as a whole leads to the conclusion that exposures and risks are not likely be above unacceptable levels.

#### 6.5.2.6 Risks Associated with Butyltin

Toxicity of butyltin compounds is summarized in Section 6.2.2. In a study, pregnant rats were given di-n-butyltin dichloride (DBT) by gastric intubation at a dose of 0, 2.5, 5.0, 7.5 or 10.0 mg/kg on days 7-15 of pregnancy. Maternal toxicity occurred in the 7.5 and 10.0 mg/kg groups as evidenced by a significant increase in maternal death and decrease in food consumption and body weight gain. The incidence of fetuses with malformations was roughly proportional to the dose of DBT, and was significantly increased in the 5.0, 7.5 and 10.0 mg/kg groups (Ema et al. 1991). Our literature search identified this study as the clinical study with the lowest dose at which an adverse effect was observed. The lowest adverse effect level, 5 mg/kg (i.e., 696 ng tin/g), was compared against highest concentration measured in shellfish, 298 ng tin/g. This analysis indicated that lowest adverse effect level was two-fold higher than highest concentration detected in shellfish tissue collected from Allen Harbor. If the same comparison made against the highest average concentration detected in shellfish tissue collected from Allen Harbor (i.e., 46.13 ng tin/g), a 14-fold increase would be obtained.

Because the concentrations of butyltin measured in shellfish are significantly lower than the lowest observed adverse effect level identified through a literature survey, it is unlikely that exposures and risks due to butyltin exposure via shellfish ingestion will be above acceptable levels. However, without any peer-reviewed toxicity information, potential health effects associated with exposure to butyltin in shellfish are difficult to predict.

### 6.5.3 Uncertainties and Limitations in Estimating Health Risks

The risk assessment process has been described in a systematic fashion, and EPA risk assessment guidance documents provide methods for organizing, analyzing, and presenting information on the nature and magnitude of risks to public health from potential exposure to chemicals (EPA 1988a, 1989a,b, 1992a, 1994a). In spite of advancements in this methodology, uncertainties and limitations are an intrinsic part of the HHRA process. While there are uncertainties in the assessment, whenever possible, EA has made choices that are likely to result in an overestimate of risk to provide greater assurance of public health protection.

In general, the uncertainties and limitations can be classified in the following categories:

- Sampling and analysis,
- Chemical fate and transport modeling,
- Toxicological assessment, and
- Exposure assessment.

#### 6.5.3.1 Sampling and Analysis Uncertainties

The first step in this risk assessment was to evaluate existing sampling and analysis data and identify data that were considered adequate for use in defining potential health risks. The 95th percentile upper confidence limit on the mean (95 UCLM) was used to represent contaminant concentrations in assessed media over the entire site. If areas of high concentrations were missed, then the 95 UCLM would not be representative of site-wide concentrations. In addition, if there were relatively few samples in a given medium, the 95 UCLM could be greater than the maximum detected value, requiring the use of the maximum contaminant concentration to represent concentrations over the entire site. Concentration estimates would not be representative of concentrations over the entire site to the extent that either of these instances impacted estimates of the 95 UCLM.

A further cause for uncertainty arises because samples from more than one contractor were combined for several of the media. If analytic or QA/QC procedures were different for the different contractors, then analytic data may not be directly comparable, which introduces an element of uncertainty when data are combined.

Finally, the lack of data for surface water precluded the assessment of exposures and risks for this environmental media. Had analytical data been available, it would have been possible to determine if any chemicals were present at levels of concern in surface water. Thus, potential risks to populations exposed to surface water (e.g., recreational users) may be underestimated. However, if the experience at the Allen Harbor Landfill can be assumed to be indicative of potential surface water exposures at Calf Pasture Point, we can surmise that exposures and risks associated with surface soil and ground water are much greater than those associated with surface water.

#### 6.5.3.2 Chemical Fate and Transport Modeling Uncertainties

Chemical fate and transport modeling was not performed in support of this HHRA.

#### 6.5.3.3 Toxicological Assessment Uncertainties

Available scientific information, in general, is insufficient to provide a thorough understanding of all potential toxic properties of chemicals to which humans are potentially exposed. It is necessary to infer these properties, using best professional judgment, by extrapolating them from data obtained under other conditions of exposure, and usually from experimental laboratory animals.

**Uncertainties Associated with COCs Lacking Toxicity Values**

In this HHRA, risks to benzotriazole, chlorinated benzotriazole, and lead could not be evaluated quantitatively because appropriate toxicity values were not available. Risks associated with exposures to lead are discussed qualitatively in Section 6.5.2.5. The available toxicological information on the other compounds is briefly summarized below. Because these compounds were not included in the quantitative HHRA, total cancer and noncancer health risks associated with exposures to COCs at Site 07 could be underestimated.

**Butyltin**—There are no data indicating that butyltin is carcinogenic. Data on noncancer effects show that developmental toxicity and teratogenic effects are the critical health effects. Of the onsite and offshore media evaluated, butyltin is a COC in shellfish only (an offshore media). Without any toxicity information, potential health effects associated with exposure to butyltin are difficult to predict. Therefore, total risks of cancer and noncancer health effects associated with consumption of shellfish at Site 07 may be underestimated.

**Benzotriazole**—There are no data indicating that benzotriazole, which can exist in two tautomeric forms, is carcinogenic. Data on noncancer effects are also lacking (HSDB 1995). Benzotriazole is a COC in shellfish only. Without any toxicity information, potential health effects associated with exposure to benzotriazole in shellfish are difficult to predict. Therefore, totals risks of cancer and noncancer health effects associated with consumption of shellfish at Site 07 may be underestimated.

**Chlorinated Benzotriazole**—There are no data indicating that chlorinated benzotriazole is carcinogenic. Data on noncancer effects are also lacking (HSDB 1995). Chlorinated benzotriazole is a COC in shellfish only. Without any toxicity information, potential health effects associated with exposure to chlorinated benzotriazole in shellfish are difficult to predict. Therefore, totals risks of cancer and noncancer health effects associated with consumption of shellfish at Site 07 may be underestimated.

**Uncertainties Associated with Noncarcinogenic Effects**

**Interspecies Extrapolation**—The majority of toxicological information comes from experiments with laboratory animals. Experimental animal data have been relied on by regulatory agencies to assess the hazards of human chemical exposure. Even though there has been some empirical observations, there may be interspecies differences in chemical absorption, metabolism, excretion, and toxic responses. There may also be uncertainties concerning the relevance of animal studies using exposure routes that differ from human exposure routes.

The EPA often bases RfDs and RfCs for noncarcinogenic effects on the most sensitive animal species, and uses uncertainty and modifying factors as adjustments for proper interpretation.

**Intraspecies Extrapolation**—There are differences among humans in individual susceptibility, such as to the effect of chemical exposure from differences in genetic factors (e.g., glucose-6-phosphate dehydrogenase deficiency), lifestyle factors (e.g., cigarette smoking and alcohol consumption), age, and hormonal status (e.g., pregnancy). To take into account the diversity of human populations and their differing susceptibilities to chemically-induced injury or disease, a safety factor is used. EPA uses a factor between 1 and 10. Where there is sufficient experience with a chemical in humans to suggest that no sensitive subpopulations are likely to exist, then a smaller safety factor is used.

**Exposure Routes**—When experimental data available on one route of administration are different from the actual route of exposure that is of interest, route-to-route extrapolation must be performed before the risk can be assessed. Several criteria must be satisfied before route-to-route extrapolation can be undertaken. The most important assumption is that a chemical injures the same organ(s) regardless of route, even though the injury can be to varying degrees. Another assumption is that the behavior of a substance in the body is similar by all routes of contact. This may not be the case where, for example, materials absorbed via the gastrointestinal tract pass through the liver prior to reaching the systemic circulation, whereas by inhalation the same chemical will reach other organs before the liver. For many chemicals, the liver eliminates or changes (beneficially or detrimentally) a sizable proportion of the chemical prior to its reaching the systemic circulation and other possible target organs.

**Chemical Mixtures**—Exposures of humans to chemicals generally are in the form of multiple-chemical exposures rather than single-chemical exposures. The approach to evaluating risks from exposure to mixtures of chemicals recommended by EPA (1989a) assumes additivity of risks and does not account for potential synergism, antagonism, or differences in target organ specificity and mechanism of action.

**Uncertainties Associated with Carcinogenic Effects**

**Interspecies Extrapolation**—The majority of toxicological information for carcinogenic assessments comes from experiments with laboratory animals. There is uncertainty about whether animal carcinogens are also carcinogenic in humans. While many chemical substances are carcinogenic in one or more animal species, only a very small number of chemical substances are known to be human carcinogens. The fact that some chemicals are carcinogenic in some animal species but not in others (or in humans) raises the possibility that not all animal carcinogens are human carcinogens. Regulatory agencies assume that humans are as sensitive to carcinogens as the most sensitive animal species. This policy decision, designed to prevent underestimation of risk, introduces the potential to overestimate carcinogenic risk.

**High-Dose to Low-Dose Extrapolation**—Typical cancer bioassays provide limited low-dose data on responses in experimental animals for chemicals being assessed for carcinogenic or chronic effects. The usual dose regime involves three dose groups per assay. The first dose group is given the highest dose that can be tolerated, the second is exposed to one-half that dose, and the third group is unexposed (control group) (NRC 1983). Because this dosing

method does not reflect how animals would react to much lower doses of a chemical, a dose-response assessment normally requires extrapolation from high to low doses using mathematical modeling that incorporates to varying degrees information about physiologic processes in the body (NRC 1983).

A central problem with the low-dose extrapolation models is that they all too often fit the data from animal bioassays equally well, and it is not possible to determine their validity based on goodness of fit. Each model may fit experimental data equally well, but they are not all equally plausible biologically. The dose-response curves derived from different models diverge substantially in the dose range of interest (NRC 1983). Therefore, low-dose extrapolation is more than a curve-fitting process, and considerations of biological plausibility of the models must be taken into account before choosing the best model for a particular set of data.

**Use of the Linearized Multi-Stage Model**—The preferred EPA cancer risk model, used to calculate a slope factor, is a mechanistic type,[8] known as the "linearized multistage model." The key tenet of this model is the assumption that the production of a malignant cell is a multi-step process. Furthermore, it assumes that, at low doses, the risk of cancer is directly proportional to the dose of the carcinogen. This model was chosen by EPA in 1986, because its theoretical basis most closely approximated then-current thought on the mechanisms of cancer induction (EPA 1986).

EPA acknowledges that the actual slope factor is likely to be between zero and the estimate from the model. However, the lack of knowledge regarding the validity and accuracy of this model contributes to the uncertainties and potential overestimates of cancer risks.

### 6.5.3.4 Exposure Assessment Uncertainties

HHRAs typically require assumptions in order to assess potential human exposure because site-specific measurements are usually lacking. This risk assessment includes assumptions about general characteristics and potential patterns of human exposure of people at the Site 07 (onsite media) and to selected adjacent offshore media were based on guidance provided by EPA (1989a, 1989b, 1990, 1994a), information from people knowledgeable about Site 07, and best professional judgment. Risk estimations necessitate modeling hypothetical scenarios that may in fact never occur, resulting in the quantification of potential risks that are actually nonexistent.

[8] A mechanistic model assumes that there is no threshold for carcinogenic effects and *any* exposure to a carcinogen results in an incremental risk of cancer. This is in contrast to a statistical model which assumes that each individual in a population has a threshold below which cancer will not occur, and the distribution of thresholds in a population is distributed as a probability function or an enhancement model. An enhancement model modifies the mechanistic model by incorporating experimental data on the behavior of the chemical in the body along with data on the mechanisms of carcinogenesis.

Best professional judgment was used chiefly in estimating exposure parameters in the remediation/construction and recreational scenarios. In the remediation/construction scenario, typical construction time estimates were used to identify appropriate values for exposure frequency and exposure duration. The uncertainty of this approach stems from the uncertainty in the construction estimate and plans themselves. Should the construction require more time than described in this chapter, the values used for the exposure parameters would result in possible underestimates of risk. For the recreational scenario, estimates of the frequency with which youths will visit the harbor were employed to estimate exposure frequency. In this HHRA, youths were assumed to spend one to four days per week in the summer at the harbor. Use of this range may underestimate or overestimate potential exposures at the harbor, because it is possible that some segment of the population would visit more or less frequently. The inability to know with any certainty the potential use patterns of the Calf Pasture Point area for recreation contributes another source of uncertainty to this HHRA.

Exposure to deep ground water assumes residential exposure, which is unlikely to occur at Site 07 given the designated future use of the NCBC Davisville and the fact that ground water is not typically used for drinking water in the area. Consequently, since it is unlikely that residential consumption of the ground water will occur in the future, the HHRA significantly overstates likely future exposures and risks due to deep ground water.

Exposure to shallow ground water is based on the potential for inadvertent incidental ingestion while excavating. Exposure would only potentially occur if shallow ground water were contacted during excavation. Likely exposures and risks are potentially overstated if the exposures rates of 25 and 50 mL/day overstate likely incidental ingestion rates.

The methodology used to estimate the dermally-absorbed dose per event for dermal contact with contaminants in water is a relatively new non-steady-state approach. This methodology has been proposed by EPA (1992c) with the accompanying caution that the methodology is currently being reviewed by the scientific community. Concern has been raised that the model may be overly conservative with an estimate of uncertainty of plus-or-minus one-half order of magnitude. Currently there are very little empirical data supporting this procedure, making validation of the model difficult.

Both nondepurated and depurated shellfish samples were collected for the Marine Ecological Risk Assessment of Allen Harbor (offshore media; that portion adjacent to the Site). Prior to eating, people typically depurate shellfish in order to remove sand, grit, and other particulate matter. Therefore, only depurated shellfish samples were used in the HHRA to estimate potential exposures by humans consuming locally caught shellfish. Nondepurated shellfish samples were not used in the HHRA because such samples were not believed to be representative of actual human exposures to shellfish. Nondepurated samples were utilized only in the ecological risk assessment.

For this HHRA, depuration entailed holding the shellfish in clean water for 24 hours. During this time, sand and grit were removed by the natural activity of the shellfish. By depurating the samples, it is possible that concentrations of some chemicals in the shellfish could have

been reduced. However, the COCs in shellfish in this HHRA (i.e., arsenic, PAH, and PCB) are either relatively insoluble or highly lipophilic and are therefore not likely to have been significantly reduced in the depuration process. Comparing average and maximum concentrations of COCs in depurated and nondepurated samples from Phase III indicates only small changes that could possibly be attributed to depuration. The magnitude of these changes, on the order of a few percent, are smaller than the differences reported for duplicate samples and analyses. Given the small changes in exposures and risks that would result from including nondepurated samples, the Navy did not incorporate data on nondepurated shellfish in the HHRA.

Risks to offshore populations from inhalation of particulates and volatiles were not quantified in this assessment. However, since there were no COCs in air for onsite exposures, it is likely that inhalation exposures would present extremely low risks to offsite populations.

## 6.6 SUMMARY AND CONCLUSIONS

### 6.6.1 Summary

The objective of this human health risk assessment was to evaluate the potential for adverse health effects to populations exposed to chemicals of concern at NCBC Davisville, Site 07 (onsite media) and to adjacent offshore media. Exposed populations included future remediation/construction workers, future recreational users, consumers of locally caught shellfish, and hypothetical future residents. Potential adverse health effects were attributable to potential exposures to chemicals of concern in (1) soil, ground water, and air (onsite media), and (2) sediment, surface water, and shellfish (offshore media). Exposures of the populations at Site 07 to the chemicals of concern were characterized. Risks were estimated using the exposure estimates and available toxicological data.

Oral, inhalation, and dermal exposures were evaluated for both the onsite and offshore media. Attendant cancer and noncancer risks were estimated for COCs. Risk estimates were developed for the population/exposure scenarios listed below.

**Future Remediation/Construction Workers**

- Incidental ingestion of soil (onsite media)
- Dermal contact with soil (onsite media)
- Incidental ingestion of shallow ground water (onsite media)

**Future Recreational Users**

- Incidental ingestion of surface soil (onsite media)
- Dermal contact with surface soil (onsite media)
- Incidental ingestion of sediment (offshore media)
- Dermal contact with sediment (offshore media)
- Inhalation of volatiles deep and bedrock ground water during showering (onsite media)

- Dermal contact with deep and bedrock ground water during showering (onsite media)
- Incidental ingestion of surface water (offshore media)
- Dermal contact with surface water (offshore media)

**Consumers of Locally Caught Shellfish**

- Ingestion of shellfish (offshore media)

**Hypothetical Future Residents**

- Ingestion of deep and bedrock ground water (onsite media)

This evaluation was based on conservatively high simplifying assumptions that are designed to avoid underestimating potential risks and are likely to overestimate actual risks. This methodology was employed in order to provide assurance that human health is protected. The risks estimated in this investigation will serve as a helpful tool in considering the need to clean up contamination at Site 07 and, if cleanup is necessary, the degree to which the site needs to be cleaned up.

#### 6.6.1.1 Summary of Cancer Risk Estimates

Estimated cancer risks for all exposure pathways described in this chapter are summarized in Table 6-50. Cancer risk for the different exposure scenarios evaluated in this HHRA ranged from six in hundred million ($5.8 \times 10^{-8}$) to one in one hundred ($1.1 \times 10^{-2}$) under average exposure assumptions and from one in ten million ($1.1 \times 10^{-7}$) to three in ten ($3.0 \times 10^{-1}$) under RME assumptions. For comparison, regulatory agencies have generally treated lifetime cancer risks at or less than one in one million ($10^{-6}$) as requiring no regulatory action. However, risks between one in ten thousand ($10^{-4}$) and one in one million ($10^{-6}$) may be considered acceptable, depending on site-specific conditions. Pathways and chemicals contributing the greatest portion to the total estimated cancer risks for each receptor population are summarized in the paragraphs below.

For future construction workers, total estimated cancer risks ranged from $5.8 \times 10^{-8}$ (average) to $1.1 \times 10^{-7}$ (RME). Risks for all exposure pathways (i.e., incidental ingestion of total soil and incidental ingestion of shallow ground water) were less than $10^{-6}$.

For future recreational users, total estimated cancer risks ranged from $2.0 \times 10^{-3}$ (average) to $3.7 \times 10^{-2}$ (RME). Exposure to 1,1,2,2-tetrachloroethane, trichloroethene, vinyl chloride, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, chloroform, and benzene via dermal contact with deep ground water while showering and inhalation of volatiles from deep ground water while showering contributed most significantly to overall risk. Risks greater than $10^{-6}$ were also associated with incidental ingestion of sediments containing arsenic (RME). For future recreational users of the Entrance Channel, total estimated cancer risks via dermal contact with surface water ranged from $1.6 \times 10^{-6}$ (average) to $2.6 \times 10^{-5}$ (RME) for adults and from $7.2 \times 10^{-7}$ (average) to $7.5 \times 10^{-6}$ (RME) for children. Incidental ingestion of surface water also contributed insignificantly to the total risk under the reasonable maximum

exposure scenarios ($2.3 \times 10^{-6}$ for adults; $1.4 \times 10^{-6}$ for children). Exposure to 1,1,2,2-tetrachloroethane via dermal contact with surface water and ingestion of surface water contributed the most to overall risk.

For consumers of shellfish, total estimated cancer risks ranged from $2.4 \times 10^{5}$ (average) to $2 \times 10^{-3}$ (RME). Arsenic and PCB contributed cancer risks greater than $10^{-6}$ under both average and RME conditions. PAH contributed risks greater than $10^{-6}$ under RME conditions. Arsenic was the principal contributor to the total risk in both cases, accounting for the majority of the total risk under average and RME exposure conditions. This is an offshore media. Upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the shellfish and (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling and analyses conducted to date by the Navy have identified no related unacceptable risk.

For hypothetical future residents, total cancer risks associated with consumption of deep and bedrock ground water were estimated to range from $1.1 \times 10^{-2}$ (average) to $3.2 \times 10^{-1}$ (RME). Individual COCs in deep and bedrock ground water associated with cancer risks greater than $10^{-6}$ under both average (deep and bedrock ground water) and reasonable (bedrock) maximum exposure conditions include: arsenic, 1,2-dichloroethane, 1,1-dichloroethene, 1,1,2-trichloroethane, trichloroethene, vinyl chloride, 1,1,2,2-tetrachloroethane, tetrachloroethene, chloroform. Benzene and beryllium in deep ground water were also associated with cancer risks greater than $10^{-6}$ under both average and reasonable maximum exposure conditions. Chloroform and 1,2-dichloroethane each individually contributed cancer risks greater than $10^{-6}$ only under reasonable maximum bedrock ground-water exposure conditions. In both average and reasonable maximum cases, 1,1,2,2-tetrachloroethane accounted for more than 70 percent of the total cancer risk.

### 6.6.1.2 Summary of Risks for Health Effects Other than Cancer

For health effects other than cancer, hazard indices (HIs) for each exposure pathway described in this chapter are summarized in Table 6-51. Total HIs for the exposed populations evaluated in this HHRA were estimated to range from $5 \times 10^{-3}$ to 105 under average exposure assumptions and from $4 \times 10^{-2}$ to 770 under reasonable maximum exposure assumptions. HIs of 1.0 or greater are considered to pose a potential threat to human health. HIs that are less than 1.0 are not considered to pose a potential threat to human health. The smaller the HI, the greater the confidence that injury will not result from the defined exposure.

Total HIs were less than 1.0 for future remediation/construction workers (average and RME scenarios).

For recreational users under average and reasonable maximum exposure conditions, the total HI was estimated to be 10.2 and 216, respectively. Exposures to trichloroethene (HQ = 5 for inhalation of volatiles from deep ground water; HQ = 4 for inhalation of volatiles from

bedrock ground water) via inhalation of volatiles from deep and bedrock ground water while showering contributed the greatest portion of the total HI under average exposure conditions. Exposures to trichloroethene (HQ = 146 for inhalation of volatiles from deep ground water; HQ = 33 for inhalation of volatiles from bedrock ground water) via inhalation of volatiles from ground water while showering also contributed the greatest portion of the total HI under RME conditions. Trichloroethene was also responsible for (HQ = 14 for dermal contact with deep ground water; HQ = 3 for dermal contact with bedrock ground water) most of the risk associated with dermal contact exposures. Because the total HI is greater than 1.0, the COCs were separated according to their specific target organ toxicity and organ-specific HIs were calculated. The critical effect for chloroform (HQ = 2 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), 1,1,2-trichloroethane (HQ = 5 and 0.7 for deep and bedrock ground water, respectively), tetrachloroethene (HQ = 2 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), 1,1-dichloroethene (HQ = 2.0 and 0.2 for inhalation of volatiles from deep and bedrock ground water, respectively), and 1,2-dichloroethene (HQ = 5 and 2 for inhalation of volatiles from deep and bedrock ground water, respectively) is the liver. Thus, the HI for the liver is greater than 1.0 in both cases, indicating that adverse health effects may be observed in exposed populations under reasonable maximum exposure conditions. The critical effect for trichloroethene is the kidney. The HI for the renal effects is also greater than 1.0, indicating that adverse health effects may be observed in exposed populations under average and reasonable maximum exposure conditions. For future recreational users of the Entrance Channel, exposure pathway-specific HIs for incidental ingestion of and dermal contact with surface water are all less than one for adults and children, indicating that no adverse effects are likely to be expected due to exposure to COCs in surface water.

For consumers of locally caught shellfish, the total HI was estimated to be 7 and 176 under average and RME exposure conditions, respectively. Mercury (HQs = 6 and 147), zinc (HQs = 0.2 and 14), Arsenic (HQs = 0.3 and 7), copper (HQs = 0.06 and 3), cadmium (HQs = 0.04 and 2), Aroclor-1254 (HQs = 0.08 and 2), and Aroclor-1260 (HQs = 0.08 and 1) contributed the greatest portion of the total HIs. Because the HQs for these COCs are each greater than 1.0 under the reasonable maximum scenario, adverse health effects in several target organs may be observed in exposed populations. COC/target organ pairs of interest include: mercury/kidney, zinc/blood, arsenic/skin, copper/GI tract, cadmium/kidney, and PCB/liver. Under average exposure conditions, exposures to mercury in shellfish might be associated with adverse health effects. This is an offshore media. Upon evaluation of the Phase III RI hydrogeological and onsite media sample results, no clear evidence was found for a completed risk pathway from the Site (onsite media) to the shellfish (offshore media) in the adjacent portions of Allen Harbor and the Entrance Channel. In other words, based upon the Navy investigations completed to date, the discharge of shallow or deep ground water with detected CVOC or arsenic to adjacent surface water (harbor, entrance channel, and bay) has not been shown, except for the discharge of shallow ground water with CVOC to a portion of the entrance channel south of MW07-21S. However, sampling and analyses conducted to date by the Navy have identified no related unacceptable risk.

For hypothetical future residents consuming deep ground water, total HIs were estimated to range from 105 (average) to 770 (RME). For the average exposure conditions, the COCs contributing most significantly to the HI were trichloroethene (HQ = 50 and 38 for deep and

bedrock ground water, respectively), 1,2-dichloroethene (HQ = 2 and 3 for deep and bedrock ground water, respectively), manganese (HQ = 1 and 3 for deep and bedrock ground water, respectively), tetrachloroethene (HQ = 1 for deep ground water), chromium (HQ=1.6 for deep ground water), and 1,1,2-trichloroethane (HQ = 1 and 2 for deep and bedrock ground water, respectively). For the reasonable maximum exposure conditions, the COCs contributing most significantly to the HI were trichloroethene (HQ = 548 and 123 for deep and bedrock ground water), 1,2-dichloroethene (HQ = 17 and 7 for deep and bedrock ground water), and 1,1,2-trichloroethane (HQ = 17 and 3 for deep and bedrock ground water). 1,1-Dichloroethene (HQ = 8 for deep ground water), tetrachloroethene (HQ = 7 for deep ground water), chloroform (HQ = 7 for deep ground water), manganese (HQ = 4 and 19 for deep and bedrock ground water, respectively), arsenic (HQ = 3 for deep ground water), aluminum (HQ = 4 for deep ground water), and thallium (HQ = 1 for deep ground water) also had an HQ above 1 for hypothetical future residents consuming deep ground water under reasonable maximum exposures. Therefore, it is possible that adverse health effects in several target organs will be observed in exposed populations. The COC/target organ pairs are as follows: 1,2-dichloroethene/liver, 1,1-dichloroethene/liver, tetrachloroethene/liver, chloroform/liver, 1,1,2-trichloroethane/liver, trichloroethene/kidney, arsenic/skin neoplasms, aluminum/GI tract, manganese/CNS effects, chromium/lung, and thallium/increased SGOT.

#### 6.6.1.3 Summary of Risks Due to Lead

EPA OSWER Directive #9355.4-12 (EPA 1994d) recommends a screening level for lead in soil for residential land use of 400 ppm. RIDoH considers soil to be "lead-free" for a residential scenario when the lead concentration is below 150 ppm (RIDoH 1994).

Lead was detected in all 26 soil samples collected at Site 07 for which lead data are reported at concentrations ranging from 1.5 to 8.6 mg/kg. The mean lead concentration in soil was 3.7 mg/kg, and the 95 UCLM concentration was 4.5 mg/kg. Thus, all detected concentrations of lead at Site 07 are significantly below the level at which RIDoH considers soil to be "lead-free." Consideration of the lead data as a whole leads to the conclusion that exposures and risks are not likely be above unacceptable levels.

### 6.6.2 Conclusions

Based on the sampling and site characterization efforts at Site 07 and in adjacent portions of Allen Harbor, and the exposure scenarios described in this chapter, the following statements can be made (detailed descriptions of exposed groups included below are presented in the Summary section):

- COCs in deep and bedrock ground water (i.e., arsenic, beryllium, and volatiles, including benzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethene, tetrachloroethene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, trichloroethene, and vinyl chloride) were associated with estimated cancer risks to exposed residential populations that are greater than $10^{-6}$.

- Consumption of deep and bedrock ground water containing trichloroethene, manganese, arsenic, aluminum, thallium, chromium, chloroform, 1,1-dichloroethene, 1,2-dichloroethene, tetrachloroethene, and 1,1,2 trichloroethane were associated with estimated hazard quotients greater than 1.0 for some exposed residential populations under both average and RME exposure conditions. Evaluation of separate target organ HIs indicates that exposures to these COCs may result in adverse health effects in the liver, kidney, skin, gastrointestinal tract, central nervous system, and the lung.

- Dermal contact with and inhalation of volatiles from deep ground water while showering were associated with estimated cancer risks for exposed recreational populations that are greater than $10^{-6}$ under average exposure conditions. Major contributors to the total estimated risks were 1,1,2,2-tetrachloroethane, trichloroethene, vinyl chloride, 1,1,2-trichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, chloroform, and benzene.

- Dermal contact with and inhalation of volatiles from bedrock ground water while showering were associated with estimated cancer risks for exposed recreational populations that are greater than $10^{-6}$. Major contributors to the total estimated risks were 1,1,2,2-tetrachloroethane, trichloroethene, vinyl chloride, 1,1,2-trichloroethane, 1,1-dichloroethene, and chloroform.

- Dermal contact with and inhalation of volatiles from deep ground water while showering were associated with estimated hazard quotients for exposed recreational populations that are greater than 1.0 under average (only the inhalation pathway) and reasonable maximum exposure conditions. Evaluation of separate target organ HIs indicates that exposure to trichloroethene, 1,1-dichloroethene, tetrachloroethene, chloroform, 1,2-dichloroethene, and 1,1,2-trichloroethane may be associated with adverse health effects in the liver and kidney.

- Ingestion of arsenic in sediments (offshore media) was associated with cancer risks greater than $10^{-6}$ for some exposed recreational populations. This has not been directly related to the Site.

- For the Entrance Channel recreational exposure scenarios, dermal contact with surface water (offshore media) for adult receptors under average exposure scenario and incidental ingestion of and dermal contact with surface water for adults and children under reasonable maximum exposure scenario was associated with cancer risks greater than $10^{-6}$.

- COCs in shellfish (offshore media) (i.e., arsenic, benzo(a)pyrene, benzofluoranthene, dibenzo(a,h)anthracene, and PCB) were associated with estimated cancer risks that are greater than $10^{-6}$, with total risks to

exposed populations ranging from $2.4 \times 10^{-5}$ to $2 \times 10^{-3}$. This has not been directly related to the Site.

- COCs in shellfish (offshore media) (i.e., mercury, zinc, arsenic, copper, cadmium, and PCB) were associated with estimated hazard quotients for certain exposed groups that are greater than 1.0. Evaluation of separate target organ HIs indicates that exposures to these COCs may result in adverse health effects in the kidneys, skin, gastrointestinal tract, blood, and liver. This has not been directly related to the Site.

- Based on the exposure scenarios defined in this chapter, no adverse health effects would be expected to be associated with subchronic exposures to chemicals of concern at Site 07.

- Lead concentrations in soil at Site 07 were well below the EPA OSWER Directive and RIDoH screening levels. Exposures and risks due to lead would likely be below unacceptable levels at Site 07, so remediation of lead in soil is not likely to be required.

# 7. CONCLUSIONS AND RECOMMENDATIONS

The overall objective of the Phase III RI was the collection and evaluation of additional hydrogeological and ground-water quality data related to further assessment of the nature and extent of TCL VOC and TAL from beneath Site 07 to Allen Harbor and Narragansett Bay.

The impact of Site 07 on Allen Harbor and terrestrial ecology have also been addressed by the Allen Harbor Landfill and Calf Pasture Point Marine ERA (EA 1996a) and the Facility-Wide Freshwater/Terrestrial ERA (EA 1996b), respectively.

## 7.1 GEOLOGY AND HYDROGEOLOGY

The results of the Phase III field investigation, the 1997 Offshore Investigation, and previous investigations, show that the geology at Site 07 is characterized by anthropogenic fill (dredged material) and Quaternary (Pleistocene) glacial deposits mantling quartzite bedrock of the Pennsylvanian age Rhode Island Formation (undifferentiated). Based upon the Phase I, II, III RI boring logs and the related Offshore Investigation boring logs, the Site is underlain by five main stratigraphic units (from the ground surface to bedrock):

(1) The upper sand unit, a brown to gray sand with varying amounts of silt and gravel and occasional shell fragments. At five borings/wells, a layered sand and silt facies was encountered. Offshore, this upper sand unit interval is represented by organic silt and sand that forms the harbor floor.

(2) The silt unit which is present beneath Allen Harbor and most of the Site except north in the vicinity of the bedrock exposure and south in the vicinity of MW07-26, -19, -21, and -32. Where present along with an upward vertical ground-water gradient, the silt unit impedes the upward flow of ground water and migration of CVOC from the deep zones.

(3) The lower sand unit, consisting of very fine to medium sand with varying amounts of silt and encountered only beneath the eastern portion of the site.

(4) The till unit, silty gravelly sand to sandy gravelly silt which was encountered beneath the harbor and the Site.

(5) Quartzite, phyllite and gneissic bedrock which was encountered beneath the Site, the harbor, and Spink Neck.

The four Site 07 subsurface soil strata, plus bedrock, have been divided into the following three hydrogeological zones (beginning with the shallowest zone):

**Shallow Ground-Water Zone**

The shallow ground-water zone is the saturated portion of the upper sand unit (Section 3.6.2 and Figures 3-2 through 3-9A) which is under unconfined conditions. Data from the shallow (S) wells were used in contouring the water-table surface. The shallow ground-water zone may extend a short distance under the shoreline portions of the adjacent bay, harbor, and entrance channel, but ends abruptly north of Site 07 where bedrock is exposed at ground surface. In the southern portion of the Site in the vicinity of wells MW07-19S/D, MW07-21S/D/R, and MW07-26S, and the northern portion of Spink Neck at MW07-32D/R, the silt unit is not present and the upper portion of the till unit extends to within approximately 5-8 ft of ground surface. Therefore, in that area, the shallow ground-water zone also includes the upper portion of the till unit. During the Phase II RI, the water table interval was designated as "shallow" ground water; and for consistency, that designation is also used in the Phase III RI. As shown on Figures 3-12 through 3-14, the ground water flows approximately radially from a bedrock hill (located just north of the Site) toward the nearest shoreline for each of the three tidal stages.

The Site data indicate that the shallow zone discharges to surface water near the shoreline with the harbor, entrance channel, and bay.

**Deep Ground-Water Zone**

The deep ground-water zone is the lower portion of the silt unit, the lower sand unit (where present) and the till unit which is under confined/semi-confined aquifer conditions. The ground-water potentiometric water surface was mapped with data from the deep (D) wells which have screens set in those units or portions of units (Figures 3-2 through 3-9). The deep ground-water zone appears to extend in all directions from the Site except to the north where it ends abruptly in the vicinity of the hill where bedrock is exposed at ground surface. Additionally, the silt unit is not present at wells MW07-19S/D, MW07-21S/D/R, and MW07-26S in the southern portion of the Site and at MW07-32D/R in the northern portion of Spink Neck. However, the till unit thickens to more than 30 ft and the upper portion of the till unit extends to within approximately 5-8 ft of ground surface. Therefore, in that area, the shallow and deep ground-water zones are not separated by the silt unit, but rather, are the upper and lower portions, respectively, of the till unit. During the Phase II RI, the lower portion of the silt unit, the lower sand unit (where present), and the till unit were designated as "deep" ground water because deep (D) monitoring wells screened one or more portions of these units. For consistency with the Phase II RI and because of the aforementioned Phase II RI deep (D) well screen intervals, the Phase II designation of "deep" ground water must also be used in the Phase III RI. As shown on Figures 3-15 through 3-17, the ground water flows generally southeast for each of the three tidal stages.

### Bedrock Ground-Water Zone

The bedrock ground-water zone is the upper 25-30 ft of competent (coreable) bedrock which is under confined/semi-confined aquifer conditions. The potentiometric water surface was mapped with data from rock (R) wells with screens set approximately 15-25 ft below the top of competent bedrock (Section 3.6.2 and Figures 3-2 through 3-9). As shown on Figures 3-18 through 3-20, the ground water flows generally southeast for each of the three tidal stages.

### Vertical Hydraulic Gradients

Although vertically upward and downward gradients have been observed between the shallow and deep ground-water zones at various monitoring well pairs across the Site, the estimated vertical permeability is considerably less than the horizontal permeability resulting in only a small vertical component of ground-water flow between the upper sand unit and the till unit. The observed vertically downward gradients between the till and bedrock ground-water zones at MW07-05D/R and MW07-25D/R have probably aided the migration of dissolved CVOC into the bedrock in those areas.

### Tidal Stages and Ground-Water Flow

The effect of tide stages was observed as fluctuations (rise and decline) of the potentiometric water surface (pressure head in the silt, till, and bedrock units under confined/semi-confined conditions) as measured in the monitoring wells (Figures 3-12 through 3-20). Because the tidal cycle-related fluctuations recur twice daily, the overall impact on vertical movement of ground water is expected to be very minor. The tidal cycles would have their greatest impact on ground-water flow in the upper sand unit because the harbor is laterally adjacent to this unit, but the actual site data indicates that there is only a minor impact. The changing tide levels appear to most affect the ground-water levels and ground-water flow in the sand unit at the shoreline. Ground water and harbor water apparently mix and move back and forth in this layer in the immediate area along the shoreline.

### Salt-Water Intrusion Assessment

Based upon the salinity concentrations detected in the Phase III RI and Offshore Investigation ground-water samples, the ground water in the shallow, deep, and bedrock ground-water zones beneath Site 07 appears to be:

- Saline (> 10 ppt salinity) beneath the eastern portion (Narragansett Bay side) of the Site, the northern portion of Spink Neck, and the eastern portion of the harbor (near SB09-17);

- Brackish (0.5-10 ppt salinity) beneath the central and southern portion of the Site (which includes most of the VOC plume in deep ground water) and the central portion of the harbor (SB09-16); and

- Fresh (<0.5 ppt salinity) beneath the northern portion of the Site which includes the former DANC disposal area.

Based upon these data, a higher density salt water wedge appears to be present beneath the eastern portion of the Site, near the southern shoreline of the Site south to the northern portion of Spink Neck and west to the eastern portion of the harbor (Figures 4-11B, 4-12B, and 4-13B). The salinity data suggest that fresh and brackish, lower density ground water from the northern portion of the Site would flow up over the more dense salt water wedge to the south to discharge into the surface water within the zone that is a few hundred feet from the shoreline. Because of the depth of the harbor entrance channel, much of that discharge appears to be to the northern side of the channel. CVOC have been detected in samples from wells near the site perimeter in two general locations: along the west perimeter with Allen Harbor (in the deep and bedrock zones between MW07-25 and MW07-23) and along the northern perimeter with the entrance channel (at MW07-21 vicinity in the shallow, deep, and rock zones). The CVOC detected at these locations in the deep zone are in fresh and brackish ground water. Their migration downgradient may be anticipated to be affected in part by some flow component up over the denser salt water wedge south of the Site. This has been observed in the southern portion of the Site (MW07-19S and -21S area) where in the approximate vicinity of MW07-27D (Figure 4-42), the deep CVOC plume appears to split, one branch continuing down into bedrock and the other extending upward through MW07-19S and MW07-21S perhaps related to ground-water flow up over the salt water wedge. Additionally, the data appear to support the presence of some minor flow from the bedrock into the overlying till unit at MW07-21D/R. The silt unit is not present in this area to impede the vertical flow component. If the CVOC detected in samples from MW07-23D and -25D/R were to extend southwest beneath the harbor (Figure 4-26A), the impacts should be detected in the till unit samples from mid-harbor borings SB09-16 and SB09-17 where ground-water flow up over the salt water wedge would also be expected. However, CVOC were not detected in the 1997 till unit samples from those borings. Additionally, that hypothetical southwestern migration of CVOC would be cross gradient to the generally southeast interpreted direction of ground-water flow (Figure 3-16 and 3-16A).

Based upon ground-water samples, the areas of brackish and saline ground water detected in the shallow zone beneath the Site approximately correspond to the surficial portion of Site 07 which, prior to 1940, was part of Allen Harbor. Between 1942 and 1943, that area was filled with saline dredge material from the Navy's construction of the pier area along the Narragansett Bay shoreline south of Site 07.

## 7.2 NATURE AND EXTENT OF VOC

### Shallow Ground Water

CVOC were detected in the Phase III RI samples collected from five of the 17 shallow (S) wells. Based upon the Phase III RI data, there appear to be two separate CVOC plumes in shallow ground water (Figure 4-17). The first plume has relatively low concentrations of total

CVOC and is located in the vicinity of the former DANC disposal area (MW07-01S; 23 $\mu$g/L and MW07-02S; 1 $\mu$g/L). The data indicate that release of 1,1,2,2-PCA (a major component of DANC) from the former DANC disposal area appears to have migrated vertically downward through a locally present sandy facies of the underlying silt unit rather than laterally. This CVOC plume in shallow ground water is small and is surrounded by wells where no CVOC were detected. The second plume has higher concentrations of total CVOC and is located in the southwestern portion of the Site (MW07-19S; 5,950 $\mu$g/L, MW07-21S; 1,481 $\mu$g/L, and MW07-26S; 1,483 $\mu$g/L). The CVOC plume detected in samples from MW07-19S and MW07-21S is largely comprised of PCA and TCE like the plume detected in the deep ground water and appears to be an arm of that plume caused when less dense brackish ground water with dissolved CVOC flows up and over the denser salt water wedge which appears to be located near the southern shoreline. The CVOC detected in the sample from MW07-26S is comprised mostly of 1,2-DCE and may be from a separate source. However, there are no reported disposal activities in that portion of the Site.

Additionally, trace concentrations of CVOC were detected in a sample collected from one of the mid-harbor borings (SB09-16; 4 $\mu$g/L PCA and 2 $\mu$g/L TCE) (Figures 4-17 and 4-26A). These trace concentrations of CVOC do not appear to be related to disposal activities at the Site because shallow ground water from the Site would discharge to the harbor near the Site shoreline; also, CVOC were not detected at MW07-23S located in the southwest corner of the site.

**Deep Ground Water**

CVOC were detected in samples from 18 of the 25 deep (D) wells. The eighteen samples (wells) are generally located in the western portion of the Site (Figure 4-18). The available data suggest the presence of one plume in the deep ground-water (generally in the till which directly overlies bedrock). The highest total CVOC concentrations detected in this plume include four wells which are located just south of the vicinity of the apparent former DANC disposal area and within an interpreted valley in the underlying bedrock surface (Figure 1-2): MW07-17D (193,680 $\mu$g/L), MW07-04D (123,000 $\mu$g/L), MW07-05D (96,750 $\mu$g/L), and MW07-15D (93,890 $\mu$g/L). MW07-05D and MW07-17D appear to be located along the base of the northwest-southeast trending valley in the bedrock surface (Figures 1-2 and 4-25, Cross Section F-F′). This apparent valley appears to have influenced the migration and collection of the original DANC disposal release of separate phase 1,1,2,2-PCA DNAPL. The material appears to have migrated vertically downward through a sandy facies in the overlying silt unit into the till unit and then along the apparent valley in the bedrock surface until the DNAPL flowed down into fractures in the bedrock. There may be residual DNAPL TCE and/or 1,1,2,2-PCA in the vicinity of MW07-04D, MW07-05D, MW07-15D, and MW07-17D. Free-flowing DNAPL has not been observed at the Site during the Phase I, II, or III RIs. Dissolved CVOC concentrations detected in deep ground water (till unit, lower sand unit, and lower portion of the silt unit) decrease to "not detected" toward the east and south shoreline with Narragansett Bay as shown on Figures 4-18 and 4-21 through 4-24. In the approximate vicinity of MW07-27D, the deep VOC plume appears to split, one branch continuing down

into bedrock and the other extending upward through MW07-19S and MW07-21S perhaps related to ground-water flow up over the salt water wedge located near the southern shoreline. The west (detected in MW07-23D and -25D) and south (detected in MW07-21D) extent of the CVOC in deep ground water continues beneath the Site shoreline with Allen Harbor and the entrance channel, but have not been detected in till interval samples from mid-harbor borings SB09-16 and -17 nor well MW07-32D (Spink Neck) (Figure 4-18).

**Bedrock Ground Water**

CVOC were detected in samples from three of the six bedrock (R) wells (including MW07-32R located on Spink Neck). CVOC were not detected in the central (MW07-09R) and eastern (MW07-16R) portions of Site 07, or the northern portion of Spink Neck (MW07-32R). The highest concentration of total CVOC (41,730 $\mu$g/L) was detected in the sample from MW07-05R. MW07-05R is located approximately 150 ft southwest of the apparent vicinity of the former DANC disposal area. Additionally, MW07-05R is located in an apparent valley in the bedrock surface (Figure 2-1) into which the original DANC release may have migrated through the overlying till unit. The data suggest the presence of a dissolved CVOC plume in the bedrock ground-water zone from the vicinity of MW07-05R, MW07-21R, and MW07-25R (Figures 4-19 and 4-26). Related ground-water and CVOC flow is probably through fractures in the bedrock and through the overlying till unit which appears to be in direct hydraulic connection with the bedrock. The very low concentrations of CVOC detected in ground-water samples from the overlying till from MW07-19D and -21D may be CVOC associated with a slight vertical flow of ground water up to the till from the bedrock along the fresh/salt water transition zone in that area.

The CVOC plume in the bedrock which extends south beneath the Site from the release area to MW07-21R, was not detected in the sample collected from well MW07-32R located south and across the entrance channel from the Site (Figure 4-19). This suggests, along with the nondetection of CVOC in the till interval samples from mid-harbor borings SB09-16 and SB09-17, that the CVOC plume may extend in the bedrock toward the southeast beneath the northern edge of Spink Neck toward the bay.

Petroleum hydrocarbon VOC were only detected in the bedrock ground-water sample from MW07-32R (toluene at 8 $\mu$g/L). This detected toluene does not appear to be related to Site 07 because it has not been detected in samples from upgradient wells located in the southern portion of the site.

**Summary Of The DANC Release and Migration**

The DANC release appears to have occurred in the vicinity of wells MW07-14D and MW07-31I (Figures 4-40 and 4-42). The detected VOC in ground water are almost entirely PCA and TCE (perhaps an impurity) in the inferred vicinity of the release. A third key VOC, 1,2-DCE (total), is detected downgradient. Residual DNAPL may be present in the till unit adhering to the soil and/or present as ganglia in some of the void space between soil grains in the vicinity

of wells MW07-04, -05, -15, and -17. However, DNAPL is apparently not present in sufficient volume to flow freely (free-phase) in these areas, because it has not been observed as a separate phase at the bottom of these wells.

Ground water flows toward the south-to-southeast through the area where the DANC DNAPL release passed, and picks up dissolved concentrations of CVOC, particularly PCA and TCE (particularly in the till and bedrock). The 1,2-DCE may also have been a lesser impurity in the DANC and/or is a degradation product of the TCE.

The denser than water DANC migrated via gravity vertically downward through a locally present sandy facies of the silt unit (fresh ground-water zone) and into the underlying till unit and fractures of the bedrock unit (brackish and saline ground-water zones). The bedrock surface may have temporarily impeded the initial migration of the DNAPL by: (1) focusing some lateral flow along its slope south southeast toward the southeast-trending valley in its surface in the area where MW07-05D and MW07-17D are now located (Figure 2-1), and (2) confining the downward vertical flow to fractures and fracture zones that extend down into the bedrock unit. [An analogy of this situation could be the pouring of a fluid into a bath tub at the upper edge of the end of the tub (the bedrock surface in the vicinity of the DANC release). However, there are many cracks through the tub floor through which the fluid flows (escapes) before reaching the opposite end of the tub.] It is highly probable that most of the DANC DNAPL is at depth in the bedrock fractures (brackish or saline ground-water zone). Regional flow of ground water through bedrock (from areas of higher head to areas of lower head) is typically not along as direct a route as may be thought for flow through sand or gravel units. In bedrock like that beneath the Site, ground water can only flow through (along) fracture, joint, and bedding planes; not between individual grains as in sand and gravel units. It is probable that some of the key fractures and/or fracture zones through which the DNAPL and ground water must flow in bedrock are not be oriented in the same direction as the approximately southeast regional ground-water flow direction. Rather, some fractures may be locally oriented toward the south or southwest. Ground water would locally flow through such fractures in that direction until reaching other fractures/zones that are oriented more closely to the southeast regional ground-water flow direction. This is believed to be a key reason for the southerly extension of the CVOC plume. It must be noted that it is highly probable that most of the DNAPL migrated under the influence of gravity and is at depth in the bedrock fractures within saline ground water. Dissolved-phase CVOC in the saline ground water flowing through this would continue to migrate at depth along with interpreted regional southeast direction of flow.

Ground-water samples from wells screening the shallow ground-water zone around the inferred release area are ND for CVOC. Based upon the shape of the dissolved-phase CVOC plume in the deep zone and the interpreted direction of ground-water flow (south to southeast), migration of the plume appears to be south and southeast (Figure 4-18). As previously stated, the southern flow component may in part be related to, or enhanced by, flow through interconnected fractures in the bedrock (Figure 4-19) and along the interface with the till unit, including dispersion and the flow dynamics in the fresh/salt water interface (brackish water zone).

Due at least in part to dispersion of the plume as it migrates south from the inferred DANC release area and flow through underlying fracture zones, the west side of the plume in the deep and bedrock zones extend west beyond MW07-25D and -25R (Figures 4-18 and 4-19, respectively). Extrapolation of the data shown on Figure 4-18 suggests that the western edge of this plume may be located approximately 200-300 ft west of MW07-25D. Extrapolation of the data shown on Figure 4-19 suggests the western edge of this plume may be located approximately 200 ft west of MW07-25R. A monitoring well cluster will be installed west of MW07-04D/R and northwest of MW07-25D/R to monitor CVOC concentrations in that area during the long-term monitoring program. The very low concentrations of CVOC detected in ground-water samples from the overlying till from MW07-19D and -21D may be CVOC associated with a slight vertical flow of ground water up to the till from the bedrock along the fresh/salt water transition (brackish) zone in that area.

As stated previously, the general direction of ground-water flow in the deep and bedrock zones beneath the Site is southeast to south (Figures 3-15 through 3-20) and not southwest or west toward Allen Harbor. Ground-water flow in the deep and bedrock zones beneath the Site and Spink Neck is part of the regional flow toward the bay and is not anticipated to be affected by the shallower, localized effects of the entrance channel. Based upon the salinity data from mid-harbor borings SB09-16 and SB09-17, well MW07-32R on Spink Neck, and the onsite wells (Figures 4-11B, 4-12B, and 4-13B), the salt water wedge is present beneath the southern and eastern portions of the Site, Spink Neck, and portions of eastern Allen Harbor. As shown on Figure 3-16A (deep zone water surface at mid-tide for both Sites 07 and 09), the general ground-water flow direction from both sites is southeast and south. Therefore, it is anticipated that little, if any, deep and bedrock zone ground water from beneath Site 07 would discharge into the harbor. Further, with regard for potential migration of the Site CVOC plume beneath the harbor, CVOC were not detected in the samples collected from the till unit at mid-harbor borings SB09-16 and SB09-17, nor at MW07-32D on Spink Neck. Additionally, CVOC were not detected in the sample from bedrock at MW07-32R on Spink Neck. Based upon the ground-water level and sample results from the onsite monitoring wells, the two mid-harbor borings, and the well pair (MW07-32D/R) on Spink Neck, no Site-related CVOC plume was detected crossing beneath the harbor in the till unit (Figure 4-18).

## 7.3 NATURE AND EXTENT OF METALS

During the Phase III RI, samples were collected from all Site 07 monitoring wells and analyzed for TAL. Only three metals were detected above MCL or SMCL in ground-water samples: iron, manganese, and thallium. Arsenic was detected above the SDWA action level (15 ) in only one sample. The iron concentrations detected in most of the Phase III RI ground-water samples were below the NCBC background concentration of 25,500 $\mu$g/L. The manganese concentrations detected in most of the Phase III RI ground-water samples were below the NCBC background concentration of 3,292 $\mu$g/L. All of the thallium concentrations detected in the Phase III RI ground-water samples are below the 32 $\mu$g/L concentration detected in the water samples from Allen Harbor (NCBC-AH1) and Narragansett Bay (NCBC-NB1). The data do not indicate a particular source area for the locally higher detected iron and manganese

concentrations. The iron and manganese may be related to natural conditions. The higher detected concentrations of iron and manganese do not form a pattern that appear to be associated with the detected high concentrations of CVOC, ie. because they are located in both downgradient and cross gradient areas from the high concentrations of CVOC. Although it is possible for iron, manganese, and arsenic to be mobilized from native aquifer materials due to the presence/degradation of organic chemicals, it does not appear to be a dominant process beneath Site 07. This is based upon the location of the higher detected iron, manganese, and arsenic concentrations which are not located in the areas of higher detected CVOC concentrations (which would seem to be the area where the mobilization would have the greatest potential to occur, unless perhaps all of the mobilization from that area has occurred). If this process were dominant, it would seem that there would be a plume of decreasing metal concentrations extending from the areas of higher detected CVOC concentrations. However, the available data do not indicate the presence of such a plume. Additionally, most of the detections are below the related established NCBC background concentrations making it difficult to discern variations in the naturally occurring concentrations from potential site impacted concentrations.

## 7.4 POTENTIAL IMPACT ON ADJACENT SURFACE WATER BODIES BY MIGRATION OF SOLUTES IN GROUND WATER FROM SITE 07

The estimated VOC and metals concentrations for the Allen Harbor entrance channel water potentially resulting from the migration of Site 07 shallow zone ground water are significantly below AWQC, therefore, do not appear to adversely impact the surface water quality. Potential impact from deep ground water is expected to be less than that estimated for Site 07 shallow ground water because it would have to pass through shallow ground water zone prior to discharging.

## 7.5 POTENTIAL IMPACT OF SOLUTES IN GROUND WATER FROM SITE 07 ON ADJACENT INTERTIDAL SEDIMENT

The potential for ground-water modeling to aid in assessment of the migration of detected TCL VOC and TAL and their potential impact on adjacent intertidal sediment was screened using a two-step process. That process included conservative sediment partitioning theory and relatively simplistic ground-water modeling. The result of the screening process has provided a rough estimate that for the TAL, only iron and manganese may result in sediment concentrations that are above sediment screening criteria at the Allen Harbor entrance channel shoreline. Iron was not identified as a sediment COC in the Marine or Facility-Wide Freshwater/Terrestrial ERA reports. However, manganese was identified as a sediment COC, but only in the Freshwater/Terrestrial ERA report.

The result of the screening process has provided a rough estimate that for the CVOC only TCE and 1,2-DCE may result in sediment concentrations that are above sediment screening criteria (5 percent TOC) at the Allen Harbor entrance channel shoreline in either the shallow or deep/rock ground-water zones. However, VOC (including TCE and 1,2-DCE) were not identified as COC in either the Marine or Facility-Wide Freshwater/Terrestrial ERA reports.

The two-step screening process has provided rough estimation of the CVOC in ground water beneath the site when considered over short distances, eg. from MW07-19S and MW07-21S to the shoreline of the Allen Harbor entrance channel. However, the AT123D model was not consistent in the estimation of VOC concentrations across the length of the site (approximately 800 ft). Overall, the Site hydrogeology was found to be more complex than could be well simulated by the relatively simplistic AT123D computer model. Although Site parameters were used as possible to try to simulate subsurface, the results of the screening-level modeling work indicated that continued model refinement and/or development of a site-wide 3D model is not appropriate because of the relative complexity of the site subsurface, including geological variations, tides, and the flow dynamics in the interface between the fresh and saltwater zones.

## 7.6 TERRESTRIAL ECOLOGICAL RISK ASSESSMENT

The results of the Facility-Wide Freshwater/Terrestrial ERA (EA 1996b) indicate that there is no unacceptable risk to terrestrial ecological receptors from Site 07 surface soil.

Additionally, the results of the December 1997 sediment samples collected from the Site interior wetlands (near MW07-13S and MW07-19S) by EPA and analyzed for VOC, detected only trace concentrations in a few samples and did not identify unacceptable risk from VOC in shallow ground water potentially discharging to these areas.

## 7.7 MARINE ECOLOGICAL RISK ASSESSMENT

The results of the Allen Harbor Landfill and Calf Pasture Point Marine ERA (EA 1996a) indicate that regarding potential risk to the marine ecology a cause and effect relationship could not be established for Site 07.

## 7.8 HUMAN HEALTH RISK ASSESSMENT

The results for cancer risk analysis as summarized in Table 6-50 show that the exposure pathways that may be of concern are the following: ingestion of deep and bedrock ground water (onsite media) under average and RME exposure scenarios (VOC under both scenarios, and arsenic and beryllium only under RME); inhalation of VOC from deep and bedrock ground water (onsite media) while showering under average and RME exposure scenarios; dermal contact with VOC in deep and bedrock ground water (onsite media) while showering under RME scenario; and ingestion of shellfish (offshore media) under RME scenario. The other pathways studied resulted in cancer risks less than one in ten thousand ($1 \times 10^4$), indicating that the cancer risks fall in the acceptable range according to EPA policy. The elevated risk to human health from eating shellfish (offshore media) has not been directly related to Site 07 (VOC or arsenic COC at Site 07). The use of deep and bedrock ground water (onsite media) for drinking and showering are risk assessment scenarios requested by EPA, but are not required for the planned use of the Site as conservation area (municipal water is available in the vicinity). The exposure is related to ground water from the VOC plume area and not the entire Site. Additionally, the ground water beneath the site is classified by RIDEM

as GB (presumed to require treatment prior to drinking), and most of the ground water beneath the Site is naturally brackish to saline.

The results for noncancer risk analysis as summarized in Table 6-51 show that the exposure pathways that may be of concern are the following: ingestion of deep and bedrock ground water (onsite media) under average and RME exposure scenarios (VOC under both scenarios; manganese and chromium under average exposure [HQs=1 to 3]; and manganese, arsenic, aluminum, and thallium under RME [HQs=1 to 4, except HQ=19 for manganese from bedrock]); inhalation of VOC from deep and bedrock ground water (onsite media) while showering under average and RME exposure scenarios; dermal contact with VOC in deep and bedrock ground water (onsite media) while showering under RME scenario; and ingestion of shellfish (offshore media) under average and RME scenarios. The other pathways studied resulted in noncancer HQs less than one, indicating that the noncancer risks fall in the acceptable range according to EPA policy. The elevated risk to human health from eating shellfish (offshore media) is not directly related to Site 07 nor specifically to VOC (COC at Site 07). The use of deep and bedrock ground water (onsite media) for drinking and showering are risk assessment scenarios requested by EPA, but are not required for the planned use of the Site as conservation area (municipal water is available in the vicinity). The exposure is related to ground water from the VOC plume area and not the entire Site. Additionally, the ground water beneath the site is classified by RIDEM as GB (presumed to require treatment prior to drinking), and most of the ground water beneath the Site is naturally brackish to saline.

The planned use and manner of transfer of the Site will provide the manner of managing the identified risk from potential future drinking and/or showering with deep ground water. Calf Pasture Point will be transferred to the Town of North Kingstown as a public benefit conveyance for use as an open space/conservation area. Acquisition in this manner restricts the transferee to use the property for the purpose of park and recreation in perpetuity with no opportunity for resale or commercial development. In addition, the Navy will include ground-water-use restrictions in the conveyance. The ground-water-use restrictions shall remain in effect, until the petitioner can successfully demonstrate attainment of ground-water-cleanup levels throughout the site at the time of the petition. The responsibility to abide by any deed restrictions in effect on the use of the property will be that of the Town of North Kingstown in perpetuity.

## 7.9 RECOMMENDATIONS

No further action with long-term monitoring is recommended for Site 07 because there does not appear to be unacceptable Site-related risk to the environment (terrestrial and marine). The identified unacceptable risk to human health was from drinking or showering with deep ground water from within the VOC plume. Neither drinking or showering with deep ground water are necessary for the planned used of the Site as a conservation area because municipal water is available in the vicinity. The elevated risk to human health from eating shellfish is not directly related to Site 07 nor specifically to VOC (COC at Site 07). The Navy is developing the long-term monitoring plan as a separate document.

## REFERENCES

Abernathy, C.O., W. Marcus, C. Chen, H. Gibb and P. White. 1989. Memorandum to P. Cook, Office of Drinking Water, EPA, and P. Preuss, Office of Regulatory Support and Scientific Management, EPA, reporting on Arsenic (As) Work Group meetings. U.S. Environmental Protection Agency, Office of Drinking Water and Office of Research and Development. February 23.

Allen, J.R., and D.H. Norback. 1973. Polychlorinated biphenyl- and triphenyl-induced gastric mucosal hyperplasia in primates. *Science* 179: 498-499.

Anwar, R.A., R.F. Langham, C.A. Hoppert, et al. 1961. Chronic toxicity studies III. Chronic toxicity of cadmium and chromium in dogs. *Arch. Environ. Health* 3:456-460.

Attahiru, U.S., T.T. Iyaniwura, A.O. Adaudi, and J. J. Bonire. 1991. Acute toxicity studies of tri-n-butyltin and triphenyltin acetates in rats. *Vet. Hum. Toxicol.* 33(6): 554-556.

ATSDR (Agency for Toxic Substances and Disease Registry). 1987. *Draft Toxicological Profile for Beryllium*. Prepared by Syracuse Research Corporation for U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia. October.

ATSDR (Agency for Toxic Substances and Disease Registry). 1989a. *Toxicological Profile for Naphthalene*. Draft for public comment. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. 237 pp.

ATSDR (Agency for Toxic Substances and Disease Registry). 1989b. *Toxicological Profile for 1,1,1-Trichloroethane*. Draft for public comment. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. 209 pp.

ATSDR (Agency for Toxic Substances and Disease Registry). 1990. *Toxicological Profile for Polycyclic Aromatic Hydrocarbons*. Report No. TP-90-20. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. 231 pp. Available from NTIS (National Technical Information Service), Springfield, Virginia 22161, as PB91-181537.

ATSDR (Agency for Toxic Substances and Disease Registry). 1990a. *Toxicological Profile for Antimony (Draft)*. Prepared by Syracuse Research Corporation under subcontract to Clement Associates, Inc. for U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. 129 pp. October.

ATSDR (Agency for Toxic Substances and Disease Registry). 1991a. *Toxicological Profile for Arsenic*. Draft for public comment. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. 189 pp.

ATSDR (Agency for Toxic Substances and Disease Registry). 1991b. Draft Toxicological Profile for Trichloroethylene. Update draft for public comment. U.S. Department of

Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. [166 pp.] October.

ATSDR (Agency for Toxic Substances and Disease Registry). 1992. *Toxicological Profile for Zinc.* U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta.

ATSDR (Agency for Toxic Substances and Disease Registry). 1993. *Toxicological Profile for Lead.* Report No. TP-92/12. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta. Available from NTIS (National Technical Information Service), Springfield, Virginia 22161, as PB93-182475. 339 pp.

Axelsson, G., R. Rylander, and A. Schmidt. 1980. Mortality and incidence of tumors among ferrochromium workers. *Br. J. Ind. Med.* 38: 117-124.

Azar, A., H.J. Trochimowicz, and M.E. Maxfield. 1973. Review of lead studies in animals carried out at Haskell Laboratory: Two year feeding study and response to hemorrhage study, pp. 199-210 in *Environmental Health Aspects of Lead: Proceedings, International Symposium, October 1972, Amsterdam, The Netherlands* (D. Barth, A. Berlin, R. Engel, P. Recht, and J. Smeets, Eds.). Commission of the European Communities, Luxembourg.

Baes III, C.F., R.D. Sharp, A.J. Sjoreen, and R.W. Shor. 1984. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture.* ORNL-5786, Oak Ridge National Laboratory.

Baker, E.L., Jr., P.J. Landrigan, A.G. Barbour, D.H. Cox, D.S. Folland, R.N. Ligo, and J. Throckmorton. 1979. Occupational lead poisoning in the United States: Clinical and biochemical findings related to blood lead levels. *Br. J. Ind. Med.* 36: 314-322.

Baker, E.L., Jr., P.J. Landrigan, C.J. Glueck, M.M. Zack, Jr., J.A. Liddle, V.W. Burse, W.J. Housworth, and L.L. Needham. 1980a. Metabolic consequences of exposure to polychlorinated biphenyls (PCB) in sewage sludge. *Am. J. Epidemiol.* 112: 553-563.

Baker, E.L., R.A. Goyer, B.A. Fowler, U. Khettry, D.B. Bernard, S. Adler, R.D. White, R. Babayan, and R.G. Feldman. 1980b. Occupational lead nephropathy and renal cancer. *Am. J. Ind. Med.* 1: 138-148.

Barfknecht, T.R., R.A. Hites, E.L. Cavaliers, and W.G. Thilly. 1982. Human cell mutagenicity of polycyclic aromatic hydrocarbon components of diesel emissions. *Dev. Toxicol. Environ. Sci.* 10: 277-294.

Battelle Memorial Institute. 1989. *Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS): Version 1.* Prepared for the U.S. Department of Energy under Contract DE-AC06-76RKI 1830, by Pacific Northwest Laboratory, operated by Battelle Memorial Institute.

Berenblum, I., and H. Haran. 1955. The influence of croton oil and of polyethylene glycol-400 on carcinogenesis in the forestomach of the mouse. *Cancer Res.* 15: 510.

Berlin, M. 1979. Mercury. In: L. Friberg, G.F. Nordberg, and V.B. Vouk (eds.). *Handbook on the Toxicology of Metals.* Elsevier/North-Holland Biomedical Press, Amsterdam.

Bertazzi, P.A., L. Riboldi, A. Pesatori, L. Radice, and C. Zochetti. 1987. Cancer mortality of capacitor manufacturing workers. *Am. J. Ind. Med.* 11: 165-176.

Bertazzi, P.A., C. Zochetti, S. Guercilena, M.D. Foglia, A. Pesatori, and L. Riboldi. 1982. Mortality study of male and female workers exposed to PCBs, pp. 242-248 in *Prevention of Occupational Cancer: International Symposium.* Occupational Safety and Health Series No. 46. International Labour Office, Geneva.

Bhamra, R.K., and M. Costa. 1992. Trace elements aluminum, arsenic, cadmium, mercury, and nickel, pp. 575-632 in *Environmental Toxicants. Human Exposures and Their Health Effects* (M. Lippmann, Ed.). Van Nostrand Reinhold, New York.

Bingham, E., and H.L. Falk. 1969. Environmental carcinogens: The modifying effect of carcinogens on the threshold response. *Arch. Environ. Health* 19: 779-783.

Bock, F.G., and D.W. King. 1959. A study of the sensitivity of the mouse forestomach toward certain polycyclic hydrocarbons. *J. Nat. Cancer Inst.* 23: 833.

Brown, D.P., and M. Jones. 1981. Mortality and industrial hygiene study of workers exposed to polychlorinated biphenyls. *Arch. Environ. Health.* 36: 120-129.

Brown, D.P. 1987. Mortality of workers exposed to polychlorinated biphenyls—An update. *Arch. Environ. Health.* 42: 333-339.

Brune, H., R.P. Deutsch-Wenzel, M. Habs, S. Ivankovic, and D. Schmahl. 1981. Investigation of the tumorigenic response to benzo[*a*]pyrene in aqueous caffeine solution applied orally to Sprague-Dawley rats. *J. Cancer Res. Clin. Oncol.* 102(2): 153-157.

Budavari, S. 1989. *The Merck Index.* Merck and Co.,Inc., pages 483 and 773.

Byren, D., G. Engholm, A. Englund, and P. Westerholm. 1976. Mortality and cancer morbidity in a group of Swedish VCM and PVC production workers. *Environ. Health Perspect.* 17: 167–170.

Calabrese, E.J., and E.M. Kenyon. 1991. *Air Toxics and Risk Assessment.* Lewis, Chelsea, Michigan.

Carr, P.A., and Van Der Kamp, G.S. 1969. *Determining Aquifer Characteristics by the Tidal Method.* Water Resources Research 5(5):1023-1031.

CDC (Centers for Disease Control and Prevention). 1991. *Preventing Lead Poisoning in Young Children. A Statement by the Centers for Disease Control—October 1991.* U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Atlanta. 107 pp.

Challenger, F. 1945. Biological methylation. *Chem. Rev.* pp. 315-361.

Cohen, R.M., J.W. Mercer, J. Matthews. 1993. *DNAPL Site Evaluation.* USEPA. ISBN 0-87371-977-8. Published by CRC Press.

Collins, J.J., P. Conner, B.R. Friedlander, P.A. Easterday, R.S. Nair, S. Rashmi, and J. Braun. 1991. A study of the hematological effects of chronic low-level exposure to benzene. *J. Occup. Med.* 33: 619-626.

Cooper, D.A., E.P. Pendergrass, A.J. Vorwald, et al. 1968. Pneumoconiosis among workers in an antimony industry. *Am. J. Roentgenol. Rad. Ther. Nuclear Med.* 103: 495-508.

Cooper, W.C., O. Wong, and L. Kheifets. 1985. Mortality among employees of lead battery plants and lead-producing plants, 1947-1980. *Scand. J. Work. Environ. Health.* 11: 331-345.

Cowherd, J.C., G.E. Muleski, P.J. Englehart, and D.A. Grillett. 1985. *Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites.* EPA-600/8-86/002.

Cox, G.E., D.E. Bailey, and K. Morgareidge. 1975. *Toxicity Studies in Rats with 2-Butanol including Growth, Reproduction and Teratologic Observations.* Report No. 91MR R 1673. Food and Drug Research Laboratories, Inc., Waverly, NY.

Crespi, C.L., H.L. Liber, T.D. Behymer, R.A. Hites, and W.G. Thilly. 1985. A human cell line sensitive to mutation by particle-borne chemicals. *Mutat. Res.* 157: 71-75.

Cronkite, E.P., R.T. Drew, T. Inoue, Y. Hirabayashi, and J.E. Bullis. 1989. Hematotoxicity and carcinogenicity of inhaled benzene. *Environ. Health Perspect.* 82: 97-108.

Cronkite, E.P., R.T. Drew, T. Inoue, and J.E. Bullis. 1985. Benzene hematotoxicity and leukemogenesis. *Am. J. Ind. Med.* 7: 447-456.

Davis, K.J. 1965. *Pathology Report on Mice Fed Dieldrin, Aldrin, Heptachlor, or Heptachlor Epoxide for Two Years.* Internal FDA Memorandum to Dr. A. J. Lehrman, July 19.

Deknudt, G.H., and G. Gerber. 1979. Chromosomal aberrations in bone marrow cells of mice given a normal of calcium-deficient diet supplemented with various heavy metals. *Mutat. Res.* 68: 163-168.

Deknudt, G.H. 1982. Clastogenic effects of zinc in mammals. *C.R. Soc. Biol.* 176: 563-567 (in French). As cited in ATSDR (1989c).

Deutsch-Wenzel, R.P., H. Brune, G. Grimmer, G. Dettbarn, and J. Misfeld. 1983. Experimental studies in rat lungs on the carcinogenicity and dose-response relationships of eight frequently occurring environmental polycyclic aromatic hydrocarbons. *J. Nat. Cancer Inst.* 71: 539-544.

Di Toro, D.M. and L.M. Horzempa. 1982. *Reversible and resistant components of PCB absorption-desorption: Isotherms.* Env. Sci. Technol. 16:594-602.

Di Toro, D.M. and L.M. Horzempa. 1983. *Reversible and resistant component model of hexachlorobiphenyl absorption-desorption and dilution, in Physical Behavior of PCBs in the Great*

*Lakes* (D. Mackay, S. Paterson, S.J. Eisenreich, and M.S. Simmons, eds.). Ann Arbor Science,, Ann Arbor, Michigan. Pp. 89-113.

Drew, R.T., and J.R. Fouts. 1974. The lack of effects of pretreatment with phenobarbital and chlorpromazine on the acute toxicity of benzene in rats. *Toxicol. Appl. Pharmacol.* 27: 183-193.

EA Engineering, Science, and Technology, 1994. *Phase III RI Work Plan, IR Program Sites 03 and 09, Naval Construction Battalion Center, Davisville, Rhode Island.* October.

EA Engineering, Science, and Technology. 1996a. *Draft Final: Allen Harbor Landfill and Calf Pasture Point Marine Ecological Risk Assessment Report*, Naval Construction Battalion Center, Davisville, Rhode Island. February. Prepared by SAIC under contract to EA Engineering.

EA Engineering, Science, and Technology. 1996b. *Draft Final: Facility-Wide Freshwater/Terrestrial Ecological Risk Assessment Report*, Naval Construction Battalion Center, Davisville, Rhode Island. February.

EA Engineering, Science, and Technology. 1998. *Draft: IR Program Site 09, Allen Harbor Landfill, Offshore Investigation Report,* Naval Construction Battalion Center, Davisville, Rhode Island. *April.*

Echeverria, D., L. Fine, G. Langolf, A. Schork, and C. Sampaio. 1989. Acute neurobehavioural effects of toluene. *Br. J. Ind. Med.* 46: 483-495.

Ema, M., R. Kurosaka, H. Amano, and Y. Ogawa. 1996. Comparative developmental toxicity of di-, tri- and tetrabutyltin compounds after administration during late organognesis in *rats. J. Appl. Toxicol.* 16(1):71-76.

Ema, M., R. Kurosaka, H. Amano, and Y. Ogawa. 1995. Comparative developmental toxicity of butyltin trichloride and dibutyltin dichloride and tributyltin chloride in rats. *J. Appl. Toxicol.* 15(4):297-302.

Ema, M., T. Itami, H. Kawasaki. 1991. Teratogenicity of di-n-butyltin dichloride in rats. Toxicol. Lett. 58(3):347-356.

EPA (U.S. Environmental Protection Agency). 1985a. *Drinking Water Criteria Document for Vinyl Chloride (Final Draft).* Report to U.S. Environmental Protection Agency, Office of Drinking Water, Washington, D.C., by Life Systems, Inc., Cleveland, Ohio. January. 125 pp.

EPA (U.S. Environmental Protection Agency). 1985b. *Health and Environmental Effects Profile for Chloroethene.* Report No. EPA/600/X-85/374. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Criterial and Assessment Office, Cincinnati, Ohio. September. 176 pp.

EPA (U.S. Environmental Protection Agency). 1985c. *Health Assessment Document for Trichloroethylene.* Report No. EPA/600/8-82-006F. Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1986a. Guidelines for carcinogen risk assessment. *Fed. Reg.* 51: 33992–34003. September 24.

EPA (U.S. Environmental Protection Agency). 1986b. Ninety-day gavage study in albino rats using acetone. Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 1986c. *Quality Criteria for Water*, EPA 44015-86-001.

EPA (U.S. Environmental Protection Agency), 1986d. *Superfund Public Health Evaluation Manual.* Report No. EPA/540/1-86/060. Office of Emergency and Remedial Response, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1987. *o, m, p-Cresol. 90-Day oral subchronic neurotoxicity study in rats*. Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1988a. *Superfund Exposure Assessment Manual.* Report No. EPA/540/1-88/001. EPA Office of Remedial Response, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1988b. *A Cancer Risk-Specific Dose Estimate for 2,3,7,8-TCDD (External Review Draft).* Report No. EPA/600/6-88/007Aa. EPA Office of Health and Environmental Assessment, Washington, D.C. June.

EPA (U.S. Environmental Protection Agency). 1989a. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (Interim Final).* Report No. EPA/540/1-89002. EPA Office of Emergency and Remedial Response, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989b. *Supplemental Risk Assessment Guidance for the Superfund Program.* Report. No. EPA/901/5-89-001. EPA Region I Risk Assessment Work Group, Boston, Massachusetts.

EPA (U.S. Environmental Protection Agency). 1989c. *Subchronic Toxicity in Mice with Anthracene.* Final Report. Conducted by Hazelton Laboratories America, Inc., Vienna, Virginia, for EPA Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989d. *Mouse Oral Subchronic Study with Acenaphthene.* Conducted by Hazleton Laboratories, Inc., Vienna, Virginia, for EPA Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989e. *13-Week Mouse Oral Subchronic Toxicity Study with Fluoranthene.* Conducted by Toxicity Research Laboratories, Muskegon, Michigan, for EPA Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989f. *13-Week Mouse Oral Subchronic Toxicity Study with Fluorene.* Conducted by Toxicity Research Laboratories, Muskegon, Michigan, for EPA Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989g. *13-Week Mouse Oral Subchronic Toxicity Study with Pyrene.* TRL Study No. 042-012. Conducted by Toxicity Research Laboratories, Muskegon, Michigan, for EPA Office of Solid Waste, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1989h. *Health and Environmental Effects Profile for Benzo(g,h,i)perylene*, p. 24. Report No. 600/X-87/395. EPA, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1990. *Exposure Factors Handbook*. Report No. EPA/600/8-89/043. EPA Office of Health and Environmental Assessment, Exposure Assessment Group, Washington, D.C. March.

EPA (U.S. Environmental Protection Agency). 1991. *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual. Supplemental Guidance: Standard Default Exposure Factors. Interim Final*. OSWER Directive 9285.6-03. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Toxics Integration Branch, Washington, D.C. 20 pp. March 25.

EPA (U.S. Environmental Protection Agency). 1992a. *Guidelines for exposure assessment*; Notice. Fed. Reg. 57: 22887–22938. 29 May.

EPA (U.S. Environmental Protection Agency). 1992b. *Supplemental Guidance to RAGS: Calculating the Concentration Term*. Publication 9285.7-01. EPA Office of Solid Waste and Emergency Response, Washington, D.C. May.

EPA (U.S. Environmental Protection Agency). 1992c. *Dermal Exposure Assessment: Principles and Applications—Interim Report*. Report No. EPA/600/8-91/011B. EPA Office of Research and Development, Washington, D.C. January.

EPA (U.S. Environmental Protection Agency). 1993a. *Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening—Technical Guidance Manual*. Report No. EPA/903/R-93-001. EPA Region III, Office of Superfund Programs, Philadelphia. January.

EPA (U.S. Environmental Protection Agency). 1993b. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. Report. No. EPA/600/R-93/089. EPA Office of Research and Development, Washington, D.C. July.

EPA (U.S. Environmental Protection Agency). 1994a. *Risk Updates*, Number 2. EPA Region I, Waste Management Division, Boston. August.

EPA (U.S. Environmental Protection Agency). 1994b. *Health Effects Assessment Summary Tables FY-1994 Annual (Including Supplements 1 and 2)*. Report No. EPA/540/R-94/020. EPA Office of Solid Waste and Emergency Response, Washington, D.C. March.

EPA (U.S. Environmental Protection Agency). 1994c. *EPA Comments on the Draft Phase III Remedial Investigation (RI) Work Plan for Site 09, Allen Harbor Landfill and Site 03, Solvent Disposal Area*. (with cover letter from Christine Williams, EPA Region I, dated 13 December 1994).

EPA (U.S. Environmental Protection Agency). 1994d. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. OSWER Directive #9355.4-12. EPA Office of Solid Waste and Emergency Response, Washington, D.C. July.

EPA (U.S. Environmental Protection Agency). 1994e. *Soil Screening Level Guidance—Quick Reference Fact Sheet*. Report No. EPA/540/R-94/101. EPA Office of Solid Waste and Emergency Response, Washington, D.C.

EPA (U.S. Environmental Protection Agency). 1994f. *Estimating Exposures to Dioxin-Like Compounds — Volume III: Site-Specific Assessment Procedures (External Review Draft)*. Report No. EPA/600/6-88/005Cc. EPA Office of Research and Development, Washington, DC. June

EPA (U.S. Environmental Protection Agency). 1994g. *Technical Background Document for Soil Screening Guidance*, EPA540/R-94/106.

EPA (U.S. Environmental Protection Agency). 1995a. *IRIS (Integrated Risk Information System) on-line database maintained in Toxicology Data Network (TOXNET)* by the National Library of Medicine, Bethesda, Maryland. EPA Environmental Criteria and Assessment Office, Cincinnati, Ohio.

EPA (U.S. Environmental Protection Agency). 1995b. *EPA Region III Risk-Based Concentration Table (Update)*. EPA Region III, Philadelphia.

EPA (U.S. Environmental Protection Agency). 1995c. *Personal communication*, Jane Michaud, EPA Region I, Boston.

EPA (U.S. Environmental Protection Agency). 1995d. *Risk Assessment Issue Papers*. U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office, Cincinnati, Ohio. Available from USEPA Superfund Technical Support Center, operated by Labat-Anderson, Inc., tel. 1-800-424-9346.

EPA (U.S. Environmental Protection Agency). 1995e. *October 12, 1995 EPA Comments RE: Revised Draft IR Program Site 09, Phase III Remedial Investigation (RI) Report*, August 1995, Former Naval Construction Battalion Center, Davisville, RI. EPA Region I, Boston, Massachusetts.

EPA (U.S. Environmental Protection Agency). 1995f. *Risk Updates*, Number 3. EPA Region I, Waste Management Division, Boston. August.

EPA (U.S. Environmental Protection Agency). 1996. PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures, EPA/600/P-96/001A, January. External Review Draft.

Epstein, S.S. 1975. *The carcinogenicity of dieldrin*. Part 1. Sci. Total Environ. 4: 1–52.

Ernhart, C.B., B. Landa, and N.B. Schell. 1981. *Subclinical levels of lead and developmental deficit—A multivariate follow-up reassessment*. Pediatrics 67: 911–919.

Feenstra, S., D.M. MacKay, and J.A. Cherry. 1991. *A method for assessing residual NAPL based on organic chemical concentrations in soil samples*. Ground Water Monitoring Rev. 11(2):128-136.

Fenneman, N.M. 1938. *Physiography of the Eastern United States*. McGraw-Hill, New York.

Feron, V.J., A.J. Speek, M.I. Willems, D. VanBattum, and A.P. Groot. 1975. *Observations on the oral administration and toxicity of vinyl chloride in rats*. Food Cosmet. Toxicol. 13(6): 633–638.

Feron, V.J., C.F.M. Hendriksen, A.J. Speek, H.P. Til, and B.J. Spit. 1981. *Lifespan oral toxicity study of vinyl chloride in rats*. Food Cosmet. Toxicol. 19: 317-333.

Fishbein, L. 1974. *Toxicity of chlorinated biphenyls*. Ann. Rev. Pharmacol. 14: 139–156.

Fitzhugh, O.G., A.A. Nelson, and M.L. Quaife. 1964. *Chronic oral toxicity of aldrin and dieldrin in rats and dogs*. Food Cosmet. Toxicol. 2: 551–562.

Flurry, F. 1928. II. *Toxicities in modern industry. IIa. Pharmacological-toxicological aspects of intoxicants in modern industry*. Arch. Exp. Pathol. Pharmakol. 138: 65–82 (in German).

Foo, S.C., J. Jeyaratnam, and D. Koh. 1990. *Chronic neurobehavioural effects of toluene*. Br. J. Ind. Med. 47: 480–484.

Foster Wheeler Environmental Corporation. 1997. Revised Contractor's Close-Out Report For The Removal Action At Calf Pasture Point Munitions Bunkers, Naval Construction Battalion Center (NCBC), Davisville, RI. October.

Garberg, P., E. Akerblom, and G. Bolcsfoldi. 1988. *Evaluation of a genotoxicity test measuring DNA-strand breaks in mouse lymphoma cells by alkaline unwinding and hydroxyapatite elution*. Mutat Res. 203: 155-176.

Gerarde, HW 1960. *Toxicology and biochemistry of aromatic hydrocarbons*, pp. 240–321 in Monographs on Toxic Agents (E. Browning, Ed.). Elsevier, New York.

Ghetto, G., and L. Mariani. 1956. *Eye changes due to naphthalene*. Med. Law. 47:533–538 (in Italian).

Ghiorse, W.C. and J.T. Wilson. 1988. *Microbial ecology of the terrestrial subsurface*. Adv. Appl. Microbiol. 33:107-174.

Goel, K.A., V.P. Agrawal, V. Garg. 1980. *Pulmonary toxicity of beryllium in albino rat*. Bull. Environ. Contam. Toxicol. 24: 59–64.

Goldstein, B.D. 1988. *Benzene toxicity: Occupational medicine*. State of the Art Reviews. 3: 541–554.

Goyer, R.A. 1986. *Toxic effects of metals*. Pp. 582–635 in C.D. Klaassen, M.O. Amdur, and J. Doull, Eds. Casarett and Doull's Toxicology. The Basic Science of Poisons, 3rd ed. Macmillan, New York.

Gregg, D.O. 1966. *An analysis of Ground-Water Fluctuations Caused by Ocean Tides in Glynn County, Georgia*. Ground Water 4(3):24-32.

GZA GeoEnvironmental, Inc. 1992. *Phase I Report, Hunt River Aquifer Wellhead Recharge Area Study*. Prepared for the North Kingstown Planning Department, North Kingstown, Rhode Island. December.

Habs, M., D. Schmahl, and J. Misfeld. 1980. *Local carcinogenicity of some environmentally relevant polycyclic aromatic hydrocarbons after lifelong topical application to mouse skin*. Arch. Geschwulstforsch. 50: 266–274.

Halliburton NUS. 1994. *Final Study Area Screening Evaluation Report for Calf Pasture Point Munitions Bunkers*. Naval Construction Battalion Center, Davisville, RI. Prepared for Northern Division, NAV FAC Eng. Com, Contract No. N62472-90-D-1298. September.

Hammond, E.D., I.J. Selikoff, P.O. Lawther, and H. Seidman. 1976. *Inhalation of B[a]P and cancer in man*. Ann. N.Y. Acad. Sci. 271: 116–124.

Hammond, P.B. and R.P. Beliles. 1980. Metals, in *Casarett and Doull's Toxicology: The Basic Science of Poisons* (J. Doull, C.D. Klaassen, and M.O. Amdur, Eds.), 2nd ed. Macmillan, New York.

Hancock, D.G., A.E. Moffitt, Jr., and E.B. Hay. 1984. *Hematological findings among workers exposed to benzene at a coke oven by-product recovery facility*. Arch. Environ. Health 39: 414–418.

Hänninen, H., P. Mantere, S. Hernberg, A.M. Seppalainen, and B. Kock. 1979. *Subjective symptoms in low-level exposure to lead*. Neurotoxicology 1: 333–347.

Hansen, L. 1987. *Food chain modification of the composition and toxicity of polychlorinated biphenyl (PCB) residues*. Pp. 149–212 in Reviews in Environmental Toxicology, Vol. 3 (E. Hodgson, Ed.). Elsevier, New York.

Hardin, B.D., G.P. Bond, M.R. Sikov, F.D. Andrew, R.P. Beliles and R.W. Niemeier. 1981. *Testing of selected workplace chemicals for teratogenic potential*. Scand. J. Work Environ. Health 7(suppl 4): 66–75.

Harlan, W.R. 1988. *The relationship of blood lead levels to blood pressure in the U.S. population*. Environ. Health Perspect. 78: 9–13.

Fred C. Hart Associates (Hart). 1984a. *Initial Assessment Study of Naval Construction Battalion Center, Davisville, Rhode Island*. Prepared for U.S.Navy, Department of Assessment and Control of Installation Pollutants, Port Hueneme, CA. Contract No. N62474-83-C6974. September.

Fred C. Hart Associates (Hart). 1984b. *Off-Activity Site Investigations. Naval Construction Battalion Center, Davisville, Rhode Island*. Prepared for U.S.Navy, Department of Assessment and Control of Installation Pollutants, Port Hueneme, CA. September (as referenced in EPA 1989 — HRS Scoring Package).

Hecht, S.S., W.E. Bondinell, and D. Hoffmann. 1974. *Chrysene and methylchrysenes: Presence on tobacco smoke and carcinogenicity*. J. Nat. Cancer Inst. 53: 1121–1133.

Heinrich, U., F. Pott, U. Mohr, R. Fuhst, and J. Koenig. 1986. *Lung tumors in rats and mice after inhalation of polycyclic aromatic hydrocarbon-rich emissions*. Exp. Pathol. 29: 29–34.

Heldaas, S.S., S.L. Langard, and A. Anderson. 1984. *Incidence of cancer among vinyl chloride and polyvinyl chloride workers*. Br. J. Ind. Med. 41: 25–30.

Heywood, R., R.J. Sortwell, P.R.B. Noel, A.E. Street, D.E. Prentice, F.J.C. Roe, P.F. Wadsworth, A.N. Worden, and N.J. Van Abbe. 1979. *Safety evaluation of toothpaste containing chloroform: III. Long-term study in beagle dogs*. J. Environ. Pathol. Toxicol. 2: 835–851.

Hong, C.B., J. M. Winston, L.P. Thornburg, C.C. Lee, and J.S. Woods. 1981. *Follow-up study on the carcinogenicity of vinyl chloride and vinylidene chloride in rats and mice: Tumor incidence and mortality subsequent to exposure*. J. Toxicol. Environ. Health 7: 909–924.

Howard P.H. 1990. *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II Solvents*, Lewis Publishers, Chelsea MI.

Howard, P.H., R. Boethling, W. Jarvis, W. Meylan, E. Michalenko. 1991. *Handbook of Environmental Degradation Rates*, Lewis Publishers, Inc., Chelsea, Michigan.

Hoffmann, D., F. Rathkamp, S. Nesnow, and E.L. Wynder. 1972. Fluoranthenes: Quantitative determination in cigarette smoke, formation by pyrolysis, and tumor-initiating activity. *J. Nat. Cancer Inst.* 49: 1165–1175.

Hoffmann, D., and E.L. Wynder. 1966. *Beitrag zur carcinogenen Wirkung von Dibenzopyrenen*. Z. Krebsforsch. 68: 137–149 (in German).

Holmqvist, I. 1951. *Occupational arsenical dermatitis. A study among employees at a copper ore smelting work, including investigations of skin reactions to contact with arsenic compounds*. Acta Derm. Venereol. 31: 1–214.

HSDB (Hazardous Substances Data Base). 1995. *Hazardous Substances Data Bank*. Computerized chemical data file on the Toxicology Data Network (TOXNET), managed by Toxicology Information Program, National Library of Medicine, Bethesda, Maryland.

Huggins, C., and N.C. Yang. 1962. *Induction and extinction of mammary cancer*. Science 137: 257–262.

IARC (International Agency for Research on Cancer). 1983. *IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans. Vol. 32. Polynuclear Aromatic Compounds, Part 1. Chemical, Environmental and Experimental Data*. World Health Organization, International Agency for Research on Cancer, Lyon, France.

IARC (International Agency for Research on Cancer). 1987a. *Polychlorinated biphenyls (Group 2A)*. Pp. 322–326 in *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Supplement 7. Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs, Volumes 1 to 42*. World Health Organization, International Agency for Research on Cancer, Lyon, France.

IARC (International Agency for Research on Cancer). 1987b. *Vinyl chloride (Group 1)*. Pp. 373–376 in *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1 to 42. Supplement 7.* World Health Organization, International Agency for Research on Cancer, Lyon, France.

Infante, P.F., R.A. Rinsky, J.K. Wagoner, and R.J. Young. 1977. *Leukemia in benzene workers. Lancet* 2: 76–78.

Infante, P.F. 1981. *Observations of the site-specific carcinogenicity of vinyl chloride to humans.* Environ. Health Perspect. 41: 89–94.

IPCS (International Programme on Chemical Safety). 1993. *Polychlorinated Biphenyls and Terphenyls*, 2nd ed. Environmental Health Criteria No. 40. World Health Organization, Geneva. 682 pp.

Johnson, K.E., and L.Y. Marks. 1959. Groundwater Map of the Wickford Quadrangle, Rhode Island. Map GWM 1. U.S. Geological Survey, Reston, VA.

Jorgenson, T.A., C.J. Rushbrook, and D.C.L. Jones. 1982. *Dose-response study of chloroform carcinogenesis in the mouse and rat: Status report.* Environ. Health Perspect. 46: 141–149.

Kang, H.K., P.F. Infante, and J.S. Carra. 1980. *Occupational lead exposure and cancer* (letter). Science 207: 935–936.

Karickoff, S.W., V.K. McDaniel, C. Melton, A.N. Vallino, and D.E. Nute. 1991. *Predicting chemical reactivity by computer.* Env. Toxic. And Chem. Vol. 10:1405-1516.

Kennaway, E.L. 1924. *On cancer-producing tars and tar-fractions.* J. Ind. Hyg. 5: 462–488.

Kimbrough, R.D., R.A. Squire, R.E. Linder, J.D. Stranberg, R.J. Montali, and V.W. Burse. 1975. *Induction of liver tumors in Sherman strain female rats by polychlorinated biphenyl Aroclor* 1260. J. Nat. Cancer Inst. 55: 1453–1459.

Kimbrough, R.D., R.E. Linder, and T.B. Gaines. 1972. *Morphological changes in livers of rats fed polychlorinated biphenyls. Light microscopy and ultrastructure.* Arch. Environ. Health 25: 354–364.

King, Ian P. 1990a. RMA2 - *A Two Dimensional Finite Element Model for Flow in Estuaries and Streams.* Resource Management Associates, Lafayette, CA.

King, Ian P. 1990b. RMA4 - *A Two Dimensional Finite Element Water Quality Model,* Dept. Of Civil Engineering, University of California, Davis, CA.

Koller, L.D., N.I. Kerkvliet, and J.H. Exon. 1985. *Neoplasia induced in male rats fed lead acetate, ethylurea and sodium nitrite.* Toxicologic Pathol. 13: 50–57.

Lacassagne, A., N.P. Buu-Hoi, F. Zajdela, D. Lavit-Lamy, and O. Chalvet. 1963. *Carcinogenic activity of polycyclic aromatic hydrocarbons with a fluoranthene group*. Unio Int. Cancrum Acta 19: 490 (in French).

Ladefoged, O., P. Strange,, A. Moller, et al. 1991. *Irreversible effects in rats of toluene (inhalation) exposure for six months*. Pharmacol. Toxicol. (Denmark) 68(5) (May): 384-390.

Langard, S., A. Anderson, and B. Gylseth. 1980. *Incidence of cancer among ferrochromium and ferrosilicon workers*. Br. J. Ind. Med. 37: 114-120.

LaVoie, E., V. Bedenko, N. Hirota, S.S. Hecht, and D. Hoffmann. 1979. *A comparison of the mutagenicity, tumor-initiating activity and complete carcinogenicity of polynuclear aromatic hydrocarbons*. Pp. 705-721 in Polynuclear Aromatic Hydrocarbons (P.W. Jones and P. Leber, Eds.). Ann Arbor Science, Ann Arbor, Michigan.

LaVoie, E.J., L. Tully, V. Bedenko, and D. Hoffmann. 1981. *Mutagenicity of methylated fluorenes and benzofluorenes*. Mutat. Res. 91: 167-176.

LaVoie, E.J., S. Amin, S.S. Hecht, L. Furuya, and D. Hoffmann. 1982. *Tumor initiating activity of dihydrodiols of benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene*. Carcinogenesis 3: 49-52.

LaVoie, E.J., J. Braley, J.E. Rice, and A. Rivenson. 1987. *Tumorigenic activity of non-alternant polynuclear aromatic hydrocarbons in newborn mice*. Cancer Lett. 34: 15-20.

Lee, F.I., D.S. Harry, W.G.F. Adams, and M. Litchfield. 1977. *Screening for liver disease in vinyl chloride workers*. Br. J. Ind. Med. 34: 142-147.

Lee, C.C., J.C. Bhandari, J.M. Winston, W.B. House, R.L. Dixon, and J.S. Woods. 1978. *Carcinogenicity of vinyl chloride and vinylidene chloride*. J. Toxicol. Environ. Health 4: 15-30.

Lindberg, E., and G. Hedenstierna. 1983. *Chrome plating. Symptoms, findings in the upper airway, and effects of lung function*. Arch. Environ. Health 38: 367-374.

Lloyd, J.W. 1971. Long-term mortality study of steelworkers. V. Respiratory cancer in coke plant workers. *J. Occup. Med.* 13: 53-68.

Lyman, W.J., W.F. Reehl, and D.W. Rosenblatt. 1990. *Handbook of Chemical Property Estimation Methods: Environmental Behavior of Organic Compounds*. McGraw-Hill, New York.

MacKenzie, R.D., R.U. Byerrum, C.F. Decker, C.A. Hoppert, and R.F. Langham. 1958. *Chronic toxicity studies. II. Hexavalent and trivalent chromium administered in drinking water to rats*. Arch. Ind. Health 18: 232-234.

MacKenzie, K.M., and D.M. Angevine. 1981. *Infertility in mice exposed in utero to benzo[a]pyrene*. Biol. Reprod. 24: 183-191.

Maltoni, C., G. Lefemine, A. Ciliberti, G. Cotti, and D. Carretti. 1980. *Vinyl chloride carcinogenicity bioassays (BT project) as an experimental model for risk identification and*

*assessment in environmental and occupational carcinogenesis*. Pp. 11-112 in Epidemiol. Anim. Epidemiol. Hum.: Cas Chlorure Vinyle Monomere. Reun. 20, Club Cancerog. Chim., 1979. Publ. Essent., Paris.

Maltoni, C., G. Lefemine, A. Ciliberti, G. Cotti, and D. Carretti. 1981. *Carcinogenicity bioassays of vinyl chloride monomer: A model of risk assessment on an experimental basis*. Environ. Health Perspect. 41: 3-29.

Maltoni, C., B. Conti, and G. Cotti. 1983. *Benzene: A multipotential carcinogen: Results of long-term bioassays performed at the Bologna Institute of Oncology*. Am. J. Ind. Med. 4: 589-630.

Maltoni, C., G. Lefemine, and G. Cotti. 1986. *Experimental research on trichloroethylene carcinogenesis*, in Archives of Research on Industrial Carcinogenesis Series, Vol. V. (C. Maltoni and M.A. Mehlman, Eds.). Princeton Scientific, Princeton, NJ.

Mamber, S.W., V. Bryson, and S.E. Katz. 1983. *The Esherichia coli WP2/WP100 rec assay for detection of potential chemical carcinogens*. Mutat. Res. 119: 135-144.

Manahan, S.E. 1989. *Toxicological Chemistry: A Guide to Toxic Substances in Chemistry*. Lewis, Chelsea, Michigan. 317 pp.

Mancuso, T.F. 1975. *Consideration of chromium as an industrial carcinogen*. Pp. 343-356 in International Conference on Heavy Metals in the Environment, Toronto, Ontario, Canada, October 27-31. Toronto Institute for Environmental Studies, Toronto.

Maroni, M., A. Colombi, G. Arbosti, S. Cantoni, and V. Foa. 1981. *Occupational exposure to polychlorinated biphenyls in electrical workers: II. Health effects*. Brit. J. Ind. Med.38: 55-60.

Mazumdar, S., C.K. Redmond, W. Sollecito, and N. Sussman. 1975. *An epidemiological study of exposure to coal tar pitch volatiles among coke oven workers*. J. Air Pollut. Control Assoc. 25: 382-389.

McLure, K.M., and B. MacMahon. 1980. *An epidemiologic perspective of environmental carcinogenesis*. Epidemiol. Rev. 2: 19-48.

Millington, R.J. and J.P. Quirk. 1961. *Permeability of porous solids*. Trans. Faraday Soc. 57:1200-1207.

Monson, R.R., J.M. Peters, and M.N. Johnson. 1974. *Proportional mortality among vinyl-chloride workers*. Lancet 2: 397-398.

Montgomery J.H., and L.M. Walker, 1989. *Groundwater Chemical Desk Reference*. Lewis Publishers.

Müller, E. 1968. *Carcinogenic substances in water and soils. XX. Studies on the carcinogenic properties of 1,12-benzoperylene*. Arch. Hyg. 152: 23-36 (in German).

Munns, W.R., Jr., C. Mueller, D.J. Cobb, T.R. Gleason, G.G. Pesch, and R.K Johnston. 1991. *Marine Ecological Risk Assessment at Naval Construction Battalion Center, Davisville, Rhode Island, Phase I.* Naval Ocean Systems Center, San Diego, California. Technical Report 1437.

Nagasaki, H., S. Tomii, T. Mega, M. Marugami, and N. Ito. 1972. *Hepatocarcinogenicity of polychlorinated biphenyls in mice.* Gann 63: 805.

Nahum, L.H., and H.E. Hoff. 1934. *The mechanism of sudden death in experimental acute benzol poisoning.* J. Pharmacol. Exp. Therap. 50: 336–345.

Nakamura, K. 1983. *A mortality study of vinyl chloride workers in Japan.* Sangyo Ika Daigaku Zasshi 5: 49–57.

Nakamura, S., Y. Oda, T. Shimada, I. Oki, and K. Sugimoto. 1987. *SOS-inducing activity of chemical carcinogens and mutagens in Salmonella typhimurium TA1535/pSK 1002: Examination with 151 chemicals.* Mutat. Res. 192: 239-246.

NCA (National Coffee Association). 1982. *Twenty-four-month Chronic Toxicity and Oncogenicity Study of Methylene Chloride in Rats. Final Report.* Prepared by Hazleton Laboratories, America, Inc., Vienna, VA. Unpublished.

NCI (National Cancer Institute). 1976. *Report on Carcinogenesis Bioassay of Chloroform.* U.S. Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, National Cancer Institute, Bethesda, Maryland. Available from NTIS (National Technical Information Service), Springfield, Virginia 22161, as PB-264018.

NCI (National Cancer Institute). 1978a. *Bioassays of Aldrin and Dieldrin for Possible Carcinogenicity.* DHEW Publication No. (NIH) 78-821. NCI Carcinogenesis Tech. Rep. Ser. No. 21. NCI-C6-TR-21. U.S. Department of Health, Education, and Welfare, Washington, DC.

NCI (National Cancer Institute). 1978b. *Bioassay of DDT, DDD and p,p'-DDE for Possible Carcinogenicity.* NCI Report No. 131. DHEW Publ. No. (NIH) 78-1386. U.S. Department of Health, Education, and Welfare, Washington, DC.

NCI (National Cancer Institute). 1978c. *Bioassay of 1,1,2,2,-Tetrachloroethane for Possible Carcinogenicity.* Pub. No. (NIH) 78-827. U.S. Department of Health, Education, and Welfare, Washington, DC.

NCI (National Cancer Institute). 1978d. *Bioassay of 1,1,2-Trichloroethane for Possible Carcinogenicity.* Technical Report Series No. 74, Publication No. NIH 78-1324. U.S. Department of Health, Education and Welfare, National Institutes of Health, National Cancer Institute, Bethesda, Maryland.

Neal, J., and R.H. Rigdon. 1967. *Gastric tumors in mice fed benzo[a]pyrene: A quantitative study.* Tex. Rep. Biol. Med. 25: 553–557.

Nelson, J.J.K., S.O. Montgomery, W.R. Mahaffey, and P.H. Pritchard. 1987. *Biodegradation of Trichloroethylene and Involvement of an Aromatic Biodegradative Pathway.* Appl. Environ. Microbiol. 53: 949–954.

Nitschke K.D., K.A. Johnson, D.L. Wackerle, J.E. Phillips and D.A. Dittenber. 1988. *Propylene Dichloride: A 13-Week Inhalation Toxicity Study with Rats, Mice, and Rabbits.* Dow Chemical Company, Mammalian and Environmental Toxicology Research Laboratory, Midland, MI. OTS Doc. #86-870001397

Norback, D.H., and R.H. Weltman. 1985. *Polychlorinated biphenyl induction of hepatocellular carcinoma in the Sprague-Dawley rat.* Environ. Health Perspect. 60: 97-105.

NOSC/ERLN (Naval Ocean Systems Center/Environmental Research Laboratory at Narragansett). 1990. *Risk Assessment Pilot Study for Allen Harbor, Naval Construction Battalion Center Davisville, RI: Project Documentation.* San Diego, California.

Nousiainen, U., R. Torronen, and O. Hanninen. 1984. *Differential induction of various carboxylesterases by certain polycyclic aromatic hydrocarbons in the rat.* Toxicology 32: 243–251.

NRC (National Research Council). 1983. *Risk Assessment in the Federal Government: Managing the Process.* National Academy Press, Washington, DC.

NRC (National Research Council). 1989. *Diet & Health: Implications for Reducing Chronic Disease Risk.* National Academy Press, Washington, DC. 768 pp.

NTP (National Toxicology Program). 1980. *Subchronic Toxicity Study: Naphthalene (C52904), Fisher 344 Rats.* Unpublished report to NTP prepared by Batelle Columbus Laboratories, Columbus, Ohio, under Subcontract No. 76-34-106002. U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, Research Triangle Park, N.C.

NTP (National Toxicology Program). 1986a. *Toxicology and Carcinogenesis Studies of Benzene (CAS No. 71-43-2) in F344/N Rats and B5C3F$_1$ Mice (Gavage Studies).* Technical Report Series No. 289. NIH Publication No. 86-2545. National Toxicology Program, Research Triangle Park, North Carolina. 277 pp.

NTP (National Toxicology Program). 1986b. *NTP Technical Report on the Carcinogenesis Studies of 1,2-Dichloropropane (Propylene dichloride) in F344/N Rats and B6C3F1 Mice (Gavage Studies).* NTP Technical Report Series No. 263. NIH Publication No. 84-2519. National Toxicology Program, Research Triangle Park, North Carolina.

NTP (National Toxicology Program). 1990. *Toxicology and Carcinogenesis Studies of Toluene (CAS No. 108-88-3) in F344/N Rats and B5C3F$_1$ Mice (Inhalation Studies).* Technical Report Series No. 371. NIH Publication No. 90-2826. National Toxicology Program, Research Triangle Park, North Carolina. 253 pp.

NTP (National Toxicology Program). 1992. *Toxicology and Carcinogenesis Studies of Naphthalene (CAS No. 91-20-3) in B6C3F$_1$ Mice (Inhalation Studies).* Technical Report Series No. 410. NIH Publication No. 91-3141. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, National Toxicology Program, Research Triangle Park, North Carolina. 168 pp.

O'Bryan, T.R., and R.H. Ross. 1988. *Chemical scoring system for hazard and exposure identification*. J. Toxicol. Environ. Health 1: 119–134.

Ouw, H., G. Simpson, and D. Siyali. 1976. *Use and health effects of Aroclor 1242, a polychlorinated biphenyl, in an electrical industry*. Arch. Environ. Health. 31: 189–194.

Palitti, F., R. Cozzi, M. Fiore, F. Palombo, C. Polcaro, G. Perez, and E. Possagno. 1986. *An in vitro and in vivo study on mutagenic activity of fluoranthene: Comparison between cytogenetic studies and HPLC analysis*. Mutat. Res. 174: 125–130.

Parsons et al. 1984. *Biotransformation of Chlorinated Solvents in Static Microcosms*. Paper presented at the SETAC Annual Meeting.

Peckenpaugh, J.M., J. T. Dugan, R.A. Kern, and W.J. Schroeder. 1987. *Hydrogeology of the Tri-Basin and Parts of the Lower Repbulican and Central Platte Natural Resources Districts, Nebraska*. U.S. Geological Survey, Water Resources Investigations Report 87-4176. Lincoln, Nebraska.

Pinto, S.S., and C.M. McGill. 1953. *Arsenic trioxide exposure in industry*. Ind. Med. Surg. 22: 281–287.

Pokrovskaya, L.V., and N.K. Shabynina. 1973. *Carcinogenous hazards in the production of chromium ferroalloys*. Gig. Tr. Prof. Zabol. 10: 23–26 (in Russian).

Potkonjak, V., and V. Vishnijich. 1983. Antimoniosis: A particular form of pneumoconiosis. II. Experimental investigation. *Int. Arch. Occup. Environ. Health*. 51: 299-303.

Potts, A.M. 1986. *Toxic responses of the eye: Naphthalene*. Pp. 492–493 in Casarett and Doull's Toxicology (C.D. Klaassen, M.D. Amdur, and J. Doull, Eds.), 3rd ed. MacMillan, New York.

Prendergast, J.A., R.A. Jones, L.J. Jenkins Jr., et al. 1967. *Effects on experimental animals of long-term inhalation of trichloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, dichlorodifluoromethane, and 1,1-dichloroethylene*. Toxicol. Appl. Pharmacol. 10: 270-289.

Purde, M., and S. Etlin. 1980. Cancer cases among workers in the Estonia oil shale processing industry. Pp. 527–528 in *Health Implications of New Energy Technologies*. Ann Arbor Science, Ann Arbor, Michigan.

Puzanova, L., M. Doskocil, and A. Doubkova. 1978. *Disturbances of the development of chick embryos after the administration of beryllium chloride at early stages of embryogenesis*. Folia Morphologica 26: 228-231.

Quast, J.F., C.G. Humiston, C.E. Wade, et al. 1983. *A chronic toxicity and oncogenicity study in rats and subchronic toxicity study in dogs of ingested vinylidene chloride*. Fund. Appl. Toxicol. 3(1): 55–62.

Quinn, A.W. 1952. Bedrock Geology of the East Greenwich Quadrangle, Rhode Island. Map. U.S. Geological Survey, Reston, Virginia.

Redmond, E., B. Strobino, and R. Cypress. 1976. *Cancer experience among coke by-product workers*. Ann. N.Y. Acad. Sci. 2-7: 102–115.

Reigel, B., W.B. Wartman, W.T. Hill, B.B. Reeb, P. Shubik, and D.W. Stanger. 1951. *Delay of methylcholanthrene skin carcinogenesis in mice by 1,2,5,6-dibenzofluorene*. Cancer Res. 11: 301–306.

Rhode Island Development Council. 1953. *Ground-Water Resources of Rhode Island*. Geological Bulletin No. 6. Rhode Island Development Council, Providence.

Rhode Island Department of Health (RIDoH). 1994. *Rules and Regulations for Lead Poisoning Prevention* [R 23-24.6-PB]. Environmental Lead Program, Providence, Rhode Island. October.

Rhode Island Regulations. 1993. *Water Quality Standards, Class GAA and Class GA Ground Waters*. July.

Rigdon, R.H., and J. Neal. 1966. *Gastric carcinomas and pulmonary adenomas in mice fed benzo[a]pyrene*. Tex. Rep. Biol. Med. 24: 195–207.

Rigdon, R.H., and J. Neal. 1965. *Effects of feeding benzo[a]pyrene on fertility, embryos, and young mice*. J. Nat. Cancer Inst. 34: 297–305.

Robinson, J.R., J.S. Felton, R.C. Levitt, S.S. Thorgeirsson, and D.W. Nebert. 1975. *Relationship between "aromatic hydrocarbon responsiveness" and the survival times in mice treated with various drugs and environmental compounds*. Mol. Pharmacol. 11: 850-865.

Roe, F.J.C., A.K. Palmer, A.N. Worden, and N.J. Van Abbe. 1979. *Safety evaluation of toothpaste containing chloroform: I. Long-term studies in mice*. J. Environ. Pathol. Toxicol. 2: 799–819.

Rosenshein, J.S., J.B. Gonthiel, and W.B. Allen. 1968. *Hydrologic Characteristics and Sustained Yield of Principal Groundwater Units, Potowomut-Wickford Area, Rhode Island*. USGS Water Supply Paper 1775.

Rossi, L., O. Barbieri, M. Sanguineti, J.R.P. Cabral, P. Bruzzi, and L. Santi. 1983. *Carcinogenicity study with technical-grade DDT and DDE in hamsters*. Cancer Res. 43: 776–781.

Rummo, J.H., D.K. Routh, N.J. Rummo, and F.J. Brown. 1979. *Behavioral and neurological effects of symptomatic and asymptomatic lead exposure in children*. Arch. Environ. Health. 34: 120–125.

Sanders, V.M., K.L. White, Jr., G.M. Shopp, Jr. and A.E. Munson. 1985. *Humoral and cell-mediated immune status of mice exposed to 1,1,2-trichloroethane*. Drug Chem. Toxicol. 8: 357-372.

Schafer, J.P. 1961. Surficial Geology of the Wickford Quadrangle, Rhode Island. Map GQ-136. U.S. Geological Survey, Reston, Virginia.

Schmähl, D. 1955. *Examination of the carcinogenic action of naphthalene and anthracene in rats*. Z. Krebsforsch. 60: 697-710.

Schroeder, H.A., M. Mitchner and A.P. Nasor. 1970. *Zirconium, niobium, antimony, vanadium and lead in rats: Life term studies.* J. Nutr. 100(1): 59-68.

Schroeder, H.A., and M. Mitchener. 1975a. *Life-term studies in rats: Effects of aluminum, barium, beryllium and tungsten.* J. Nutr. 105: 421-427.

Schroeder, H.A., and M. Mitchener. 1975b. *Life-term effects of mercury, methyl mercury and nine other trace metals on mice.* J. Nutr. 105: 452-458.

Seidel, H.J., E. Barthel, and D. Zinser. 1989. *The hematopoietic stem cell compartments in mice during and after long-term inhalation of three doses of benzene.* Exp. Hematol. 17: 300–303.

Selevan, S.G., P.J. Landrigan, F.B. Stern, and J.H. Jones. 1985. *Mortality of lead smelter workers.* Am. J. Epidemiol. 122: 673–683.

Shear, M.J. 1938. *Studies in carcinogenesis. V. Methyl derivatives of 1:2-benzanthracene.* Am. J. Cancer. 33: 499–537.

Shevaleva, G.A. 1978. *On the effect of 3,4-benzpyrene on the development of the foetus applied at different stages of gestation.* Gig. Tr. Prof. Zabol. 7: 54.

Shubik, P., and G. della Porta. 1957. Carcinogenesis and acute intoxication with large doses of polycyclic hydrocarbons. *Arch. Pathol.* 64: 691–703.

Shuurman, H.J., H. Van Loveren, J. Rozing, and J.G. Vos. 1992. Chemicals trophic for the thymus: Risk for immunodeficiency and autoimmunity. *Int. J. Immunopharmacol.* 14(3):369-375.

Simpson, J.Y. 1847. *On a new anaesthetic agent, more efficient than sulfuric ether.* Lancet 2:549.

Sina, J.F., C.L. Bean, G.R. Dysart, V. Taylor, and M. Bradley. 1983. *Evaluation of the alkaline elution/rat hepatocyte assay as a predictor of carcinogenic/mutagenic potential.* Mutat. Res. 113: 357–391.

Skerfving, S. and J. Vostal. 1972. Symptoms and signs of intoxication. In: L. Friberg and J. Vostal (eds.). *Mercury in the Environment: Toxicological and Epidemiological Appraisal.* Chemical Rubber Co., Cleveland, OH.

Smith, J.H. 1955. Surficial Geology of the East Greenwich Quadrangle, Rhode Island. Map GQ-62. U.S. Geological Survey, Reston, Virginia.

Smith, L.R., and J. Dragun. 1984. *Degradation of Volatile Chlorinated Aliphatic Priority Pollutants in Groundwater.* Environ. Int. 19(4)a: 291–298.

Snyder, R., S.L. Longacre, C.M. Witmer, J.J. Kocsis, L.S. Andrews, and E.W. Lee. 1981. *Biochemical toxicology of benzene.* Rev. Biochem. Toxicol. 3: 123–153.

Spirtas, R., G. Beebe, P. Baxter, et al. 1983. *Angiosarcoma as a model for comparative carcinogenesis (letter).* Lancet 2(8347): 456.

Stone and Webster Environmental Technology and Services. 1996. *Basewide Groundwater Inorganics Study Report. NCBC Davisville, Rhode Island.* Prepared for Northern Division Naval Facility Engineering Command. Contract No. N62472-92-D-1296. June.

Stumm and Morgan. 1981. *Aquatic Chemistry. 2nd. Ed.* Pub. John Wiley & Sons.

Swindoll, C.M., M. Aelion, D.C. Dobbins, O. Jiang, S.C. Long, and P.F. Pfaender. 1988. *Aerobic biogegradation of natural and xenobiotic organic compounds by subsurface microbial communities.* Environ. Toxicol. Chem. 7:291-299.

Syracuse Research Corporation (SRC). 1995. *Electronic Database SRC Recommended Values.*

Thompson, D.J. 1993. *A chemical hypothesis for arsenic methylation in mammals.* Chem. Biol. Interact. 88: 89-114.

Thun, M.J., T.M. Schnorr, A. Smith, et al. 1985. *Mortality among a cohort of U.S. cadmium production workers--an update.* J. Natl. Cancer Inst. 74: 325–333.

Thyssen, J., J.K.G. Althoff, and U. Mohr. 1981. *Inhalation studies with benzo[a]pyrene in Syrian golden hamsters.* J. Nat. Cancer Inst. 66: 575–577.

Tomatis, L., V. Turusov, R.t. Charles, and M. Boicchi. 1974. *Effect of long- term exposure to 1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene, to 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane, and the two chemicals combined on CF-1 mice.* J. Natl. Cancer Inst. 52: 883–891.

TRC Environmental Corporation, Inc. 1987. *Confirmation Study — Verification Stop, Naval Construction Battalion Center, Davisville, Rhode Island.* Final Report. Prepared for Northern Division Naval Facilities Engineering Command, Philadelphia, PA. 27 February.

TRC Environmental Corporation, Inc. 1991. *Phase I Remedial Investigation and Risk Assessment, Naval Construction Center, Davisville, Rhode Island.* Final Report. Prepared for U.S. Navy Northern Division Naval Facilities Engineering Command, Philadelphia, PA. May.

TRC Environmental Corporation, Inc. 1994. *Allen Harbor Landfill Remediation Investigation Report: Technical Report, Volume I, Naval Construction Battalion Center, Davisville, Rhode Island.* June.

Tseng, W.P. 1977. *Effects and dose-response relationships of skin cancer and blackfoot disease with arsenic.* Environ. Health Perspect. 19: 109–119.

Tseng, W.P., H.M. Chu, S.W. How, J.M. Fong, C.S. KLin, and S. Yeh. 1968. *Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan.* J. Nat. Cancer Inst. 40: 453–463.

Tsuda, H., A. Haziwara, M. Shibata, M. Oshima, and N. Ito. 1982. *Carcinogenic effect of carbazole in the liver of (C57BL/6N X C3G/HEN)F1 mice.* J. Natl. Cancer Inst. 69: 1383–1389.

Uemo, S., N. Susa, Y. Furukawa, and M. Sugiyama. 1991. Comparison of hepatotoxicity caused by mono-, di- and tributyltin compounds in mice. *Arch. Toxicol.* 69(1):30-34.

U.S. Department of Agriculture (USDA) Soil Conservation Service. 1973. *Interim Soil Survey Report for North Kingstown, Rhode Island.*

U.S. Department of Agriculture (USDA) Soil Conservation Service. 1981. *Soil Survey of Rhode Island.* US Department of Agriculture, Soil Conservation Service, in cooperation with Rhode Island Experiment Station, Issued July.

U.S. Department of the Interior (USDI). 1980. *Earth Manual. A Water Resource Technical Publication (2nd. Edition).* U.S. Department of the Interior, Water and Power Resources Services. 1974.

USGS. 1988. *National Water Summary 1986 -- Ground-Water Quality: Rhode Island.* U.S. Geological Survey Water-Supply Paper 2325, prepared by H. Johnston and P. Barlow.

USGS. 1989. *National Water Summary 1987- Water Supply and Use: Rhode Island*, prepared by H. Johnston and M. Baer, USGS Water-Supply Paper 2350.

USGS. 1993. *National Water Summary 1990-91-- Stream Water Quality: Rhode Island*, U.S. Geological Survey Water-Supply Paper 2400, prepared by Richard Bell.

Van Heyningen, R., and A. Pirie. 1976. *Naphthalene cataract in pigmented and albino rabbits.* Exp. Eye Res. 22: 393–394.

Van Duuren, B.L., C. Katz, and B.M. Goldschmidt. 1973. *Cocarcinogenic agents in tobacco carcinogenesis.* J. Nat. Cancer Inst. 51: 703–705.

Van Duuren, B.L., and B.M. Goldschmidt. 1976. *Cocarcinogenic and tumor-promoting agents in tobacco carcinogenesis.* J. Nat. Cancer Inst. 51: 1237–1242.

Van Esch, E.J., and R. Kroes. 1969. The induction of renal tumors by feeding basic lead acetate to mice and hamsters. *Br. J. Cancer* 23: 765–771.

Vilkina, G.A., M.D. Pomerantseva, and L.K. Romaiia. 1978. *Lack of mutagenic activity of cadmium and zinc salts in somatic and germ mouse cells.* Genetika (Moscow) 14: 2212-2214 (in Russian). As cited in ATSDR (1989c).

Vogel and McCarty. 1987. *Transformation of halogenated aliphatic compounds.* Environ. Sci. Technol. 21(8).

Voice, T.C., and W.J. Weber. 1983. *Sorption of hydrophobic compounds by sediments, soils, and suspended solids - I. Theory and Background.* Water Res. 17:1433-1441.

Voroshilin, S.I., E.G. Plotko, T.V. Fink, and V.Y. Nikiforova. 1978. *Cytogenetic effects of inorganic and acetate compounds of tungsten, zinc, cadmium, and cobalt in animal and human somatic cells.* Tsitol. Genet. 12: 241-243 (in Russian). As cited in ATSDR (1989c).

Wang, L., S.E. Xu, G.D. Zhang, and W.Y. Wang. 1989. *Study of lead absorption and its effect on children's development.* Biomed. Environ. Sci. 2: 325–330.

Ward, D.M., and T.D. Brock. 1978. *Anaerobic metabolism of hexadecane in marine sediments.* Geomicrobiol. J. 1: 1-9.

Ward, D., R.M. Atlas, P.D. Boehm, and J.A. Calder. 1980. *Microbial biodegradation and the chemical evolution of Amoco Cadiz oil pollutants.* Ambio 9: 277-283.

White, K.L., Jr., V.M. Sanders, V.W. Barnes, G.M. Shopp, Jr. and A.E. Munson. 1985. *Toxicology of 1,1,2-trichloroethane in the mouse.* Drug Chem. Toxicol. 8: 333-355.

Williams, R. 1964. *Bedrock Geology of the Wickford Quadrangle, Rhode Island.* Geological Survey Bulletin 1158-C, prepared in cooperation with the State of Rhode Island Development Council, U.S. Government Printing Office, Washington, D.C.

Wilson, R.H., F. DeEds, and A.J. Cox. 1947. *The carcinogenic activity of 2-acetaminofluorene. IV. Action of related compounds.* Cancer Res. 7: 453-458.

Wilson, J.T., and B.H. Wilson. 1985. *Biotransformation of trichloroethylene in soil.* Appl. Environ. Microbiol. 49: 242-243.

Wilson, B.H., and M.V. White. 1986a. *A fixed-film bioreactor to treat trichloroethylene-laden waters from interdiction wells.* Pp. 425-436 in Proceedings of the Sixth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring, May 19-22, 1986. National Water Well Association, Dublin, OH.

Wilson, B.H., G.B. Smith, and J.F. Rees. 1986b. *Biotransformations of selected alkylbenzenes and halogenated aliphatic hydrocarbons in methanogenic aquifer material: A microcosm study.* Environ. Sci. Technol. 20: 997-1002.

Wolf, M.A., V.K. Rowe, D.D. McCollister, R.L. Hollingsworth, and F. Oyen. 1956. *Toxicological studies of certain alkylated benzenes and benzene.* Arch. Ind. Health 14: 387-398.

Wynder, E.L., and D. Hoffmann. 1959a. *A study of tobacco carcinogenesis. VII. The role of higher polycyclic hydrocarbons.* Cancer 12: 1079-1086.

Wynder, E.L., and D. Hoffmann. 1959b. *The carcinogenicity of benzofluoranthene.* Cancer 12: 1194.

Wynder, E.L., and L.F.N. Ritz. 1957. *Effect of concentrations of benzopyrene in skin carcinogenesis.* J. Nat. Cancer Inst. 19: 361-370.

Yadrick, M.K., M.A. Kenney and E.A. Winterfeldt. 1989. *Iron, copper, and zinc status: Response to supplementation with zinc or zinc and iron in adult females.* Am. J. Clin. Nutr. 49: 145-150.

Yeh, G.T. 1987. *Analytical Transient One, Two, and Three - Dimensional Simulation of Waste Transport in the Aquifer System,* Oak Ridge National Laboratory, IGWMC-FOS 38 PC.

Zimmerman-Tansella, C., P. Campara, F. D'Andrea, C. Savonitto, and M. Tansella. 1983. *Psychological and physical complaints of subjects with low exposure to lead.* Human Toxicol. 2: 614-623.

Zuelzer, W.W., and L. Apt. 1949. *Acute hemolytic anemia due to naphthalene poisoning: A clinical and experimental study*. J. Am. Med. Assoc. 141: 185-190.

# TABLE 1-1

## LIST OF TCL VOLATILE COMPOUNDS

IR PROGRAM SITE 07 - CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

1,1-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethane
1,2-Dichloroethene (total)
1,2-Dichloropropane
1,3-Dichloropropene (cis)
1,3-Dichloropropene (trans)
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
2-Butanone
2-Hexanone
4-Methyl-2-Pentanone
Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Carbon Tetrachloride
Carbon Disulfide
Chlorobenzene
Chloroform
Chloromethane
Dibromochloromethane
Ethylbenzene
Methylene Chloride
Styrene
Tetrachloroethene
Toluene
Trichloroethene
Vinyl Chloride
Xylene (total)

# TABLE 1-2

## LIST OF TAL METALS

IR PROGRAM SITE 07 - CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

**Table 2-1. Summary of Field and Laboratory Results for Hydroprobe Samples (ug/L)**

| Sample ID | DEPTH | T12DCE | C12DCE | PCA | TCE | 112TCA | PCE | ACETONE |
|---|---|---|---|---|---|---|---|---|
| HP-1-A | 15-17 | | | | | | | |
| HP-1-B | 25-27 | | | | | | | |
| HP-1-C | 33-35 | | | | | | | 2.3 |
| HP-02-A | 11-13 | | | | | | | |
| HP-02-B | 23-25 | | 100 | 3.8 | 4.3 | | 2.9 | |
| HP-03-A | 9-11 | | | 1 | 1.2 | | | |
| HP-03-B | 17-19 | 42 | | 135 | 41 | 12 | 2 | |
| HP-03-C | 29-31 | | | 1 | 2.6 | | | 15 |
| HP-04-A* | 9-11 | | | | | | | |
| HP-04-LAB | 9-11 | | | | 3 | | | |
| HP-04-B | 25-27 | | | 24 | 37 | 1.8 | 12 | 2.1 |
| HP-04-C | 36-38 | 2640 | | 5350 | 4410 | 152 | 88 | 12 |
| HP-05-A | 10-12 | | | | 7.7 | 8.7 | | |
| HP-05-B | 32-34 | 6140 | 154 | >26300 | >11900 | 541 | 53 | |
| HP-05-C | 39.5-41.5 | 1600 | | 2600 | 2170 | 74 | 97 | |
| HP-06-A | 10-12 | | | 7.5 | 2.3 | | | |
| HP-06-B | 29-31 | 563 | | 3130 | 4100 | 100 | 855 | |
| HP-06-C | 41.5-43.5 | 5770 | | >30000 | >16100 | 588 | 1140 | |
| HP-07-A | 10-12 | | | | | | | |
| HP-07-B | 32-34 | 1800 | | 3920 | 6360 | 310 | 76 | |
| HP-07-C* | 43-45 | 4870 | | >25600 | >15300 | 513 | 273 | |
| HP-07-LAB | 43-45 | 4100 | ** | 98000 | 120000 | 1200 | 550 | |
| HP-8-A | 10-12 | | | | | | | |
| HP-8-B | 20-22 | | | 13 | 4.5 | | 1.0 | |
| HP-8-C | 37-39 | 717 | | 1233 | 886 | 34 | 38 | 5.7 |
| HP-09-A | 10-12 | | | | 1.6 | | | |
| HP-09-B | 25-27 | | | 7.0 | 112 | 50 | 3.0 | |
| BLANK | | | | | | | | |
| HP-10-A | 14-16 | | | | | | | |
| HP-10-B* | 41-43 | 710 | | 2600 | >7910 | 275 | 2.3 | |
| HP-10-LAB | 41-43 | 8400 | ** | 10000 | 20000 | 670 | | |
| HP-10-C | 49-51 | 477 | | 1560 | 5640 | 211 | 1.7 | |
| HP-11-A | 7-9 | 65 | | 158 | 233 | 19 | | |
| HP-11-B | 23-25 | 115 | | 56 | 407 | 44 | 1.5 | |
| HP-11-C | 37-39 | | | 26 | 25 | | 1.2 | |
| HP-11-C DUP | 37-39 | | | 23 | 22 | | 1.0 | |
| HP-12-A | 10-12 | | | | | | | |
| HP-12-B | 39-41 | 13 | 10 | 8.1 | 42 | 2.6 | | |
| HP-12-C | 59-61 | | | | | | | |

**Table 2-1. Summary of Field and Laboratory Results for Hydroprobe Samples (ug/L)**

| Sample ID | DEPTH | T12DCE | C12DCE | PCA | TCE | 112TCA | PCE | ACETONE |
|---|---|---|---|---|---|---|---|---|
| HP-13-A | 12-14 | | | | | | | |
| HP-13-B | 34-36 | | | | | | | |
| HP-13-C | 55-57 | | **3.5** | | | | | |
| HP-13-C DUP | 55-57 | | | | | | | |
| HP-14-A | 10-12 | | | | | | | |
| HP-14-A DUP | 10-12 | | | | | | | |
| HP-14-B | 39-41 | | | | | | **1.5** | |
| HP-14-C | 59-61 | | | **11** | **2.3** | **9.3** | **1.3** | |
| HP-15-A | 8-10 | | | | | | | |
| HP-15-B | 40-42 | | | | | | | |
| HP-15-C | 60-62 | | | | | | | |
| HP-16-A | 13-15 | | | | | | | |
| HP-16-B | 46-48 | | | | | | | |
| HP-16-C | 67-70 | **18** | | | | | | **2.5** |
| HP-17-A | 57-60 | **74** | **34** | | | | | **2.0** |
| HP-17-B* | 64-66 | | | | | | | |
| HP-17-LAB | 64-66 | | | | | | | |
| HP-17-B DUP | 64-66 | | | | | | | |
| HP-17-C | 10-12 | | | | | | | |
| HP-18-A | 10-12 | | | | | | | |
| HP-18-B | 45-47 | | | | | | | |
| HP-18-C | 66-68 | | | | | | | |
| HP-19-A | 37-39 | | | | | | | |
| HP-19-B | 59.5-61.5 | | | | | | | |
| HP-19-B DUP | 59.5-61.5 | | | | | | | **1.2** |
| HP-19-C | 4-6 | | | | | | | |
| HP-20-A | 3-5 | | | | | | | |
| HP-20-B | 25-27 | | | **20** | **4.2** | | | |
| HP-20-C | 41-43 | | | | | | | |
| HP-20-C DUP | 41-43 | | | | | | | |
| HP-21-A | 13-15 | | | **5** | **2.5** | | | |
| HP-21-B | 31-33 | **206** | | **465** | **>438** | **44** | | **5.2** |
| HP-21-C* | 46.5-48.5 | **740** | | **1570** | **2700** | **148** | **1.9** | |
| HP-21-LAB | 46.5-48.5 | **1900** | ** | **4600** | **5500** | **250** | | |
| HP-21-C DUP | 46.5-48.5 | **650** | | **1630** | **2230** | **148** | **1.6** | |
| HP-22-A | 10-12 | | | | | | | |
| HP-22-A DUP | 10-12 | | | | | | | |
| HP-22-B | 28-30 | | | | | | | |
| HP-22-C | 43-45 | | | | | | | |

**Table 2-1. Summary of Field and Laboratory Results for Hydroprobe Samples (ug/L)**

| Sample ID | DEPTH | T12DCE | C12DCE | PCA | TCE | 112TCA | PCE | ACETONE |
|---|---|---|---|---|---|---|---|---|
| HP-23-A | 6-8 | | | | | | | |
| HP-23-B | 26-28 | **12** | **45** | | **10** | **3.2** | | **12** |
| HP-23-C | 45-47 | **647** | **102** | **1910** | **1190** | **57** | **9.9** | |
| HP-24-A | 10-12 | | | | | | | |
| HP-24-B | 38-40 | | | | | | | |
| HP-24-C* | 56-58 | **27** | | **139** | **187** | **53** | **1.5** | |
| HP-24-LAB | 56-58 | **1700** | ** | **440** | **800** | **150** | | |
| HP-25-A | 10-12 | | | | | | | |
| HP-25-B | 25-27 | **46** | | **142** | **172** | **2.7** | **7.9** | |
| HP-25-C* | 33.5-35.5 | **156** | | **454** | **289** | **5.8** | **19** | |
| HP-25-LAB | 33.5-35.5 | | | **1600** | **1000** | **15** | **55** | |
| HP-25-C DUP | 33.5-35.5 | **173** | | **465** | **322** | **7.9** | **23** | |

*Duplicate sample sent for laboratory analysis

**Laboratory results are for 1,2-DCE (total).

A blank space indicates that the compound was not detected above detection limits.

HP-XX-Y DUP indicates sample was duplicated for field analysis.

HP-XX-LAB indicates sample was duplicated for laboratory analysis.

NOTE Laboratory results of full TCL VOC analysis are presented in Appendix C

# TABLE 2-2
## MONITORING WELL and SOIL BORING DATA
IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III REMEDIAL INVESTIGATION,
NCBC-DAVISVILLE, RHODE ISLAND

| Well Number | Date Installed | RI Coordinates, 1927 NAD | | Ground Elevation | Riser Elevation | Screen Depth (ft bgs) | | Screen Elevation (ft msl) | | Geologic Unit Screened (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | North | East | | | top | bottom | top | bottom | |
| MW07-01S* | 3/27/85 | 197664 74 | 524639 02 | 12 0 | 13 75 | 4 0 | 14 0 | 8 0 | -2 0 | Upper Sand (10) |
| MW07-02S* | 3/27/85 | 197658 06 | 524597 46 | 12 3 | 14 07 | 4 0 | 14.0 | 8 3 | -1 7 | Upper Sand (10) |
| MW07-03S* | 10/16/89 | 197642 49 | 524781 30 | 11 7 | 15 47 | 2.0 | 12.0 | 9.7 | -0 3 | Upper Sand (10) |
| MW07-03D+ | 6/23/93 | 197644 66 | 524793 84 | 11.7 | 13.80 | 40 0 | 50 0 | -28.3 | -38 3 | Silt (4), lower sand (1.5), till (4 5) |
| MW07-04S* | 10/16/89 | 197510 36 | 524496 20 | 11.7 | 15 60 | 6.1 | 16.1 | 5.6 | -4.4 | Upper Sand (8.4), silt (1.6) |
| MW07-04D | 7/21/95 | 197578 05 | 524482 05 | 11 3 | 13 13 | 25.5 | 35 5 | -14 2 | -24 2 | Silt (8), till (2) |
| MW07-05S+ | 6/23/93 | 197534 98 | 524611 29 | 10.2 | 12 06 | 4 0 | 16.0 | 6.2 | -5.8 | Upper sand (11), silt (1) |
| MW07-05D+ | 6/24/93 | 197537.86 | 524612.14 | 10 2 | 13.27 | 41.4 | 51 4 | -31.2 | -41 2 | Silt (3.1), till (4), rock (qtz/phyl) (2.9) |
| MW07-05R | 8/22/95 | 197588 42 | 524597 83 | 10 3 | 11 62 | 64 0 | 74 0 | -53 7 | -63 7 | Bedrock (quartzite/ phyllite) (10) |
| MW07-06S+ | 6/24/93 | 197818 69 | 524879.69 | 13 4 | 15 55 | 4 0 | 14 0 | 9 4 | -0.6 | Upper sand (10) |
| MW07-07S+ | 6/15/93 | 197937 70 | 524562 04 | 19 7 | 21 43 | 4 0 | 16 0 | 15.7 | 3.7 | Upper sand (4), till (8) |
| MW07-08S+ | 6/15/93 | 198171.73 | 524793.57 | 15 3 | 17.79 | 4.0 | 14.0 | 11 3 | 1 3 | Upper sand (10) |
| MW07-09D+ | 3/30/94 | 197289 58 | 524971 91 | 6.9 | 9.10 | 45.0 | 55.0 | -38 1 | -48.1 | Silt (1), lower sand (6), till (3) |
| MW07-09R | 8/24/95 | 197341 40 | 524956 72 | 6 8 | 9 09 | 73 0 | 83 0 | -66 2 | -76 2 | Bedrock (quartzite) (10) |
| MW07-10S | 8/10/95 | 197319 59 | 524396.14 | 9.2 | 11 48 | 4 5 | 13.5 | 4 7 | -4.3 | Upper Sand (9) |
| MW07-10D+ | 3/31/94 | 197263 16 | 524399.04 | 9 2 | 12 04 | 27 5 | 37 5 | -18.3 | -28 3 | Silt (8), till (1), bedrock (1) |
| MW07-11D+ | 4/5/94 | 196830.91 | 525190 86 | 7.4 | 10 70 | 47 5 | 57 5 | -40.1 | -50.1 | Silt(2.5), lower sand (7.5) |

| Well Number | Date Installed | RI Coordinates, 1927 NAD North | East | Ground Elevation | Riser Elevation | Screen Depth (ft bgs) top | bottom | Screen Elevation (ft msl) top | bottom | Geologic Unit Screened (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| MW07-12D+ | 4/4/94 | 197023.37 | 524224.74 | 7 5 | 10 13 | 25.0 | 35 0 | -17.5 | -27.5 | Till (10) |
| MW07-13S | 8/15/95 | 196924 23 | 524736.03 | 5 1 | 6 88 | 4 0 | 13 0 | 1.1 | -7.9 | Upper sand (10) |
| MW07-13D+ | 4/6/94 | 196868 85 | 524739 84 | 4 7 | 6 97 | 35.0 | 45 0 | -30.3 | -40.3 | Till (10) |
| MW07-14D | 7/20/95 | 197781 58 | 524572 85 | 11.9 | 13 44 | 24 0 | 34 0 | -12.1 | -22.1 | Till (10) |
| MW07-15D | 7/21/95 | 197673 67 | 524607.10 | 11.5 | 13 27 | 37 0 | 47 0 | -25 5 | -35 5 | Till (10) |
| MW07-16D | 7/26/95 | 197157 82 | 525852 14 | 6.1 | 7 53 | 74 0 | 84.0 | -67.9 | -77.9 | Till (10) |
| MW07-16R | 8/15/95 | 197155 95 | 525845.46 | 5 8 | 7 49 | 100 0 | 110 0 | -94.2 | -104.2 | Bedrock (quartzite/gneiss) (10) |
| MW07-17D | 7/25/95 | 197531 24 | 524719.47 | 8.4 | 9 88 | 38.0 | 48 0 | -29.6 | -39 6 | Lower sand (6), till (4) |
| MW07-18D | 7/27/95 | 197030 86 | 525538.93 | 5 8 | 7.18 | 62 0 | 72 0 | -56.2 | -66 2 | Lower sand (10) |
| MW07-19S | 8/1/95 | 196972 54 | 524475.28 | 4 9 | 6 30 | 13 0 | 23 0 | -8 1 | -18.1 | Till (10) |
| MW07-19D | 7/31/95 | 196970 58 | 524470 40 | 4.8 | 6 05 | 34 5 | 39 5 | -29.7 | -34.7 | Till (5) |
| MW07-20S | 7/28/95 | 196768 62 | 525448 01 | 3 8 | 5 61 | 4 9 | 14.9 | -1.1 | -11.1 | Upper sand (2.4), silt (7.6) |
| MW07-20D | 8/2/95 | 196777 12 | 525449 70 | 3 7 | 5 10 | 64.0 | 74.0 | -60.3 | -70 3 | Till (10) |
| MW07-21S | 8/4/95 | 196826 64 | 524501.74 | 4.5 | 6.65 | 10 0 | 20 0 | -5 5 | -15.5 | Till (10) |
| MW07-21D | 8/3/95 | 196820 82 | 524500.84 | 4.0 | 5 96 | 33 0 | 38 0 | -29.0 | -34.0 | Till (5) |
| MW07-21R | 11/2/95 | 196827 97 | 524492.82 | 4.6 | 6 80 | 55 3 | 65 3 | -50.8 | -60.8 | Bedrock (quartzite) (10) |
| MW07-22S | 8/3/95 | 197809 79 | 524376.50 | 15 4 | 17 11 | 8 0 | 13 0 | 7.4 | 2 4 | Upper sand (4), silt (1) |
| MW07-22D | 8/7/95 | 197803 29 | 524376 44 | 15 4 | 16.94 | 21 0 | 31.0 | -5 6 | -15.6 | Till (10) |
| MW07-23S | 8/16/95 | 196832 47 | 524211 45 | 4 4 | 6.47 | 4 0 | 8 0 | 0.4 | -3.6 | Upper sand (0 3), silt (3.7) |
| MW07-23D | 8/8/95 | 196831 04 | 524206.73 | 4.6 | 6 07 | 34 5 | 44 5 | -29 9 | -39.9 | Till (10) |
| MW07-24S | 10/18/95 | 196639 63 | 524924.73 | 4 6 | 6 23 | 9 5 | 19 5 | -4 9 | -14.9 | Up Sd. (3 2), S&S lay(6), silt (0 8) |

| Well Number | Date Installed | RI Coordinates, 1927 NAD North | East | Ground Elevation | Riser Elevation | Screen Depth (ft bgs) top | bottom | Screen Elevation (ft msl) top | bottom | Geologic Unit Screened (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| MW07-24D | 8/24/95 | 196636 62 | 524928 21 | 4 4 | 5 80 | 43.0 | 53.0 | -38.6 | -48.6 | Till (10) |
| MW07-25D | 10/24/95 | 197302.91 | 524229 56 | 10 0 | 11 48 | 33 0 | 38.0 | -23.0 | -28 0 | Till (5) |
| MW07-25R | 11/8/95 | 197313.51 | 524231 78 | 10.0 | 11.95 | 57.0 | 67 0 | -47 0 | -57 0 | Bedrock (quartzite) (10) |
| MW07-26S | 8/9/95 | 197163 73 | 524531 68 | 8 9 | 10 42 | 13 0 | 18 0 | -4 1 | -9 1 | Till (5) |
| MW07-27D | 8/14/95 | 197320 91 | 524662 37 | 8 3 | 9 84 | 45 0 | 52 0 | -36 7 | -43 7 | Till (7) |
| MW07-28D | 10/17/95 | 197720 44 | 525065 18 | 7 4 | 9 07 | 42 0 | 46 0 | -34 6 | -38 6 | Till (4) |
| MW07-29D | 10/26/95 | 197434 84 | 525472 45 | 6 2 | 7 65 | 66 5 | 76 5 | -60.3 | -70.3 | Till (10) |
| MW07-30D | 11/1/95 | 197381 11 | 525824.82 | 5 6 | 7 80 | 60.8 | 70.8 | -55 2 | -65.2 | Lower sand (8 2), till (1 8) |
| MW07-31I | 11/14/95 | 197741.61 | 524575.69 | 12.7 | 13 94 | 14.8 | 24 8 | -2 1 | -12 1 | Sandy silt facies (9.2), till (0.8) |
| MW07-32D | 12/10/97 | 196228 46 | 524416 68 | 5 8 | 7.96 | 41.6 | 51 6 | -35.8 | -45 8 | Fine sand (5 4), till (4 6) |
| MW07-32R | 12/24/97 | 196235.23 | 524420.22 | 5.6 | 7 86 | 67.5 | 77.5 | -61 9 | -72.0 | Bedrock (quartzite) (10) |
| SB07-01 | 7/19/95 | 197635.90 | 524675.91 | 10 8 | NA | NA | NA | NA | NA | NA |
| SB07-02 | 7/18/95 | 197514.59 | 524515.81 | 9.1 | NA | NA | NA | NA | NA | NA |
| SB07-03 | 11/9/95 | 197838 41 | 524569 93 | 13 2 | NA | NA | NA | NA | NA | NA |
| SB09-16~ | 11/11/97 | 196694 | 523219 | -15 1 | NA | NA | NA | NA | NA | NA |
| SB09-17~ | 11/18/97 | 196405 | 523625 | -16 1 | NA | NA | NA | NA | NA | NA |

All wells and borings are EA 1995, 1997 (Phase III RI) except
* = TRC 1985, 1989 (Phase I RI)
+ = TRC 1993, 1994 (Phase II RI)
~ = coordinates obtained utilizing differential GPS, accurate to within a meter
MW07-32D/R and SB09-16/17 installed as part of the IR Program Site 09 Allen Harbor Landfill Offshore Investigation, 1997
bgs = below ground surface
msl = mean sea level
NA = Not Applicable

# Summary of VOC in Hydroprobe Samples (ug/L)

## TABLE 2-2A
**Site 07, NCBC Davis ille, R.I.**

| **Sample I.D.** | | HP-04 | | HP-21 | | Trip Blank 1 | | HP-10 | | HP-10 DL | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample interval (Ft b** | | 9-11 ft | | 46.5-48.5 ft | | | | 41-43 ft | | 41-43 ft | |
| **Date Collected** | | 06/19/95 | | 06/21/95 | | 06/21/95 | | 06/22/95 | | 06/22/95 | |
| **Method Blank** | | VBLKEP | | VBLKEN | | VBLKEN | | VBLKEQ | | VBLKER | |
| **ANALYT** | **CRQL** | | | | | | | | | | |
| * Chlorom | 10 | 10 | U | 500 | U | 10 | U | 500 | U | **770** | **DJ** |
| Bromomet | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Vinyl Ch | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Chloroet | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| Methylene | 10 | 22 | UJ | 500 | UJ | **12** | **J** | 500 | UJ | 2400 | BD |
| Acetone | 10 | 11 | U | 500 | UJ | **63** | **J** | 500 | U | **780** | **DJ** |
| Carbon Di | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,1-Dich | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,1-Dich | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,2-Dich | 10 | 10 | U | **1900** | | 10 | U | **8400** | | 7500 | D |
| * Chlorofo | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,2-Dich | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| 2-Butanon | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 590 | BDJ |
| * 1,1,1-Tri | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Carbon | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| Bromodich | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| 1,2-Dichlo | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| cis-1,3-Dic | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Trichlor | 10 | **3** | | **5500** | | 10 | U | **20000** | **D** | **20000** | **D** |
| Dibromoc | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,1,2-Tri | 10 | 10 | U | **250** | | 10 | U | **670** | | **660** | **DJ** |
| < Benzen | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| trans-1,3- | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| Bromofor | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| 4-Methyl-2 | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| 2-Hexanon | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 310 | BDJ |
| * Tetrachl | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * 1,1,2,2- | 10 | 10 | U | **4600** | | 10 | U | **10000** | **D** | **10000** | **D** |
| < Toluen | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Chlorobe | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| < Ethylbe | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| Styrene | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| < Total X | 10 | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| DILUTION FACTOR | | 1 | | 50 | | 1 | | 50 | | 200 | |
| < Total BTEX | | 10 | U | 500 | U | 10 | U | 500 | U | 2000 | U |
| * Total Chlorinated V | | 3 | | 12250 | | 10 | U | 39070 | | 38930 | |

| **NOTES:** | All values reported in micrograms per liter (ug/L) | **NOTES:** |
|---|---|---|
| CRQL | = contract required quantitation limit | CRQL |
| UJ | = estimated value (below laboratory detection limit) | UJ |
| U | = unqualified (below laboratory detection limit) | U |
| J | = estimated value below sample qualification limit (SQL) | J |
| BJ | = estimated value below SQL where analyte is detected in method blank and sample | BJ |
| D | = analysis at a secondary dilution factor | D |

# Summary of VOC in Hydroprobe Samples (ug/L)

## TABLE 2-2A
**Site 07, NCBC Davis**

| **Sample I.D.** | | HP-07 | | HP-07 DL | | Trip Blank 2 | | HP-17 | | Trip Blank 3 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample interval (Ft b** | | 43-45 ft | | 43-45 ft | | | | 64-66 ft | | | |
| **Date Collected** | | 06/23/95 | | 06/23/95 | | 06/23/95 | | 06/29/95 | | 06/30/95 | |
| **Method Blank** | | VBLKEQ | | VBLKEV | | VBLKEQ | | VBLKEE | | VBLKED | |
| **ANALYT** | **CRQL** | | | | | | | | | | |
| * Chlorom | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| Bromomet | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Vinyl Ch | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Chloroet | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| Methylene | 10 | 500 | UJ | 36000 | BD | **8** | **J** | 24 | U | **12** | |
| Acetone | 10 | 500 | U | 3000 | BDJ | **12** | | 11 | U | **9** | |
| Carbon Di | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,1-Dich | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,1-Dich | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dich | 10 | **4100** | | **3700** | **DJ** | 10 | U | 10 | U | 10 | U |
| * Chlorofo | 10 | **170** | | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dich | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| 2-Butanon | 10 | 500 | U | 3100 | BDJ | 10 | U | 10 | U | **2** | |
| * 1,1,1-Tri | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Carbon | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| Bromodich | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| 1,2-Dichlo | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| cis-1,3-Dic | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Trichlor | 10 | **120000** | **D** | **120000** | **D** | 10 | U | 10 | U | 10 | U |
| Dibromoc | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2-Tri | 10 | **1200** | | **1600** | **DJ** | 10 | U | 10 | U | 10 | U |
| < Benzen | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| trans-1,3- | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| Bromofor | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| 4-Methyl-2 | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| 2-Hexanon | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | **2** | **J** |
| * Tetrachl | 10 | **550** | | 10000 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2,2- | 10 | **9800** | **D** | **98000** | **D** | 10 | U | 10 | U | 10 | U |
| < Toluen | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Chlorobe | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| < Ethylbe | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| Styrene | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| < Total X | 10 | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| DILUTION FACTOR | | 50 | | 1000 | | 1 | | 1 | | 1 | |
| < Total BTEX | | 500 | U | 10000 | U | 10 | U | 10 | U | 10 | U |
| * Total Chlorinated V | | 135820 | | 223300 | | 10 | U | 10 | U | 10 | U |

All values reported in micrograms per liter (ug/L)
= contract required quantitation limit
= estimated value (below laboratory detection limit)
= unqualified (below laboratory detection limit)
= estimated value below sample qualification limit (SQL)
= estimated value below SQL where analyte is detected in method blank and sample
= analysis at a secondary dilution factor

**NOTES:**

| | |
|---|---|
| CRQL | = contract required quant |
| UJ | = estimated value (below |
| U | = unqualified (below labo |
| J | = estimated value below |
| BJ | = estimated value below in method blank and s |
| D | = analysis at a secondary |

All values reported in mic

# Summary of VOC in Hydroprobe Samples (ug/L)

## TABLE 2-2A
**Site 07, NCBC Davis**

| **Sample I.D.** | | Trip Blank 4 | | HP-25 | | HP-24 | |
|---|---|---|---|---|---|---|---|
| **Sample interval (Ft b** | | | | 33-35 ft | | 56-58 ft | |
| **Date Collected** | | 07/07/95 | | 07/07/95 | | 07/07/95 | |
| **Method Blank** | | VBLKEK | | VBLKEM | | VBLKHC | |
| **ANALYT** | **CRQL** | | | | | | |
| * Chlorom | 10 | 10 | U | 100 | U | 100 | U |
| Bromomet | 10 | 10 | U | 100 | U | 100 | U |
| * Vinyl Ch | 10 | 10 | U | 100 | U | 100 | U |
| * Chloroet | 10 | 10 | U | 100 | U | 100 | U |
| Methylene | 10 | **6** | **J** | 100 | U | 100 | U |
| Acetone | 10 | **7** | | 100 | U | 130 | U |
| Carbon Di | 10 | 10 | U | 100 | U | 100 | U |
| * 1,1-Dich | 10 | 10 | U | 100 | U | 100 | U |
| * 1,1-Dich | 10 | 10 | U | 100 | U | 100 | U |
| * 1,2-Dich | 10 | 10 | U | 100 | U | **1700** | |
| * Chlorofo | 10 | 10 | U | 100 | U | 100 | U |
| * 1,2-Dich | 10 | 10 | U | 100 | U | 100 | U |
| 2-Butanon | 10 | 10 | U | 180 | U | **320** | |
| * 1,1,1-Tri | 10 | 10 | U | 100 | U | 100 | U |
| * Carbon | 10 | 10 | U | 100 | U | 100 | U |
| Bromodich | 10 | 10 | U | 100 | U | 100 | U |
| 1,2-Dichlo | 10 | 10 | U | 100 | U | 100 | U |
| cis-1,3-Dic | 10 | 10 | U | 100 | U | 100 | U |
| * Trichlor | 10 | 10 | U | **1000** | | **800** | |
| Dibromoc | 10 | 10 | U | 100 | U | 100 | U |
| * 1,1,2-Tri | 10 | 10 | U | **15** | | **150** | |
| < Benzen | 10 | 10 | U | 100 | U | 100 | U |
| trans-1,3- | 10 | 10 | U | 100 | U | 100 | U |
| Bromofor | 10 | 10 | U | 100 | U | 100 | U |
| 4-Methyl-2 | 10 | 10 | U | 100 | U | 100 | U |
| 2-Hexanon | 10 | 10 | U | 100 | U | 100 | U |
| * Tetrachl | 10 | 10 | U | **55** | | 100 | U |
| * 1,1,2,2- | 10 | 10 | U | **1600** | | **440** | |
| < Toluen | 10 | 10 | U | 100 | U | 100 | U |
| * Chlorobe | 10 | 10 | U | 100 | U | 100 | U |
| < Ethylbe | 10 | 10 | U | 100 | U | 100 | U |
| Styrene | 10 | 10 | U | 100 | U | 100 | U |
| < Total X | 10 | 10 | U | 100 | U | 100 | U |
| DILUTION FACTOR | | 1 | | 10 | | 10 | |
| < Total BTEX | | 10 | U | 100 | U | 100 | U |
| * Total Chlorinated V | | 10 | U | 2670 | | 3090 | |

ograms per liter (ug/L)
tation limit
aboratory detection limit)
atory detection limit)
ample qualification limit (SQL)
QL where analyte is detected
mple
dilution factor

# TABLE 2-3
## WELL DEVELOPMENT GROUND-WATER QUALITY FIELD DATA
IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI,
NCBC DAVISVILLE, RHODE ISLAND

| Well Number | Date | Total Gallons | Time | pH | Temperature (°C) | Conductivity (mS/cm) | Eh (mV) | Turbidity (NTU) | Dissolved Oxygen | Salinity (%) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW07-04D | 10/20/95 | 118 0 | 1215 | 6 79 | 14 3 | 0.90 | -12.2 | >999 | 1 29 | 0.03 | Pumped |
| MW07-05R | 10/19/95 | 113.5 | 1258 | 6.52 | 15.6 | 2.26 | 1.4 | 0.9 | 1 39 | 0.10 | Pumped |
| MW07-09R | 10/17/95 | 104 0 | 1218 | 6 27 | 12 2 | 26.50 | 27 7 | 2.4 | 1 70 | 1 61 | Pumped |
| MW07-10S | 10/25/95 | 42 0 | 1059 | 6 66 | 15 7 | 1 18 | -110.7 | 65 0 | 3 85 | 0.05 | Bailed |
| MW07-13S | 10/27/95 | 44 0 | 1517 | 7 38 | 14 9 | 1.60 | -134 0 | 110.0 | 1 74 | 0 07 | Bailed |
| MW07-14D | 10/23/95 | 99.0 | 1705 | 6 18 | 14 8 | 0.44 | -30 3 | 28 8 | -1 14 | 0 01 | Pumped |
| MW07-15D | 10/20/95 | 146.5 | 1204 | 6 12 | 13 1 | 0 72 | -28 1 | 9 8 | -1.73 | 0 03 | Pumped |
| MW07-16D | 10/12/95 | 189 0 | 1252 | 6 82 | 16 8 | 48 30 | 65.8 | 20 4 | 1 21 | 3 17 | Pumped |
| MW07-16R | 10/11/95 | 111 0 | 1605 | 6.69 | 14 0 | 35 40 | 85.9 | 1.4 | 0 57 | 2 23 | Pumped |
| MW07-17D | 10/23/95 | 78.0 | 1616 | 6 15 | 13 6 | 1 61 | -85 3 | 3 0 | 0.66 | 0 07 | Pumped |
| MW07-18D | 10/6/95 | 115.0 | 1042 | 6 44 | 15 6 | 47 00 | -21.1 | 6 5 | 1 71 | 3.08 | Pumped |
| MW07-19S | 10/24/95 | 57 5 | 1651 | 6 72 | 14.3 | 2 24 | -131 5 | 25 1 | -1 79 | 0.10 | Pumped |
| MW07-19D | 10/24/95 | 172 5 | 1734 | 6.44 | 12 6 | 18 60 | -132.9 | 27 0 | -1 85 | 1 08 | Pumped |
| MW07-20S | 10/12/95 | 32 0 | 1700 | 6 84 | 19 8 | 49 20 | -40 3 | 19.4 | 1 18 | 3.23 | Pumped |
| MW07-20D | 10/13/95 | 184.0 | 1243 | 6.36 | 15.0 | 40 60 | -108 0 | 25.8 | 0.46 | 2.58 | Pumped |
| MW07-21S | 10/10/95 | 71 0 | 1016 | 6 72 | 14 5 | 2.56 | -192 0 | 1.7 | 1 77 | 0.12 | Pumped |
| MW07-21D | 10/10/95 | 84 5 | 1553 | 6 59 | 13.3 | 18.60 | -156 4 | 2.1 | 1 54 | 1 09 | Pumped |
| MW07-21R | 11/14/95 | 99 0 | 1138 | 6 48 | 11 2 | 15 30 | -7 4 | 0.6 | 1 72 | 0 87 | Pumped |
| MW07-22S | 11/1/95 | 11 5 | 856 | 6 06 | 13 4 | 0.15 | 141.5 | >999 | 7 25 | 0 00 | Bailed |
| MW07-22D | 10/5/95 | 122.5 | 1208 | 6 92 | 14 5 | 0 16 | -7.8 | 4 3 | 3 66 | 0.00 | Pumped |
| MW07-23S | 11/1/95 | 18 0 | 931 | 6.37 | 13.9 | 6 55 | -165 2 | 20 6 | 1 94 | 0 34 | Bailed |
| MW07-23D | 10/9/95 | 112 0 | 1221 | 6 67 | 14 1 | 14 30 | -343 0 | 50.9 | 1 44 | 0.82 | Pumped |
| MW07-24S | 11/13/95 | 40 0 | 1557 | 6 69 | 12 5 | 22.50 | -114 5 | 225 0 | 7 04 | 1.34 | Bailed |
| MW07-24D | 11/13/95 | 133 0 | 1511 | 6 43 | 11 0 | 28 20 | -132.9 | 3 1 | 1 95 | 1.71 | Pumped |
| MW07-25D | 11/10/95 | 115 0 | 1448 | 5 95 | 11 3 | 0 55 | 113 2 | 6 5 | 1 26 | 0 02 | Pumped |
| MW07-25R* | 12/6/95 | 61 0 | 1531 | 7 69 | 15 1 | 14 78 | -59 0 | <1 | 0 37 | 8 6+ | Pumped |
| MW07-26S | 10/31/95 | 22 0 | 731 | 6 69 | 11 5 | 7 64 | -104 5 | 90.0 | 1 90 | 0 40 | Bailed |
| MW07-27D | 10/18/95 | 270 0 | 1237 | 6 92 | 12.9 | 2.32 | 24.1 | 3 6 | 1 50 | 0.11 | Pumped |
| MW07-28D | 11/6/95 | 82.0 | 1629 | 6 05 | 11 4 | 7.28 | -50.9 | 225 0 | 1 54 | 0 38 | Pumped |
| MW07-29D | 11/7/95 | 117.0 | 1342 | 6 28 | 12.1 | 33 40 | -29.3 | 2.7 | 0 90 | 2 07 | Pumped |
| MW07-30D* | 12/13/95 | 88.0 | 1353 | 6.67 | 12.3 | 34.50 | -195.0 | 3.0 | 0.01 | 21.7+ | Pumped |

| Well Number | Date | Total Gallons | Time | pH | Temperature (°C) | Conductivity (mS/cm) | Eh (mV) | Turbidity (NTU) | Dissolved Oxygen | Salinity (%) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW07-31I* | 12/12/95 | 24 0 | 1454 | 6.89 | 13.0 | 0 36 | 41 0 | 197 0 | 7.60 | 0 2+ | Pumped |
| MW07-32D | 1/21/98 | 39.0 | 1400 | 9 19 | 13 1 | 44 90 | 107.0 | 1.4 | 2.72 | 29.10 | Pumped |
| MW07-32R | 1/14/98 | 100 0 | 1502 | 6.03 | 13.8 | 45.62 | 113.0 | 7 7 | 0 65 | 29.50 | Pumped |

NOTES: Readings taken with Horiba U10 Water Quality Checker Orion 250A Eh Meter and Hach 2100P Turbidimeter except where noted
*- Readings taken with a Grant YSI 3800 Water Quality Meter with flow through cell, salinity in parts per thousand (ppt)

# TABLE 2-4

## WELL SAMPLING GROUND-WATER QUALITY FIELD DATA
IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI,
NCBC DAVISVILLE, RHODE ISLAND

| Well Number | Date | Gallons Pumped | Time | pH | Temperature (°C) | Conductivity (mS/cm) | Eh (mV) | Turbidity (NTU) | Dissolved Oxygen (mg/L) | Salinity (ppt) | Water Level from Top of Riser |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW07-01S+ | 12/27/95 | 10.3 | 1053 | 7.23 | 8.3 | 0.31 | -86 | 6.0 | 4.53 | 0.1 | 6.45 |
| MW07-02S+ | 12/27/95 | 11.3 | 1426 | 6.73 | 8.6 | 0.48 | -15 | 8.5 | 1.83 | 0.2 | 7.92 |
| MW07-03S+ | 12/28/95 | 8.3 | 1132 | 7.29 | 8.3 | 0 29 | 18 | 3.0 | 5.42 | 0.1 | 7 72 |
| MW07-03Da+ | 5/22/96 | 3.4 | 1510 | 7.48 | 17.1 | 0.50 | -74 | 13.0 | 6.50 | 0.2 | 9.27 |
| MW07-04S+ | 12/27/95 | 12.5 | 1124 | 6.87 | 7.7 | 0.65 | 90 | 69.0 | 3.04 | 0.3 | 9.51 |
| MW07-04Da | 5/28/96 | 4.3 | 1540 | 6.30 | 15.0 | 1.62 | -195 | 34.0 | 1.35 | 0.6 | 8.74 |
| MW07-05S+ | 12/26/95 | 4 3 | 1515 | 6.85 | 5.9 | 0.62 | -68 | 45.0 | 0.96 | 0.3 | 4.66 |
| MW07-05Da+ | 5/23/96 | 3.3 | 1650 | 6.48 | 14.9 | 0.59 | -119 | 58.0 | 0 77 | 0.3 | 7.54 |
| MW07-05Ra | 5/23/96 | 5.9 | 1405 | 7.19 | 16.0 | 1.39 | -261 | 26.0 | 0.87 | 0 7 | 8.46 |
| MW07-06S+ | 12/14/95 | 17.0 | 1515 | 7 52 | 10.4 | NR | -60 | 175.0 | 4.20 | NR | 7.11 |
| MW07-07S+ | 12/21/95 | 7.5 | 1520 | 5.66 | 11 9 | 0.08 | 300 | 537.0 | 9.55 | 0.0 | 12.77 |
| MW07-08S+ | 12/20/95 | 1.3 | 954 | 6 76 | 9.1 | 0.24 | 71 | 12.0 | 6.70 | 0 1 | 8.80 |
| MW07-09Da+ | 5/22/96 | 3.7 | 1245 | 6.70 | 15.0 | 6 61 | -81 | 3.0 | 1.76 | 3.6 | 6.76 |
| MW07-09R | 12/20/95 | 10.5 | 1608 | 6.56 | 11.2 | 25.72 | -60 | 0.96 * | 2.06 | 15.7 | 7.25 |
| MW07-10S | 12/22/95 | 2.5 | 1205 | 6.72 | 6.7 | 1.23 | -164 | 3.13 * | 2.30 | 0.6 | 5.86 |
| MW07-10Da+ | 5/23/96 | 3.5 | 1345 | 6.03 | 22.1 | 1.32 | 53 | 10.3 | 7.31 | 0.7 | 9.22 |
| MW07-11D+ | 12/19/95 | 26.0 | 1325 | 6 36 | 10.8 | 21.58 | 5 | 158 * | 0.59 | 13.0 | 10.20 |
| MW07-12Da+ | 5/29/96 | 3.2 | 1800 | 5.94 | 13.7 | 3.90 | 18 | 12.2 | 3 61 | 2.1 | 7.69 |
| MW07-13S | 12/18/95 | 20.5 | 1455 | 6 83 | 9.3 | 1.69 | -110 | 97.0 | 0.01 | 0.9 | 4.31 |
| MW07-13D+ | 12/18/95 | 12.5 | 1620 | 7.19 | 10.8 | 2.78 | -40 | 44.0 | 0.03 | 1.4 | 14.41 |
| MW07-14Da | 5/30/96 | 3.3 | 1615 | 6 66 | 11.4 | 0.38 | -224 | 0.8 | 0 75 | 0.2 | 5.55 |
| MW07-15Da | 5/24/96 | 3.7 | 1345 | 6.25 | 16.2 | 0.55 | -82 | 74.0 | 1 49 | 0.3 | 8.39 |
| MW07-16D | 12/14/95 | 2.0 | 1530 | 7.44 | 8.9 | 45.72 | -130 | 9.0 | 1.90 | 29 4 | 6.60 |
| MW07-16R | 12/15/95 | 2.0 | 1208 | 7.38 | 9.4 | 46.12 | -204 | 4.0 | 2.85 | 29.7 | 5.33 |
| MW07-17Da | 5/22/96 | 3.2 | 1750 | 6.57 | 16.6 | 1.03 | -215 | 71.0 | 2.15 | 0.5 | 6 69 |
| MW07-18D | 12/14/95 | 7.0 | 1120 | 6 88 | 10.4 | 37.61 | -99 | 67.0 | 3.66 | 23 8 | 5.29 |
| MW07-19Sa | 5/29/96 | 3.5 | 1022 | 6.76 | 12.0 | 1.52 | -36 | 0.7 | 0.89 | 0 8 | 4.54 |
| MW07-19D | 12/19/95 | 17.5 | 1240 | 6.56 | 10 7 | 19.73 | -281 | 0.0 | 0.10 | NR | 5.07 |
| MW07-20S | 12/14/95 | 9.0 | 1443 | 7.09 | 12.2 | 36.79 | -66 | 253.0† | 2.40 | 23.2 | 4.14 |
| MW07-20D | 12/14/95 | 13.3 | 1106 | 6 54 | 11.6 | 42.33 | -95 | <100 | 4.10 | 27.1 | 4.77 |
| MW07-21S | 12/18/95 | 13.0 | 1425 | 6.70 | 11.7 | 3.24 | -96 | 35.0 | 0.11 | 1.7 | 5.20 |
| MW07-21Da | 5/24/96 | 1.7 | 1140 | 6.55 | 13.6 | 9.57 | -96 | 1.2 | 2.35 | 7.0 | 4.41 |
| MW07-21Ra | 5/24/96 | 3.2 | 1017 | 6 76 | 14.6 | 7.61 | -258 | 1.3 | 2.52 | 5.4 | 4.70 |
| MW07-22S | 12/7/95 | 1.4 | 1413 | 6.27 | 11.6 | 5.84 | 181 | <1.0 | 4.54 | 3.2 | 10.63 |
| MW07-22D | 12/8/95 | 1.9 | 1219 | 6 42 | 10.1 | 0.13 | 110 | 0.0 | 2.92 | 0.1 | 10.36 |
| MW07-23S | 12/20/95 | 1.5 | 1130 | 6.76 | 7.2 | 5.38 | -245 | 113.0 | 4.43 | 2.9 | 9.03 |
| MW07-23Da | 5/29/96 | 3.? | 1236 | 7.04 | 14.0 | 8.55 | 149 | 7 6 | 0.58 | 4.8 | 5.67 |

| Well Number | Date | Gallons Pumped | Time | pH | Temperature (°C) | Conductivity (mS/cm) | Eh (mV) | Turbidity (NTU) | Dissolved Oxygen (mg/L) | Salinity (ppt) | Water Level from Top of Riser |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW07-24S | 12/12/95 | 5.0 | 1206 | 7.32 | 10.5 | 42.43 | -156 | 15.0 | 6.94 | 27.1 | 6.83 |
| MW07-24D | 12/12/95 | 17.0 | 1305 | 6.63 | 11.2 | 27.63 | -229 | NR | 1.79 | 17.0 | 6.80 |
| MW07-25Da | 5/22/96 | 1.7 | 1601 | 6.08 | 14.9 | 0.33 | -40 | 1.0 | 4.46 | 0.2 | 7.75 |
| MW07-25Ra | 5/21/96 | 3.5 | 1618 | 8.91 | 20.4 | 0.86 | 19 | 1.4 | 6.34 | 0.5 | 11.27 |
| MW07-26Sa | 5/28/96 | ? | 18 13 | 6.90 | 12.1 | 6.20 | -151 | 31.3 | 1.45 | 3.4 | 12.67 |
| MW07-27D | 12/19/95 | 1.2 | 1600 | 9.61 | 7.6 | 2.13 | -99 | 10.0 | 5.70 | 1.1 | 6.67 |
| MW07-28D | 12/19/95 | 15.5 | 1635 | 6.50 | 11.0 | 0.65 | -100 | 240.0 | 2.28 | 0.3 | 13.67 |
| MW07-29D | 12/14/95 | 4 8 | 1125 | 6.82 | 8.5 | 33.84 | -85 | 5.0 | 1.51 | 21.1 | 6.28 |
| MW07-30D | 12/20/95 | 27.0 | 1140 | 6.48 | 10.5 | 34.02 | -77 | 137.0 | 0.28 | 21.3 | 12.62 |
| MW07-31Ia | 5 /30/96 | 3.3 | 1245 | 6 67 | 11.5 | 0.36 | -162 | 2.4 | 1 82 | 0.2 | 7.73 |
| MW07-32D | 2/2/98 | 8.0 | 1430 | 9.50 | 11.6 | 46.03 | 29 | 3.39* | 1.70 | 29.8 | 7.93 |
| MW07-32R | 1/28/98 | 4.5 | 1423 | 5.96 | 8.1 | 46.54 | 97 | 7.63* | 2.24 | 29.9 | 8.33 |

NOTES Table shows last set of parameters taken prior to sampling
All measurements taken with a Grant YSI 3800 Water Quality Meter using a flow- through cell
* - Turbidity measurements taken with Hach 2100P Turbidimeter
⋆ - Turbidity measurements taken with HF Scientific DRT 15 CE Turbidimeter
† - Turbidity reading was not representative of the sample Visual inspection of the sample indicated that the turbidity should have been <100 NTU.
– - TRC well, installed prior to Phase III RI
NR - no reading
ppt - parts per thousand
a - Signifies wells that have been resampled

TABLE 3-1

# DEPTH AND ELEVATION OF TOP OF GEOLOGIC UNITS

IR PROGRAM SITE 07, CALF PASTURE POINT
NCBC DAVISVILLE, RHODE ISLAND

| Well or Boring Number | Upper Sand | | Silt & Sand lyrs | | Silt | | Lower Sand | | Till | | Bedrock | | Total Depth | | Screen Interval | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | Elev. (ft msl) | Depth (ft bgs) | | Elev. (ft msl) | |
| MW07-01S+ | 0 0 | 12 0 | ** | NA | ** | NA | ** | NA | ** | NA | ** | NA | 14 0 | -2 0 | 4 0 | 14 0 | 8 0 | -2 0 |
| MW07-02S+ | NE | NA | 0 | 12 3 | 14 0 | -14 0 | ** | NA | ** | NA | ** | NA | 18 0 | -5 7 | 4 0 | 14 0 | 8 3 | -1 7 |
| MW07-03S+ | 0 0 | 11 7 | * | * | * | * | * | * | * | * | * | * | 12 0 | -0 3 | 2 0 | 12 0 | 9 7 | -0 3 |
| MW07-03D | 0 0 | 11 7 | NE | NA | 14 0 | -2 3 | 44 0 | -32 3 | 45 5 | -33 8 | 51 0 | -39 3 | 60 9 | -49 2 | 40 0 | 50 0 | -28 3 | -38 3 |
| MW07-04S+ | 0 0 | 11 7 | * | * | * | * | * | * | * | * | * | * | 21 0 | -9 3 | 6 1 | 16 1 | 5 6 | -4 4 |
| MW07-04D | 0 0 | 11 3 | NE | NA | 14 5 | -3 2 | NE | NA | 33 5 | -22 2 | 35 8 | -24 5 | 43 0 | -31 7 | 25 5 | 35 5 | -14 2 | -24 2 |
| MW07-05S+ | 0 0 | 10 2 | * | * | * | * | * | * | * | * | * | * | 16 0 | -5 8 | 4 0 | 16 0 | 6 2 | -5 8 |
| MW07-05D | 0 0 | 10 2 | * | * | * | * | * | * | * | * | * | * | 61 5 | -51 3 | 41 4 | 51 4 | -31 2 | -41 2 |
| MW07-05R | 0 0 | 10 3 | NE | NA | 15 0 | -4 7 | NE | NA | 44 5 | -34 2 | 48 5 | -38 2 | 78 0 | -67 7 | 64 0 | 74 0 | -53 7 | -63 7 |
| MW07-06S+ | 0 0 | 13 4 | NE | NA | 14 0 | -0 6 | ** | NA | ** | NA | ** | NA | 16 0 | -2 6 | 4 0 | 14 0 | 9 4 | -0 6 |
| MW07-07S+ | 0 0 | 19 7 | NE | NA | NE | NA | NE | NA | 8 0 | 11 7 | 16 0 | 3 7 | 26 0 | -6 3 | 4 0 | 16 0 | 15 7 | 3 7 |
| MW07-08S+ | 0 0 | 15 3 | ** | NA | ** | NA | ** | NA | ** | NA | ** | NA | 16 0 | -0 7 | 4 0 | 14 0 | 11 3 | 1 3 |
| MW07-09D | 0 0 | 6 9 | * | * | * | * | * | * | * | * | * | * | 55 0 | -48 1 | 45 0 | 55 0 | -38 1 | -48 1 |
| MW07-09R | 0 0 | 6 8 | 8 0 | -1 2 | 17 0 | -10 2 | 46 0 | -39 2 | 52 0 | -45 2 | 56 3 | -49 5 | 87 0 | -80 2 | 73 0 | 83 0 | -66 2 | -76 2 |
| MW07-10S | 0 0 | 9 2 | NE | NA | 13 5 | -4 3 | * | * | * | * | * | * | 16 0 | -6 8 | 4 5 | 13 5 | 4 7 | -4 3 |
| MW07-10D | 0 0 | 9 2 | * | * | * | * | NE | NA | 35 5 | -26 3 | 36 5 # | -27 3 # | 37 5 | -28 3 | 27 5 | 37 5 | -18 3 | -28 3 |
| MW07-11D | 0 0 | 7 4 | NE | NA | 15 0 | -7 6 | 50 0 | -42 6 | NE | NA | 57 5 # | -50 1 # | 57 5 | -50 1 | 47 5 | 57 5 | -40 1 | -50 1 |
| MW07-12D | 0 0 | 7 5 | NE | NA | 10 0 | -2 5 | NE | NA | 21 5 | -14 0 | 35 1 # | -27 6 # | 35 1 | -27 6 | 25 0 | 35 0 | -17 5 | -27 5 |
| MW07-13S | 0 0 | 5 1 | NE | NA | 14 0 | -8 9 | * | * | * | * | * | * | 18 0 | -12 9 | 4 0 | 13 0 | 1 1 | -7 9 |
| MW07-13D | 0 0 | 4 7 | * | * | * | * | NE | NA | 30 0 | -25 3 | 45 0 # | -40 3 # | 45 0 | -40 3 | 35 0 | 45 0 | -30 3 | -40 3 |
| MW07-14D | 0 0 | 11 9 | NE | NA | 13 0 | -1 1 | NE | NA | 24 0 | -12 1 | 35 0 | -23 1 | 42 5 | -30 6 | 24 0 | 34 0 | -12 1 | -22 1 |
| MW07-15D | 0 0 | 11 5 | NE | NA | 15 0 | -3 5 | NE | NA | 29 0 | -17 5 | 48 0 | -36 5 | 55 0 | -43 5 | 37 0 | 47 0 | -25 5 | -35 5 |
| MW07-16D | 0 0 | 6 1 | NE | NA | 17 0 | -10 9 | 44 0 | -37 9 | 59 0 | -52 9 | 84 5 | -78 4 | 91 7 | -85 6 | 74 0 | 84 0 | -67 9 | -77 9 |
| MW07-16R | 0 0 | 5 8 | * | * | * | * | * | * | * | * | * | * | 114 1 | -108 3 | 100 0 | 110 0 | -94 2 | -104 2 |
| MW07-17D | 0 0 | 8 4 | NE | NA | 16 0 | -7 6 | 29 0 | -20 6 | 44 0 | -35 6 | 49 0 | -40 6 | 57 0 | -48 6 | 38 0 | 48 0 | -29 6 | -39 6 |
| MW07-18D | 0 0 | 5 8 | NE | NA | 18 0 | -12 2 | 44 0 | -38 2 | 72 0 | -66 2 | 73 0 | -67 2 | 83 0 | -77 2 | 62 0 | 72 0 | -56 2 | -66 2 |
| MW07-19S | 0 0 | 4 9 | * | * | * | * | * | * | * | * | * | * | 24 0 | -19 1 | 13 0 | 23 0 | -8 1 | -18 1 |
| MW07-19D | 0 0 | 4 8 | NE | NA | NE | NA | NE | NA | 5 5 | -0 7 | 41 5 | -36 7 | 49 0 | -44 2 | 34 5 | 39 5 | -29 7 | -34 7 |
| MW07-20S | 0 0 | 3 8 | NE | NA | 12 5 | -8 7 | * | * | * | * | * | * | 18 0 | -14 2 | 4 9 | 14 9 | -1 1 | -11 1 |
| MW07-20D | 0 0 | 3 7 | * | * | * | * | 59 5 | -55 8 | 63 0 | -59 3 | 74 9 | -71 2 | 83 0 | -79 3 | 64 0 | 74 0 | -60 3 | -70 3 |
| MW07-21S | 0 0 | 4 5 | * | * | * | * | * | * | * | * | * | * | 21 0 | -16 5 | 10 0 | 20 0 | -5 5 | -15 5 |
| MW07-21D | 0 0 | 4 0 | NE | NA | NE | NA | NE | NA | 7 0 | -3 0 | 39 3 | -35 3 | 48 0 | -44 0 | 33 0 | 38 0 | -29 0 | -34 0 |
| MW07-21R | 0 0 | 4 6 | * | * | * | * | * | * | * | * | * | * | 69 7 | -65 1 | 55 3 | 65 3 | -50 8 | -60 8 |
| MW07-22S | 0 0 | 15 4 | NE | NA | 12 0 | 3 4 | NE | NA | * | * | * | * | 18 0 | -2 6 | 8 0 | 13 0 | 7 4 | 2 4 |
| MW07-22D | 0 0 | 15 4 | * | * | * | * | * | * | 17 0 | -1 6 | 32 0 | -16 6 | 40 5 | -25 1 | 21 0 | 31 0 | -5 6 | -15 6 |
| MW07-23S | 0 0 | 4 4 | * | * | * | * | * | * | * | * | * | * | 10 0 | -5 6 | 4 0 | 8 0 | 0 4 | -3 6 |
| MW07-23D | 0 0 | 4 6 | NE | NA | 4 5 | 0 1 | NE | NA | 11 5 | -6 9 | 45 5 | -40 9 | 53 7 | -49 1 | 34 5 | 44 5 | -29 9 | -39 9 |
| MW07-24S | 0 0 | 4 6 | * | * | * | * | * | * | * | * | * | * | 20 0 | -15 4 | 9 5 | 19 5 | -4 9 | -14 9 |
| MW07-24D | 0 0 | 4 4 | 12 5 | -8 1 | 18 5 | -14 1 | NE | NA | 29 0 | -24 6 | 59 8 | -55 4 | 65 7 | -61 3 | 43 0 | 53 0 | -38 6 | -48 6 |
| MW07-25D | 0 0 | 10 0 | NE | NA | 15 0 | -5 0 | NE | NA | 33 0 | -23 0 | 39 3 | -29 3 | 46 7 | -36 7 | 33 0 | 38 0 | -23 0 | -28 0 |
| MW07-25R | 0 0 | 10 0 | * | * | * | * | * | * | * | * | * | * | 68 0 | -58 0 | 57 0 | 67 0 | -47 0 | -57 0 |
| MW07-26S | 0 0 | 8 9 | NE | NA | NE | NA | NE | NA | 12 0 | -3 1 | ** | NA | 24 0 | -15 1 | 13 0 | 18 0 | -4 1 | -9 1 |
| MW07-27D | 0 0 | 8 3 | NE | NA | 8 0 | 0 3 | NE | NA | 18 0 | -9 7 | 53 0 | -44 7 | 59 3 | -51 0 | 45 0 | 52 0 | -36 7 | -43 7 |
| MW07-28D | 0 0 | 7 4 | NE | NA | 8 0 | -0 6 | NE | NE | 36 5 | -29 1 | 46 5 | -39 1 | 54 0 | -46 6 | 42 0 | 46 0 | -34 6 | -38 6 |
| MW07-29D | 0 0 | 6 2 | NE | NA | 8 3 | -2 1 | 44 0 | -37 8 | 59 0 | -52 8 | 77 5 | -71 3 | 84 0 | -77 8 | 66 5 | 76 5 | -60 3 | -70 3 |
| MW07-30D | 0 0 | 5 6 | NE | NA | 18 0 | -12 4 | 40 8 | -35 2 | 69 0 | -63 4 | 84 0 | -78 4 | 91 0 | -85 4 | 60 8 | 70 8 | -55 2 | -65 2 |
| MW07-31I | 0 0 | 12 7 | NE | NA | 14 0 | -1 3 | NE | NA | 24 0 | -11 3 | ** | NA | 26 0 | -13 3 | 14 8 | 24 8 | -2 1 | -12 1 |
| MW07-32D | 0 0 | 5 8 | NE | NA | NE | NA | NE | NA | 47 0 | -41 2 | 51 2 | -45 4 | 59 2 | -53 4 | 41 6 | 51 6 | -35 8 | -45 8 |
| MW07-32R | 0 0 | 5 6 | NE | NA | NE | NA | NE | NA | 47 0 | -41 4 | 48 5 | -42 9 | 77 5 | -71 9 | 67 5 | 77 5 | -61 9 | -71 9 |
| SB07-01 | 0 0 | 10 8 | NE | NA | 9 2 | 1 6 | NE | NA | 33 2 | -22 4 | 44 3 | -33 5 | 47 5 | -36 7 | NA | NA | NA | NA |
| SB07-02 | 0 0 | 9 1 | 7 4 | 1 7 | 13 3 | -4 2 | NE | NA | 31 0 | -21 9 | 36 5 | -27 4 | 39 0 | -29 9 | NA | NA | NA | NA |
| SB07-03 | 0 0 | 13 2 | NE | NA | 11 0 | 2 2 | NE | NA | 23 8 | -10 6 | ** | NA | 30 5 | -17 3 | NA | NA | NA | NA |
| SB09-16 | 0 0 | -15 0 | NE | NA | 8 0 | -23 0 | NE | NA | 40 0 | -55 0 | 46 8 | -61 8 | 49 8 | -64 8 | NA | NA | NA | NA |
| SB09-17 | 0 0 | -10 0 | NE | NA | 6 0 | -16 0 | NE | NA | 31 5 | -41 5 | 62 2 | -72 2 | 65 2 | -75 2 | NA | NA | NA | NA |

NOTES
NE - Unit not encountered in this boring
NA - Not applicable
+- TRC well installed prior to Phase III RI
* - Use data from other well in cluster
**-No Data, boring too shallow
#-Phase II RI well drilled to refusal (bedrock surface not confirmed)
SB09-16 and -17 drilled as part of the Site 09 Offshore Study in NOV'97 (Upper Sand Unit is actually an organic silt and sand layer that forms the harbor floor)
MW07-32D/R were installed as part of the Site 09 Offshore Study in DEC'97

## TABLE 3-2 SUMMARY OF GROUND-WATER ELEVATIONS, IR PROGRAM SITE 07, NCBC DAVISVILLE, R.I.

| Well Number | Elev Top of Riser | Depth to Water | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 08/13/93 | 04\26\94 | 12\02\94 | 07\12\95 | 08/24/95 | 12/1/95a | 12/1/95b | 12/1/95c | 1/16/96a | 1/16/96b | 1/17/96a | 1/17/96b | 1/17/96c |
| MW07-01S | 13 75 | 8 33 | 4 24 | 8 13 | 6 91 | 8 17 | 6 14 | 6 14 | 6 14 | 5 10 | 5 10 | 4 91 | 4 78 | 5 59 |
| MW07-02S | 14 07 | 8 34 | 4 55 | 8 95 | 7 21 | 8 54 | 6 47 | 6 47 | 6 43 | 5 47 | 5 46 | 5 37 | 5 30 | 5 17 |
| MW07-03S | 15 47 | 10 36 | 6 35 | 9 84 | 8 89 | 10 18 | 7 83 | 7 80 | 7 79 | 6 74 | 6 72 | 6 55 | 6 40 | 6 22 |
| MW07-03D | 13 80 | 11 02 | 8 81 | 10 14 | 10 25 | 10 84 | 9 17 | 9 22 | 9 22 | 9 39 | 9 33 | 8 96 | 9 10 | 9 12 |
| MW07-04S | 15 60 | 10 59 | 6 42 | 10 26 | 9 25 | 10 38 | 7 79 | 7 72 | 7 67 | 7 16 | 7 03 | 6 48 | 6 26 | 6 18 |
| MW07-04D | 13 13 | N I | N I | N I | N I | 9 15 | 7 22 | 7 23 | 7 19 | 7 00 | 6 91 | 6 70 | 6 75 | 6 67 |
| MW07-05S | 12 06 | 7 70 | 3 64 | 6 84 | 6 58 | 7 60 | 4 73 | 4 51 | 4 45 | 3 93 | 5 90 | 3 50 | 3 38 | 3 32 |
| MW07-05D | 12 07 | 9 52 | 7 32 | 8 41 | 8 87 | 9 42 | 7 68 | 7 74 | 7 68 | 7 83 | 7 68 | 7 42 | 7 59 | 7 46 |
| MW07-05R | 11 62 | N I | N I | N I | N I | 9 04 | 7 84 | 7 88 | 7 69 | 8 13 | 7 73 | 7 84 | 7 95 | 7 56 |
| MW07-06S | 15 55 | 9 99 | 6 20 | 9 69 | 8 26 | 9 79 | 7 58 | 7 58 | 7 59 | 6 65 | 6 64 | 6 58 | 6 58 | 6 55 |
| MW07-07S | 21 43 | 16 63 | 10 83 | 15 38 | 14 55 | 16 50 | 13 25 | 13 25 | 13 28 | 12 83 | 12 81 | 12 71 | 12 74 | 12.68 |
| MW07-08S | 17 79 | 11 92 | 7 87 | 11 79 | 10 06 | 12 74 | 9 51 | 9 51 | 9 52 | 8 69 | 8 69 | 8 63 | 8 68 | 8 60 |
| MW07-09D | 9 10 | N I | 7 02 | 6 63 | 7 81 | 8 05 | 6 74 | 6 92 | 6 76 | 7 40 | 6 98 | 6 81 | 7 21 | 6 83 |
| MW07-09R | 9 09 | N I | N I | N I | N I | N M | 6 49 | 6 57 | 6 14 | 7 09 | 6 58 | 6 67 | 6 93 | 6 42 |
| MW07-10S | 11 48 | N I | N I | N I | N I | 8 66 | 5 00 | 4 87 | 4 82 | 4 90 | 4 84 | 4 51 | 4 46 | 4 50 |
| MW07-10D | 12 04 | N I | 7 75 | 8 24 | N M | 10 01 | 7 99 | 8 06 | 7 91 | 8 53 | 8 01 | 8 20 | 8 27 | 7 84 |
| MW07-11D | 10 70 | N I | 8 16 | 8 53 | 10 40 | 10 27 | 8 81 | 9 17 | 8 51 | 9 84 | 8 59 | 9 62 | 9 78 | 8 43 |
| MW07-12D | 10 13 | N I | 6 07 | 6 55 | 8 53 | 8 86 | 6 96 | 6 87 | 6 33 | 7 16 | 6 31 | 7 11 | 7 08 | 6 12 |
| MW07-13S | 6 88 | N I | N I | N I | N I | 5 71 | 3 61 | 3 48 | 3 35 | 3 50 | 3 04 | 3 12 | 3 10 | 2 90 |
| MW07-13D | 6 97 | N I | 4 86 | 4 99 | 6 63 | 6 91 | 5 42 | 5 39 | 4 99 | 5 72 | 5 06 | 5 40 | 5 52 | 4 77 |
| MW07-14D | 13 44 | N I | N I | N I | N I | 8 47 | 6 12 | 6 08 | 6 12 | 5 68 | 5 65 | 5 55 | 5 55 | 5 54 |
| MW07-15D | 13 27 | N I | N I | N I | N I | 10 01 | 8 23 | 8 28 | 8 24 | 8 26 | 8 16 | 7 89 | 8 01 | 7 94 |
| MW07-16D | 7 53 | N I | N I | N I | N I | 6 58 | 5 41 | 6 23 | 5 32 | 6 89 | 5 42 | 7 12 | 6 90 | 5 26 |
| MW07-16R | 7 49 | N I | N I | N I | N I | 5 93 | 5 41 | 5 30 | 4 41 | 6 01 | 4 62 | 6 15 | 6 00 | 4 48 |
| MW07-17D | 9 88 | N I | N I | N I | N I | 7 75 | 6 19 | 6 28 | 6 19 | 6 52 | 6 31 | 6 02 | 6 27 | 6 08 |
| MW07-18D | 7 18 | N I | N I | N I | N I | 6 40 | 5 50 | 5 42 | 4 62 | 6 12 | 4 79 | 6 09 | 6 09 | 4 62 |
| MW07-19S | 6 30 | N I | N I | N I | N I | 5 42 | 3 95 | 3 86 | 3 34 | 4 23 | 3 42 | 4 18 | 4 10 | 3 20 |
| MW07-19D | 6 05 | N I | N I | N I | N I | 5 10 | 3 77 | 3 70 | 3 17 | 4 02 | 3 24 | 3 86 | 3 90 | 3 02 |
| MW07-20S | 5 61 | N I | N I | N I | N I | 4 33 | 3 45 | 3 43 | 3 43 | 2 78 | 2 74 | 2 52 | 2 41 | 2 22 |
| MW07-20D | 5 10 | N I | N I | N I | N I | 4 75 | 3 90 | 3 70 | 2 72 | 4 35 | 2 89 | 4 60 | 4 36 | 2 71 |
| MW07-21S | 6 65 | N I | N I | N I | N I | N I | 5 08 | 5 91 | 4 08 | 5 26 | 4 15 | 5 37 | 5 21 | 3 93 |
| MW07-21D | 5 96 | N I | N I | N I | N I | N I | 4 35 | 4 20 | 3 40 | 4 57 | 3 46 | 4 65 | 4 50 | 3 24 |
| MW07-21R | 6 80 | N I | N I | N I | N I | N I | 4 31 | 4 26 | 3 70 | 4 61 | 3 89 | 4 58 | 4 50 | 3 68 |
| MW07-22S | 17 11 | N I | N I | N I | N I | 12 23 | 10 55 | 10 55 | 10 57 | 10 22 | 10 21 | 10 15 | 10 15 | 10 16 |
| MW07-22D | 16 94 | N I | N I | N I | N I | 12 19 | 10 01 | 10 01 | 10 02 | 9 72 | 9 67 | 9 60 | 9 61 | 9 58 |
| MW07-23S | 6 47 | N I | N I | N I | N I | 5 60 | 4 26 | 4 46 | 4 34 | 4 69 | 4 48 | 4 11 | 4 48 | 4 30 |
| MW07-23D | 6 07 | N I | N I | N I | N I | 5 90 | 4 83 | 4 68 | 4 78 | 5 23 | 3 69 | 5 25 | 5 18 | 3 51 |
| MW07-24S | 6 23 | N I | N I | N I | N I | N I | 4 49 | 4 57 | 4 19 | 5 03 | 4 25 | 4 51 | 4 80 | 5 88 |
| MW07-24D | 5 80 | N I | N I | N I | N I | N I | 4 21 | 4 16 | 3 46 | 4 71 | 3 51 | 4 53 | 4 67 | 3 51 |
| MW07-25D | 11 48 | N I | N I | N I | N I | N I | 7 99 | 7 84 | 7 37 | 8 06 | 7 23 | 8 02 | 7 91 | 7 05 |
| MW07-25R | 11 95 | N I | N I | N I | N I | N I | 8 74 | 8 66 | 8 17 | 9 00 | 8 02 | 8 88 | 8 90 | 7 86 |
| MW07-26S | 10 42 | N I | N I | N I | N I | 8 76 | 7 01 | 7 15 | 7 04 | 7 49 | 7 42 | 6 99 | 7 19 | 7 15 |
| MW07-27D | 9 84 | N I | N I | N I | N I | 8 13 | 6 50 | 6 56 | 6 40 | 6 85 | 6 53 | 6 38 | 6 59 | 6 28 |
| MW07-28D | 9 07 | N I | N I | N I | N I | N I | 5 75 | 5 92 | 5 89 | 6 52 | 6 17 | 5 80 | 6 11 | 5 96 |
| MW07-29D | 7 65 | N I | N I | N I | N I | N I | 5 80 | 5 88 | 5 34 | 6 53 | 5 41 | 6 28 | 6 47 | 5 26 |
| MW07-30D | 7 80 | N I | N I | N I | N I | N I | 6 08 | 5 91 | 5 00 | 6 85 | 5 39 | 7 13 | 6 86 | 5 23 |
| MW07-31I | 13 94 | N I | N I | N I | N I | N I | 6 69 | 6 68 | 6 69 | 6 03 | 6 02 | 5 93 | 5 94 | 5 91 |
| Time Range of Water Level Measurements | | | | | 1255-1545 | 1310 1405 | 0920-0951 | 1215-1247 | 1515-1543 | 1250-1328 | 1600-1626 | 1027-1059 | 1324-1348 | 1651-1736 |
| * Time of Low Tide | | | | | 1403 | 1259 | 0942 | 0942 | | 929 | | 1038 | 1038 | |
| * Time of High Tide | | | | | | | | 1530 | 1530 | 1612 | 1612 | | 1710 | 1710 |

NOTE N I = NOT INSTALLED
N M = NOT MEASURED

* 11 minutes added to Newport RI tide

## TABLE 3-2 SUMMARY OF GROUND-WATER ELEVATIONS, Pg. 2
## IR PROGRAM SITE 07, NCBC DAVISVILLE, R.I.

| Well Number | Elev Top of Riser | Elevation to Water Surface | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 08/13/93 | 04\26\94 | 12\02\94 | 07\12\95 | 08/24/95 | 12/1/95a | 12/1/95b | 12/1/95c | 1/16/96a | 1/16/96b | 1/17/96a | 1/17/96b | 1/17/96c |
| MW07-01S | 13 75 | 5 42 | 9 51 | 5 62 | 6 84 | 5 58 | 7 61 | 7 61 | 7 61 | 8 65 | 8 65 | 8 84 | 8 97 | 8 16 |
| MW07-02S | 14 07 | 5 73 | 9 52 | 5 12 | 6 86 | 5 53 | 7 60 | 7 60 | 7 64 | 8 60 | 8 61 | 8 70 | 8 77 | 8 90 |
| MW07-03S | 15 47 | 5 11 | 9 12 | 5 63 | 6 58 | 5 29 | 7 64 | 7 67 | 7 68 | 8 73 | 8 75 | 8 92 | 9 07 | 9 25 |
| MW07-03D | 13 80 | 2 78 | 4 99 | 3 66 | 3 55 | 2 96 | 4 63 | 4 58 | 4 58 | 4 41 | 4 47 | 4 84 | 4 70 | 4 68 |
| MW07-04S | 15 60 | 5 01 | 9 18 | 5 34 | 6 35 | 5 22 | 7 81 | 7 88 | 7 93 | 8 44 | 8 57 | 9 12 | 9 34 | 9 42 |
| MW07-04D | 13 13 | N I | N I | N I | N I | 3 98 | 5 91 | 5 90 | 5 94 | 6 13 | 6 22 | 6 43 | 6 38 | 6 46 |
| MW07-05S | 12 06 | 4 36 | 8 42 | 5 22 | 5 48 | 4 46 | 7 33 | 7 55 | 7 61 | 8 13 | 6 16 | 8 56 | 8 68 | 8 74 |
| MW07-05D | 12 07 | 2 55 | 4 75 | 3 66 | 3 20 | 2 65 | 4 39 | 4 33 | 4 39 | 4 24 | 4 39 | 4 65 | 4 48 | 4 61 |
| MW07-05R | 11 62 | N I | N I | N I | N I | 2 58 | 3 78 | 3 74 | 3 93 | 3 49 | 3 89 | 3 78 | 3 67 | 4 06 |
| MW07-06S | 15 55 | 5 56 | 9 35 | 5 86 | 7 29 | 5 76 | 7 97 | 7 97 | 7 96 | 8 90 | 8 91 | 8 97 | 8 97 | 9 00 |
| MW07-07S | 21 43 | 4 80 | 10 60 | 6 05 | 6 88 | 4 93 | 8 18 | 8 18 | 8 15 | 8 60 | 8 62 | 8 72 | 8 69 | 8 75 |
| MW07-08S | 17 79 | 5 87 | 9 92 | 6 00 | 7 73 | 5 05 | 8 28 | 8 28 | 8 27 | 9 10 | 9 10 | 9 16 | 9 11 | 9 19 |
| MW07-09D | 9 10 | N I | 2 08 | 2 47 | 1 29 | 1 05 | 2 36 | 2 18 | 2 34 | 1 70 | 2 12 | 2 29 | 1 89 | 2 27 |
| MW07-09R | 9 09 | N I | N I | N I | N I | N M | 2 60 | 2 52 | 2 95 | 2 00 | 2 51 | 2 42 | 2 16 | 2 67 |
| MW07-10S | 11 48 | N I | N I | N I | N I | 2 82 | 6 48 | 6 61 | 6 66 | 6 58 | 6 64 | 6 97 | 7 02 | 6 98 |
| MW07-10D | 12 04 | N I | 4 29 | 3 80 | N M | 2 03 | 4 05 | 3 98 | 4 13 | 3 51 | 4 03 | 3 84 | 3 77 | 4 20 |
| MW07-11D | 10 70 | N I | 2 54 | 2 17 | 0 30 | 0 43 | 1 89 | 1 53 | 2 19 | 0 86 | 2 11 | 1 08 | 0 92 | 2 27 |
| MW07-12D | 10 13 | N I | 4 06 | 3 58 | 1 60 | 1 27 | 3 17 | 3 26 | 3 80 | 2 97 | 3 82 | 3 02 | 3 05 | 4 01 |
| MW07-13S | 6 88 | N I | N I | N I | N I | 1 17 | 3 27 | 3 40 | 3 53 | 3 38 | 3 84 | 3 76 | 3 78 | 3 98 |
| MW07-13D | 6 97 | N I | 2 11 | 1 98 | 0 34 | 0 06 | 1 55 | 1 58 | 1 98 | 1 25 | 1 91 | 1 57 | 1 45 | 2 20 |
| MW07-14D | 13 44 | N I | N I | N I | N I | 4 97 | 7 32 | 7 36 | 7 32 | 7 76 | 7 79 | 7 89 | 7 89 | 7 90 |
| MW07-15D | 13 27 | N I | N I | N I | N I | 3 26 | 5 04 | 4 99 | 5 03 | 5 01 | 5 11 | 5 38 | 5 26 | 5 33 |
| MW07-16D | 7 53 | N I | N I | N I | N I | 0 95 | 2 12 | 1 30 | 2 21 | 0 64 | 2 11 | 0 41 | 0 63 | 2 27 |
| MW07-16R | 7 49 | N I | N I | N I | N.I. | 1 56 | 2 08 | 2 19 | 3 08 | 1 48 | 2 87 | 1 34 | 1 49 | 3 01 |
| MW07-17D | 9 88 | N I | N I | N I | N I | 2 13 | 3 69 | 3 60 | 3 69 | 3 36 | 3 57 | 3 86 | 3 61 | 3 80 |
| MW07-18D | 7 18 | N I | N I | N I | N I | 0 78 | 1 68 | 1 76 | 2 56 | 1 06 | 2 39 | 1 09 | 1 09 | 2 56 |
| MW07-19S | 6 30 | N I | N I | N I | N.I. | 0 88 | 2 35 | 2 44 | 2 96 | 2 07 | 2 88 | 2 12 | 2 20 | 3 10 |
| MW07-19D | 6 05 | N I | N I | N I | N I | 0 95 | 2 28 | 2 35 | 2 88 | 2 03 | 2 81 | 2 19 | 2 15 | 3 03 |
| MW07-20S | 5 61 | N I | N I | N I | N I | 1 28 | 2 16 | 2 18 | 2 18 | 2 83 | 2.87 | 3 09 | 3 20 | 3 39 |
| MW07-20D | 5 10 | N I | N I | N I | N.I. | 0 35 | 1 20 | 1 40 | 2 38 | 0 75 | 2 21 | 0 50 | 0 74 | 2 39 |
| MW07-21S | 6 65 | N I | N I | N I | N I | N I | 1 57 | 0 74 | 2 57 | 1 39 | 2 50 | 1 28 | 1 44 | 2 72 |
| MW07-21D | 5 96 | N I | N I | N I | N I | N I | 1 61 | 1 76 | 2 56 | 1 39 | 2 50 | 1 31 | 1 46 | 2 72 |
| MW07-21R | 6 80 | N I | N I | N I | N.I. | N I | 2 49 | 2 54 | 3 10 | 2 19 | 2 91 | 2 22 | 2 30 | 3 12 |
| MW07-22S | 17 11 | N I | N I | N I | N I | 4 88 | 6 56 | 6 56 | 6.54 | 6 89 | 6 90 | 6 96 | 6.96 | 6 95 |
| MW07-22D | 16 94 | N I | N I | N I | N I | 4 75 | 6 93 | 6 93 | 6 92 | 7 22 | 7 27 | 7 34 | 7 33 | 7 36 |
| MW07-23S | 6 47 | N I | N I | N I | N.I. | 0 87 | 2 21 | 2 01 | 2 13 | 1 78 | 1 99 | 2 36 | 1 99 | 2 17 |
| MW07-23D | 6 07 | N I | N I | N I | N I | 0 17 | 1 24 | 1 39 | 1 29 | 0 84 | 2 38 | 0 82 | 0 89 | 2 56 |
| MW07-24S | 6 23 | N I | N I | N I | N I | N I | 1 74 | 1 66 | 2 04 | 1 20 | 1 98 | 1 72 | 1 43 | 0 35 |
| MW07-24D | 5 80 | N I | N I | N I | N I | N I | 1 59 | 1 64 | 2 34 | 1 09 | 2 29 | 1 27 | 1 13 | 2.29 |
| MW07-25D | 11 48 | N I | N I | N I | N I | N I | 3 49 | 3 64 | 4 11 | 3 42 | 4 25 | 3 46 | 3 57 | 4 43 |
| MW07-25R | 11 95 | N I | N I | N I | N I | N I | 3 21 | 3 29 | 3 78 | 2 95 | 3 93 | 3 07 | 3 05 | 4 09 |
| MW07-26S | 10 42 | N I | N I | N I | N.I. | 1 66 | 3 41 | 3 27 | 3 38 | 2 93 | 3 00 | 3 43 | 3 23 | 3 27 |
| MW07-27D | 9 84 | N I | N I | N I | N I | 1 71 | 3 34 | 3 28 | 3 44 | 2 99 | 3 31 | 3 46 | 3 25 | 3 56 |
| MW07-28D | 9 07 | N I | N I | N I | N I | N I | 3 32 | 3 15 | 3 18 | 2 55 | 2 90 | 3 27 | 2 96 | 3 11 |
| MW07-29D | 7 65 | N I | N I | N I | N.I. | N I | 1 85 | 1 77 | 2 31 | 1 12 | 2 24 | 1 37 | 1.18 | 2 39 |
| MW07-30D | 7 80 | N I | N I | N I | N I | N I | 1 72 | 1 89 | 2 80 | 0 95 | 2 41 | 0 67 | 0 94 | 2 57 |
| MW07-31I | 13 94 | N I | N I | N I | N I | N I | 7 25 | 7 26 | 7 25 | 7 91 | 7 92 | 8 01 | 8 00 | 8 03 |
| Time Range of Water Level Measurements | | | | | 1255-1545 | 1310-1405 | 0920-0951 | 1215-1247 | 1515-1543 | 1250-1328 | 1600-1626 | 1027-1059 | 1324-1348 | 1651-1736 |
| * Time of Low Tide | | | | | 1403 | 1259 | 0942 | 0942 | | 929 | | 1038 | 1038 | |
| * Time of High Tide | | | | | | | | 1530 | 1530 | 1612 | 1612 | | 1710 | 1710 |

NOTE N I = NOT INSTALLED
N M = NOT MEASURED

* 11 minutes added to Newport RI tide

# Table 3-2B
## Summary of Ground Water Laboratory Analytical Program
## EBS Review Item 21 Site Investigation Work Plan
## NCBC Davisville, RI

| Sample No. | Media | Number of Sample Analyses | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TCL VOC SW 5030A 8260B | TCL SVOC SW 3520A 8270B | Total Organic Carbon SW 9060 | Nitrate EPA 300.0 | Sulfate EPA 8051 | Arsenic | Lead | Chromium | Copper | Iron | Managanese | Nickel |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21MWXX- | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Subtotals I | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Duplicate (m) | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Rinsate | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Source Water | water | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Trip Blanks | water | 4 | | | | | | | | | | | |
| Subtotals II | | 16 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 |

# TABLE 3-3

## VERTICAL HYDRAULIC GRADIENTS

IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Shallow to Deep Well Cluster | Date | Vertical Distance (ft) | Head Difference (ft) | Hydraulic Gradient (ft/ft) |
|---|---|---|---|---|
| MW07-03 | 08/13/93 | 38 41 | -2 33 | -6 07E-02 |
| | 04/26/94 | 42 42 | -4 13 | -9 74E-02 |
| | 12/02/94 | 38 93 | -1 97 | -5 06E-02 |
| | 07/12/95 | 39 88 | -3 03 | -7 60E-02 |
| | 08/24/95 | 38 59 | -2 33 | -6 04E-02 |
| | 12/1/95a | 40 94 | -3 01 | -7 35E-02 |
| | 12/1/95b | 40 97 | -3 09 | -7 54E-02 |
| | 12/1/95c | 40 98 | -3 10 | -7 56E-02 |
| | 1/16/96b | 42 03 | -4 32 | -1 03E-01 |
| | 1/16/96c | 42 05 | -4 28 | -1 02E-01 |
| | 1/17/96a | 42 22 | -4 08 | -9 66E-02 |
| | 1/17/96b | 42 37 | -4 37 | -1 03E-01 |
| | 1/17/96c | 42 55 | -4 57 | -1 07E-01 |
| MW07-04 | 08/24/95 | 24 42 | -1 24 | -5 08E-02 |
| | 12/1/95a | 27 01 | -1 90 | -7 03E-02 |
| | 12/1/95b | 27 08 | -1 98 | -7 31E-02 |
| | 12/1/95c | 27 13 | -1 99 | -7 34E-02 |
| | 1/16/96b | 27 64 | -2 31 | -8 36E-02 |
| | 1/16/96c | 27 77 | -2 35 | -8 46E-02 |
| | 1/17/96a | 28 32 | -2 69 | -9 50E-02 |
| | 1/17/96b | 28 54 | -2 96 | -1 04E-01 |
| | 1/17/96c | 28 62 | -2 96 | -1 03E-01 |
| MW07-05 | 08/13/93 | 40 56 | -1 81 | -4 46E-02 |
| | 04/26/94 | 44 62 | -3 67 | -8 23E-02 |
| | 12/02/94 | 41 42 | -1 56 | -3 77E-02 |
| | 07/12/95 | 41 68 | -2 28 | -5 47E-02 |
| | 08/24/95 | 40 66 | -1 81 | -4 45E-02 |
| | 12/1/95a | 43 53 | -2 94 | -6 75E-02 |
| | 12/1/95b | 43 75 | -3 22 | -7 36E-02 |
| | 12/1/95c | 43 81 | -3 22 | -7 35E-02 |
| | 1/16/96b | 44 33 | -3 89 | -8 78E-02 |
| | 1/16/96c | 42 36 | -1 77 | -4 18E-02 |
| | 1/17/96a | 44 76 | -3 91 | -8 74E-02 |
| | 1/17/96b | 44 88 | -4 20 | -9 36E-02 |
| | 1/17/96c | 44 94 | -4 13 | -9 19E-02 |
| MW07-10 | 08/24/95 | 26 12 | -0 79 | -3 02E-02 |
| | 12/1/95a | 29 78 | -2 43 | -8 16E-02 |
| | 12/1/95b | 29 91 | -2 63 | -8 79E-02 |
| | 12/1/95c | 29 96 | -2 53 | -8 44E-02 |
| | 1/16/96b | 29 88 | -3 07 | -1 03E-01 |
| | 1/16/96c | 29 94 | -2 61 | -8 72E-02 |
| | 1/17/96a | 30 27 | -3 13 | -1 03E-01 |
| | 1/17/96b | 30 32 | -3 25 | -1 07E-01 |
| | 1/17/96c | 30 28 | -2 78 | -9 18E-02 |
| MW07-13 | 08/24/95 | 36 47 | -1 11 | -3 04E-02 |
| | 12/1/95a | 38 57 | -1 72 | -4 46E-02 |
| | 12/1/95b | 38 70 | -1 82 | -4 70E-02 |
| | 12/1/95c | 38 83 | -1 55 | -3 99E-02 |
| | 1/16/96b | 38 68 | -2 13 | -5 51E-02 |
| | 1/16/96c | 39 14 | -1 93 | -4 93E-02 |
| | 1/17/96a | 39 06 | -2 19 | -5 61E-02 |
| | 1/17/96b | 39 08 | -2 33 | -5 96E-02 |
| | 1/17/96c | 39 28 | -1 78 | -4 53E-02 |

| Shallow to Deep Well Cluster | Date | Vertical Distance (ft) | Head Difference (ft) | Hydraulic Gradient (ft/ft) |
|---|---|---|---|---|
| MW07-19 | 08/24/95 | 33 08 | 0 07 | 2 12E-03 |
| | 12/1/95a | 34 55 | -0 07 | -2 03E-03 |
| | 12/1/95b | 34 64 | -0 09 | -2 60E-03 |
| | 12/1/95c | 35 16 | -0 08 | -2 28E-03 |
| | 1/16/96b | 34 27 | -0 04 | -1 17E-03 |
| | 1/16/96c | 35 08 | -0 07 | -2 00E-03 |
| | 1/17/96a | 34 32 | 0 07 | 2 04E-03 |
| | 1/17/96b | 34 40 | -0 05 | -1 45E-03 |
| | 1/17/96c | 35 30 | -0 07 | -1 98E-03 |
| MW07-20 | 08/24/95 | 66 58 | -0 93 | -1 40E-02 |
| | 12/1/95a | 67 46 | -0 96 | -1 42E-02 |
| | 12/1/95b | 67 48 | -0 78 | -1 16E-02 |
| | 12/1/95c | 67 48 | 0 20 | 2 96E-03 |
| | 1/16/96b | 68 13 | -2 08 | -3 05E-02 |
| | 1/16/96c | 68 17 | -0 66 | -9 68E-03 |
| | 1/17/96a | 68 39 | -2 59 | -3 79E-02 |
| | 1/17/96b | 68 50 | -2 46 | -3 59E-02 |
| | 1/17/96c | 68 69 | -1 00 | -1 46E-02 |
| MW07-21 | 12/1/95a | 33 07 | 0 04 | 1 21E-03 |
| | 12/1/95b | 32 24 | 1 02 | 3 16E-02 |
| | 12/1/95c | 34 07 | -0 01 | -2 94E-04 |
| | 1/16/96b | 32 89 | 0 00 | 0 00E+00 |
| | 1/16/96c | 34 00 | 0 00 | 0 00E+00 |
| | 1/17/96a | 32 78 | 0 03 | 9 15E-04 |
| | 1/17/96b | 32 94 | 0 02 | 6 07E-04 |
| | 1/17/96c | 34 22 | 0 00 | 0 00E+00 |
| MW07-22 | 08/24/95 | 15 48 | -0 13 | -8 40E-03 |
| | 12/1/95a | 17 16 | 0 37 | 2 16E-02 |
| | 12/1/95b | 17 16 | 0 37 | 2 16E-02 |
| | 12/1/95c | 17 14 | 0 38 | 2 22E-02 |
| | 1/16/96b | 17 49 | 0 33 | 1 89E-02 |
| | 1/16/96c | 17 50 | 0 37 | 2 11E-02 |
| | 1/17/96a | 17 56 | 0 38 | 2 16E-02 |
| | 1/17/96b | 17 56 | 0 37 | 2 11E-02 |
| | 1/17/96c | 17 55 | 0 41 | 2 34E-02 |
| MW07-23 | 08/24/95 | 35 77 | -0 70 | -1 96E-02 |
| | 12/1/95a | 37 11 | -0 97 | -2 61E-02 |
| | 12/1/95b | 36 91 | -0 62 | -1 68E-02 |
| | 12/1/95c | 37 03 | -0 84 | -2 27E-02 |
| | 1/16/96b | 36 68 | -0 94 | -2 56E-02 |
| | 1/16/96c | 36 89 | 0 39 | 1 06E-02 |
| | 1/17/96a | 37 26 | -1 54 | -4 13E-02 |
| | 1/17/96b | 36 89 | -1 10 | -2 98E-02 |
| | 1/17/96c | 37 07 | 0 39 | 1 05E-02 |
| MW07-24 | 12/1/95a | 45 34 | -0 15 | -3 31E-03 |
| | 12/1/95b | 45 26 | -0 02 | -4 42E-04 |
| | 12/1/95c | 45 64 | 0 30 | 6 57E-03 |
| | 1/16/96b | 44 80 | -0 11 | -2 46E-03 |
| | 1/16/96c | 45 58 | 0 31 | 6 80E-03 |
| | 1/17/96a | 45 32 | -0 45 | -9 93E-03 |
| | 1/17/96b | 45 03 | -0 30 | -6 66E-03 |
| | 1/17/96c | 43 95 | 1 94 | 4 41E-02 |

| Deep to Rock Well Cluster | Date | Vertical Distance (ft) | Head Difference (ft) | Hydraulic Gradient (ft/ft) |
|---|---|---|---|---|
| MW07-05 | 08/24/95 | 61 35 | -0 07 | -1 14E-03 |
| | 12/1/95a | 63 09 | -0 61 | -9 67E-03 |
| | 12/1/95b | 63 03 | -0 59 | -9 36E-03 |
| | 12/1/95c | 63 09 | -0 46 | -7 29E-03 |
| | 1/16/96b | 62 94 | -0 75 | -1 19E-02 |
| | 1/16/96c | 63 09 | -0 50 | -7 93E-03 |
| | 1/17/96a | 63 35 | -0 87 | -1 37E-02 |
| | 1/17/96b | 63 18 | -0 81 | -1 28E-02 |
| | 1/17/96c | 63 31 | -0 55 | -8 69E-03 |
| MW07-09 | 12/1/95a | 73 56 | 0 24 | 3 26E-03 |
| | 12/1/95b | 73 38 | 0 34 | 4 63E-03 |
| | 12/1/95c | 73 54 | 0 61 | 8 29E-03 |
| | 1/16/96b | 72 90 | 0 30 | 4 12E-03 |
| | 1/16/96c | 73 32 | 0 39 | 5 32E-03 |
| | 1/17/96a | 73 49 | 0 13 | 1 77E-03 |
| | 1/17/96b | 73 09 | 0 27 | 3 69E-03 |
| | 1/17/96c | 73 47 | 0 40 | 5 44E-03 |
| MW07-16 | 08/24/95 | 100 15 | 0 61 | 6 09E-03 |
| | 12/1/95a | 101 32 | -0 04 | -3 95E-04 |
| | 12/1/95b | 100 50 | 0 89 | 8 86E-03 |
| | 12/1/95c | 101 41 | 0 87 | 8 58E-03 |
| | 1/16/96b | 99 84 | 0 84 | 8 41E-03 |
| | 1/16/96c | 101 31 | 0 76 | 7 50E-03 |
| | 1/17/96a | 99 61 | 0 93 | 9 34E-03 |
| | 1/17/96b | 99 83 | 0 86 | 8 61E-03 |
| | 1/17/96c | 101 47 | 0 74 | 7 29E-03 |
| MW07-21 | 12/1/95a | 57 41 | 0 88 | 1 53E-02 |
| | 12/1/95b | 57 56 | 0 78 | 1 36E-02 |
| | 12/1/95c | 58 36 | 0 54 | 9 25E-03 |
| | 1/16/96b | 57 19 | 0 80 | 1 40E-02 |
| | 1/16/96c | 58 30 | 0 41 | 7 03E-03 |
| | 1/17/96a | 57 11 | 0 91 | 1 59E-02 |
| | 1/17/96b | 57 26 | 0 84 | 1 47E-02 |
| | 1/17/96c | 58 52 | 0 40 | 6 84E-03 |
| MW07-25 | 12/1/95a | 55 49 | -0 28 | -5 05E-03 |
| | 12/1/95b | 55 64 | -0 35 | -6 29E-03 |
| | 12/1/95c | 56 11 | -0 33 | -5 88E-03 |
| | 1/16/96b | 55 42 | -0 47 | -8 48E-03 |
| | 1/16/96c | 56 25 | -0 32 | -5 69E-03 |
| | 1/17/96a | 55 46 | -0 39 | -7 03E-03 |
| | 1/17/96b | 55 57 | -0 52 | -9 36E-03 |
| | 1/17/96c | 56 43 | -0 34 | -6 03E-03 |

NOTES
Vertical Distance is the difference in elevation between the water table in the shallow well and the middle of the screened interval in the deep well
Head Difference is the elevation of the deep well piezometric level minus the water table elevation Thus negative signs represent downward gradients
Hydraulic Gradient is the Head Difference divided by the Vertical Distance

a - low tide
b - mid tide
c - high tide
1993 and 1994 data are from TRC Phase II RI (1994)

# TABLE 3-4 SUMMARY OF HYDRAULIC CONDUCTIVITY CALCULATED FROM PHASE II RI MONITORING WELL SLUG TEST RESULTS, IR PROGRAM SITE 07, CALF PASTURE POINT, PHASE III RI, NCBC DAVISVILLE, RHODE ISLAND

## BASED UPON PHASE II RI SLUG TEST RESULTS (TRC 1994)

| Monitoring Well | Screen Depth (ft below ground surface) | | Hydraulic Conductivity (ft/day) | Geological Unit Within Screened Interval (ft) |
|---|---|---|---|---|
| | Top | Bottom | | |
| MW07-03D | 40.0 | 50.0 | 1.2 | Silt (4), lower sand (1.5), till (4.5) |
| MW07-05S | 4.0 | 16.0 | 19.2/17.5[1] | Upper sand (11), silt (1) |
| MW07-05D | 41.4 | 51.4 | 4.6 | Silt (3.1), till (4), bedrock (8+3/phyl) (2.9) |
| MW07-06S | 4.0 | 14.0 | 32.6/32.3[1] | Upper sand (10) |
| MW07-07S | 4.0 | 16.0 | NT[2] | Upper sand (4), till (8) |
| MW07-08S | 4.0 | 14.0 | 35.2 | Upper sand (10) |
| MW07-9D | 45.0 | 55.0 | 2.19/1.89[1] | Silt (1), lower sand (6), till (3 ft) |
| MW07-10D | 27.5 | 37.5 | 0.32 | Silt (8), till (1), bedrock (1) |
| MW07-11D | 47.5 | 57.5 | 3.56/3.46[1] | Silt (2.5), lower sand (7.5) |
| MW07-12D | 25.0 | 35.0 | 1.86 | Till (10) |
| MW07-13D | 35.0 | 45.0 | 0.41/0.37[1] | Till (10) |

1 Where two slug tests were run, both analysis results are presented.
2 This well was not tested because of insufficient water column.

# TABLE 3-5 SUMMARY OF HYDRAULIC CONDUCTIVITY CALCULATED FROM PHASE III RI MONITORING WELL SLUG TEST RESULTS, IR PROGRAM SITE 07, CALF PASTURE POINT, PHASE III RI, NCBC DAVISVILLE, RHODE ISLAND

## BASED UPON PHASE III RI SLUG TEST RESULTS

| Monitoring Well | Screen Depth (ft below ground surface) | | Hydraulic Conductivity (ft/day) | Geologic Unit within Screened Interval (ft) |
|---|---|---|---|---|
| | Top | Bottom | | |
| MW-07-04D | 25.5 | 35.5 | 0.1 | Silt (8.4), till (1.6) |
| MW07-05R | 64.0 | 74.0 | 1.7 | Bedrock (quartzite/phyllite) (10) |
| MW07-10S | 4.5 | 13.5 | 8.9 | Upper sand (9) |
| MW07-10D | 27.5 | 37.5 | 1.2 | Silt (8), till (1), bedrock (1) |
| MW07-13S | 4.0 | 13.0 | 113.5 | Upper sand (10) |
| MW07-13D | 35.0 | 45.0 | 3.3 | Till (10) |
| MW07-14D | 24.0 | 34.0 | 7.6 | Till (10) |
| MW07-15D | 37.0 | 47.0 | 5.3 | Till (10) |
| MW07-16D | 74.0 | 84.0 | 1.6 | Till (10) |
| MW07-16R | 100.0 | 110.0 | 3.6 | Bedrock (quartzite/gneiss) (10) |
| MW07-17D | 38.0 | 48.0 | 3.2 | Lower sand (6), till (4) |
| MW07-18D | 62.0 | 72.0 | 21.8 | Lower sand (10) |
| MW07-19S | 13.0 | 23.0 | 139.0 | Till (10) |
| MW07-19D | 34.5 | 39.5 | 32.5 | Till (5) |
| MW07-20S | 4.9 | 14.9 | 146.5 | Upper sand (2.4), silt (2.6) |
| MW07-20D | 64.0 | 74.0 | 17.7 | Till (10) |
| MW07-21S | 10.0 | 20.0 | 379.0 | Till (10) |
| MW07-21D | 33.0 | 38.0 | 45.5 | Till (5) |
| MW07-21R | 55.3 | 65.3 | 15.0 | Bedrock (quartzite) (10) |
| MW07-22S | 8.0 | 13.0 | 68.0 | Sand and silt (4), silt (1) |
| MW07-22D | 21.0 | 31.0 | 11.0 | Till (10) |
| MW07-23S | 4.0 | 8.0 | 19.3 | Upper sand (0.3), silt (3.7) |
| MW07-23D | 34.5 | 44.5 | 2.3 | Till (10) |
| MW07-24S | 9.5 | 19.5 | 1.5 | Upper Sand (3.2, sand and silt (6.0), silt (0.8) |
| MW07-24D | 43.0 | 53.0 | 5.0 | Till (10) |
| MW07-25D | 33.0 | 38.0 | 44.0 | Till (5) |
| MW07-25R | 57.0 | 67.0 | 0.1 | Bedrock (quartzite) (10) |
| MW07-26S | 13.0 | 18.0 | 0.4 | Till (5) |
| MW07-27D | 45.0 | 52.0 | 26.5 | Till (7) |
| MW07-28D | 42.0 | 46.0 | 5.0 | Till (4) |
| MW07-29D | 66.5 | 76.5 | 1.0 | Till (10) |
| MW07-30D | 60.8 | 70.8 | 1.2 | Lower sand (8.2), till (1.8) |
| MW07-31I | 14.8 | 24.8 | 1.4 | Sand, silt facies (9.2), till (0.8) |

# TABLE 3-6 HYDRAULIC CONDUCTIVITY CALCULATED FROM PHASE III RI MONITORING WELL PACKER TEST RESULTS, IR PROGRAM SITE 07, CALF PASTURE POINT, PHASE III RI, NCBC DAVISVILLE, RHODE ISLAND

| Monitoring Well | Test Conditions | | Hydraulic Conductivity (ft/day) |
|---|---|---|---|
| | Packer Interval (ft) | Head Pressure (psi) | |
| MW07-21R | 55.3-60.3 | 17.0 | 2.5 |
| MW07-21R | 55.3-60.3 | 34.0 | 3.2 |
| MW07-21R | 55.3-60.3 | 68.0 | 3.5 |
| MW07-21R | 60.3-65.3 | 18.0 | 0.4 |
| MW07-25R | 59.0-64.0 | 70.0 | 0.02 |

# TABLE 3-6 HYDRAULIC CONDUCTIVITY CALCULATED FROM PHASE III RI MONITORING WELL PACKER TEST RESULTS, IR PROGRAM SITE 07, CALF PASTURE POINT, PHASE III RI, NCBC DAVISVILLE, RHODE ISLAND

| Monitoring Well | Test Conditions | | Hydraulic Conductivity (ft/day) |
|---|---|---|---|
| | Packer Interval (ft) | Head Pressure (psi) | |
| MW07-21R | 55.3-60.3 | 17.0 | 2.5 |
| MW07-21R | 55.3-60.3 | 34.0 | 3.2 |
| MW07-21R | 55.3-60.3 | 68.0 | 3.5 |
| MW07-21R | 60.3-65.3 | 18.0 | 0.4 |
| MW07-25R | 59.0-64.0 | 70.0 | 0.02 |

# TABLE 3-7 TIDAL EFFICIENCIES FOR THE MONITORING WELLS IN VARIOUS GEOLOGICAL UNITS

| Monitoring Well | Unit(s) | $TE_{AP}$ from Peaks[a] | $TE_{TRUE}$[b] |
|---|---|---|---|
| MW07-05S[c] | 1 | -0.02 | -0.02 |
| MW07-20S | 1 | 0.03 | 0.04 |
| MW07-05D | 2 | 0.08 | 0.82 |
| MW07-09D | 2&3 | 0.21 | 0.70 |
| MW07-16D | 3 | 0.61 | 0.74 |
| MW07-20D | 3 | 0.59 | 0.73 |
| MW07-21S[d] | 3 | 1.55 | 1.35 |
| MW07-21D[e] | 3 | 0.88 | 0.77 |
| MW07-25D | 3 | 0.28 | 0.32 |
| MW07-26S | 3 | 0.08 | 0.43 |
| MW07-27D | 3 | 0.14 | 0.52 |
| MW07-28D | 3 | 0.13 | 0.66 |
| MW07-05R | 4 | 0.14 | 0.28 |
| MW07-09R | 4 | 0.20 | 0.50 |
| MW07-16R | 4 | 0.55 | 0.67 |
| MW07-21R | 4 | 0.11 | 0.16 |
| MW07-25R | 4 | 0.35 | 0.49 |

(a) The apparent TE for each well was determined by dividing the high tide peak in water levels by the high tide peak after correcting both levels for barometric pressure and correcting the tidal water level for density effects of sea water versus fresh water.
(b) The true TE corrects the apparent TE for time lags that occur in the water level peaks compared to the tidal peaks.
(c) Data for this well was not evaluated further because of the negative TE.
(d) Data for this well was not evaluated further because the TE was greater than 1.0.
(e) Data for this well was evaluated further even though $TE_{TRUE}$ was smaller than $TE_{APP}$.

Unit 1 = Upper sand unit
Unit 2 = Lower portion of the silt unit
Unit 3 = Till unit and/or the lower sand unit (where present)
Unit 4 = Upper portion of bedrock

# TABLE 3-8 HYDRAULIC CONDUCTIVITY AND STORAGE BASED ON THE GROUND-WATER LEVEL AND TIDAL MONITORING DATA

| Monitoring Well | Unit(s) | Hydraulic Conductivity (ft/day) | Saturated Thickness of Unit(s) (ft) | Storage (unitless) |
|---|---|---|---|---|
| MW07-20S | 1 | 1.4 | 54.6 | (a) |
| MW07-05D | 2 | 2.6-5.3[(b)] | 63.5 | $1.4 \times 10^{-4}$ |
| MW07-09D | 2&3 | 9.3-9.7[(b)] | 10.3 | $1.4 \times 10^{-5}$ |
| MW07-16D | 3 | 15.2 | 44.5 | $6.8 \times 10^{-5}$ |
| MW07-20D | 3 | 11.6 | 15.4 | $2.3 \times 10^{-5}$ |
| MW07-21D | 3 | 265.8-365.8[(b)] | 32.3 | $5.4 \times 10^{-5}$ |
| MW07-25D | 3 | 95.5-263.4[(b)] | 6.3 | $3.6 \times 10^{-6}$ |
| MW07-26S | 3 | 1.2-1.6[(b)] | 11.0 | $7.6 \times 10^{-6}$ |
| MW07-27D | 3 | 3.0-4.4[(b)] | 35.0 | $2.9 \times 10^{-5}$ |
| MW07-28D | 3 | 5.5-7.9[(b)] | 10.0 | $1.2 \times 10^{-5}$ |
| MW07-05R | 4 | 2.5-5.1[(b)] | 30.0 | $5.5 \times 10^{-6}$ |
| MW07-09R | 4 | 3.4-3.5[(b)] | 30.0 | $7.8 \times 10^{-6}$ |
| MW07-16R | 4 | 4.0 | 30.0 | $1.2 \times 10^{-5}$ |
| MW07-21R | 4 | 4.1-5.6[(b)] | 30.0 | $4.7 \times 10^{-6}$ |
| MW07-25R | 4 | 4.5-12.3 | 30.0 | $7.7 \times 10^{-6}$ |

(a) Unconfined aquifer (unit); therefore, no storage value.

(b) Hydraulic conductivity values are based upon the distance to Allen Harbor both south and west of the well site.

Unit 1 = Upper sand unit
Unit 2 = Lower portion of the silt unit
Unit 3 = Till unit and/or the lower sand unit (where present)
Unit 4 = Upper portion of bedrock

# TABLE 3-9 HYDRAULIC CONDUCTIVITY AND SPECIFIC YIELD ESTIMATED FROM DESCRIPTION OF MATERIAL COMPRISING A LITHOLOGIC UNIT

| Grain Size Code | Grain-Size Class or Range From Sample Description | Hydraulic Conductivity (ft/day)[a] | | | | | | Specific Yield[b] |
|---|---|---|---|---|---|---|---|---|
| | | Estimated From Degree of Sorting | | | Estimated From Silt Content | | | |
| | | Poor | Moderate | Well | Slight | Moderate | Large | |
| FINE-GRAINED MATERIALS: | | | | | | | | |
| | Clay | -- | -- | -- | 2 | -- | -- | 0.020 |
| | Silt, slightly clayey | -- | -- | -- | 18 | -- | -- | 0.170 |
| | Silt, moderately clayey | -- | -- | -- | 11 | -- | -- | 0.110 |
| | Silt, very clayey | -- | -- | -- | 7 | -- | -- | 0.070 |
| | Silt; loess; sandy silt | -- | -- | -- | 20 | -- | -- | 0.240 |
| SANDS AND GRAVELS[c]: | | | | | | | | |
| 10 | Very fine sand | 13 | 20 | 27 | 23 | 19 | 13 | 0.210 |
| 11 | Very fine to fine sand | 27 | 27 | -- | 24 | 20 | 13 | 0.215 |
| 12 | Very fine to medium sand | 36 | 41-47 | -- | 32 | 27 | 21 | 0.224 |
| 13 | Very fine to coarse sand | 48 | -- | -- | 40 | 31 | 24 | 0.225 |
| 14 | Very fine to very coarse sand | 59 | -- | -- | 51 | 40 | 29 | 0.224 |
| 15 | Very fine sand to fine gravel | 76 | -- | -- | 67 | 52 | 38 | 0.223 |
| 16 | Very fine sand to medium gravel | 99 | -- | -- | 80 | 66 | 49 | 0.222 |
| 17 | Very fine sand to coarse gravel | 128 | -- | -- | 107 | 86 | 64 | 0.221 |
| 18 | Fine sand | 27 | 40 | 53 | 33 | 27 | 20 | 0.220 |
| 19 | Fine to medium sand | 53 | 67 | -- | 48 | 39 | 30 | 0.245 |
| 20 | Fine to coarse sand | 57 | 67-72 | -- | 53 | 43 | 32 | 0.250 |
| 21 | Fine to very coarse sand | 70 | -- | -- | 60 | 47 | 35 | 0.245 |
| 22 | Fine sand to fine gravel | 88 | -- | -- | 74 | 59 | 44 | 0.244 |
| 23 | Fine sand to medium gravel | 114 | -- | -- | 94 | 75 | 57 | 0.243 |
| 24 | Fine sand to coarse gravel | 145 | -- | -- | 107 | 87 | 72 | 0.242 |
| 25 | Medium sand | 67 | 80 | 94 | 64 | 51 | 40 | 0.270 |
| 26 | Medium to coarse sand | 74 | 94 | -- | 72 | 57 | 42 | 0.275 |
| 27 | Medium to very coarse sand | 84 | 98-111 | -- | 71 | 61 | 49 | 0.274 |
| 28 | Medium sand to fine gravel | 103 | -- | -- | 84 | 68 | 52 | 0.273 |
| 29 | Medium sand to medium gravel | 131 | -- | -- | 114 | 82 | 66 | 0.272 |
| 30 | Medium sand to coarse gravel | 164 | -- | -- | 134 | 108 | 82 | 0.271 |
| 31 | Coarse sand | 80 | 107 | 134 | 94 | 74 | 53 | 0.280 |
| 32 | Coarse to very coarse sand | 94 | 134 | -- | 94 | 75 | 57 | 0.275 |
| 33 | Coarse sand to fine gravel | 116 | 134-156 | -- | 107 | 88 | 68 | 0.273 |
| 34 | Coarse sand to medium gravel | 147 | -- | -- | 114 | 94 | 74 | 0.271 |
| 35 | Coarse sand to coarse gravel | 184 | -- | -- | 134 | 100 | 92 | 0.268 |

(a) Hydraulic conductivity values are from an unpublished, undated paper by E.C. Reed and R. Piskin, Conservation and Survey Division, University of Nebraska.

(b) Specific yield values are modified from Johnson, A.I. 1967, Specific Yield—Compilation of Specific Yield for Various Materials, U.S. Geological Survey Water-Supply Paper 1662-D, 74 pp.

(c) Reduce hydraulic conductivity by 10 percent if grains are subangular.

| Grain Size Code | Grain-Size Class or Range From Sample Description | Hydraulic Conductivity (ft/day)[a] | | | | | | Specific Yield[b] |
|---|---|---|---|---|---|---|---|---|
| | | Estimated From Degree of Sorting | | | Estimated From Silt Content | | | |
| | | Poor | Moderate | Well | Slight | Moderate | Large | |
| SANDS AND GRAVELS (Cont.): | | | | | | | | |
| 36 | Very coarse sand | 107 | 147 | 187 | 114 | 94 | 74 | 0.270 |
| 37 | Very coarse sand to fine gravel | 134 | 214 | -- | 120 | 104 | 87 | 0.265 |
| 38 | Very coarse sand to medium gravel | 170 | 199-227 | -- | 147 | 123 | 99 | 0.263 |
| 39 | Very coarse sand to coarse gravel | 207 | -- | -- | 160 | 132 | 104 | 0.258 |
| 40 | Fine gravel | 160 | 214 | 267 | 227 | 140 | 107 | 0.260 |
| 41 | Fine to medium gravel | 201 | 334 | -- | 201 | 167 | 134 | 0.255 |
| 42 | Fine to coarse gravel | 245 | 289-334 | -- | 234 | 189 | 144 | 0.245 |
| 43 | Medium gravel | 241 | 321 | 401 | 241 | 201 | 160 | 0.250 |
| 44 | Medium to coarse gravel | 294 | 468 | -- | 294 | 243 | 191 | 0.240 |
| 45 | Coarse gravel | 334 | 468 | 602 | 334 | 284 | 234 | 0.230 |

# TABLE 3-10 HYDRAULIC CONDUCTIVITY, STORAGE, AND SPECIFIC YIELD FOR THE GEOLOGICAL UNITS AT VARIOUS WELL CLUSTERS/SITES BASED UPON SLUG TEST, PACKER TEST, GEOLOGIC LOG, AND TIDAL AND GROUND-WATER MONITORING DATA

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 3 | ST | | | | | | | 1.2[2] | | | | | | 2 0 - 12.0 Unit 1 40.0 - 50.0 Units 2 & 3 | U1--0 0-14.0 U2--14.0-44.0 U3--44.0-51.0 U4--51.0-60.9→ |
| | GL | 59.5 | | 0.25 | 15.0 | | 0 17 | 59.0 | | 0.24 | | | | | |
| | SEL | 59.5 | | 0.25 | 15.0 | | | 59.0 | | | | | | | |
| 4 | ST | | | | 0.1 | | | | | | | | | 6.1 - 16.1 Units 1 & 2 25.5-35.5 Units 2 & 3 | U1--0.0-14.5 U2--14.5-33.5 U3--33.5-35.8 U4--35.8-43.0→ |
| | GL | 22.1 | | 0.22 | 15.0 | | 0.17 | 27.5 | | 0.22 | | | | | |
| | SEL | 22.1 | | 0.22 | 15.0 | | | 27.5 | | | | | | | |
| 5 | TGW | --[3] | -- | | | | | 2.6-5.3 | 1.4E-04 | | 2.5-5.1 | 5.5E-06 | | 4.0-16.0 Units 1&2 41.4-51.4 Units 2,3,4 64.0-74.0 Unit 4 | U1--0.0-15.0 U2--15.0-44.5 U3--44.5-48.5 U4--48.5-78.0→ |
| | ST | 17.5-19 2[2] | | | | | | 4.6[2] | | | 1.7 | | | | |
| | GL | 30.0 | | 0.22 | 15.0 | | 0.17 | 35.0 | | 0.22 | | | | | |
| | SEL | 24.0 | | 0.22 | 15.0 | | | 30.0 | 1.4E-04 | | 3.8 | 5.5E-06 | | | |
| 6 | TGW | *[4] | * | | | | | | | | | | | 4.0-14.0 Unit 1 | U1--0.0-14.0 U2--14.0 |
| | ST | 30 3-32.6 | | | | | | | | | | | | | |
| | GL | 53.0 | | 0.24 | | | | | | | | | | | |
| | SEL | 42.0 | | 0.24 | | | | | | | | | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 7 | ST | **[5] | ** | | | | | | | | | | | 4.0-16.0 Unit 1 | U1--0.0-8.0 U3--8.0-16.0 U4--16.0-26.0→ |
| | GL | ***[6] | | ***[6] | | | | 33.0 | | 0.22 | | | | | |
| | SEL | | | | | | | 33.0 | | 0.22 | | | | | |
| 8 | ST | 35.2[2] | | | | | | | | | | | | 4.0-14.0 Unit 1 | U1--0.0-16.0? |
| | GL | 20.0 | | 0.22 | | | | | | | | | | | |
| | SEL | 60.0 | | 0.24 | | | | | | | | | | | |
| 9 | TGW | | | | | | | 9.3-9.7 | 1.4E-05 | | 3.4-3.5 | 7.8E-06 | | 45.0-55.0 Units 2 & 3 73.0-83.0 Unit 4 | U1--0.0-17 0 U2--17.0-46.0 U3--46.0-56.3 U4--56.3-87.0→ |
| | ST | | | | | | | 1.9-2.2[2] | | | 0.6 | | | | |
| | GL | 35.2 | | .22 | 15.0 | | 0.17 | 44.2 | | 0.22 | | | | | |
| | SEL | 35.2 | | .22 | 15.0 | | | 44.2 | 1.4E-05 | | 3.5 | 7.8E-06 | | | |
| 10 | ST | 8.9 | | | 0.3[2]-1.2 | | | | | | | | | 4.5-13.5 Unit 1 27.5-37.5 Units 2 & 3 | U1--0.0-13.5 U2--13.5-35.5 U3--35.5-37.5 |
| | GL | 37.7 | | 0.23 | 15.0 | | 0.17 | | 15.0 | 0.17 | | | | | |
| | SEL | 37.7 | | 0.23 | 15.0 | | | | 15.0 | | | | | | |
| 11 | ST | | | | | | | 3.6[2] | | | | | | 47.5-57.5 Units 2&3 | U1--0.0-15.0 U2--15.0-50.0 U3--50.0-57.5? |
| | GL | 67.0 | | 0 27 | 15.0 | | 0.17 | 241 | | 0.25 | | | | | |
| | SEL | 67.0 | | 0.27 | 15.0 | | | 241 | | | | | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 12 | ST | | | | | | | 1.9[2] | | | | | | 25.0-35.0 Unit 3 | U1--0.0-10.0 U2--10.0-21.5 U3--21.5-35.1 |
| | GL | 40.0 | | 0.22 | 15.0 | | 0.17 | 27.0 | | 0.22 | | | | | |
| | SEL | 40.0 | | 0.22 | 15.0 | | | 27.0 | | | | | | | |
| 13 | ST | 113.5 | | | | | | 0.4[2]-3.3 | | | | | | 4.0-13.0 Unit 1 | U1--0.0-14.0 U2--14.0-30.0 U3--30.0-45.0? |
| | GL | 30.0 | | 0.24 | 15.0 | | 0.17 | 44.5 | | 0.23 | | | | | |
| | SEL | 30.0 | | 0.24 | 15.0 | | | 44.5 | | | | | | 35.0-45.0 Unit 3 | |
| 14 | ST | | | | | | | 7.6 | | | | | | 24.0-34.0 Unit 3 | U1--0.0-13.0 U2--13.0-24.0 U3--24.0-35.0 U4--35.0-42.5→ |
| | GL | 34.0 | | 0.23 | 15.0 | | 0.17 | 40.0 | | 0.27 | | | | | |
| | SEL | 24.0 | | 0.22 | 15.0 | | | 40.0 | | | | | | | |
| 15 | ST | | | | | | | 5.3 | | | | | | 37.0-47.0 Unit 3 | U1--0.0-15.0 U2--15.0-29.0 U3--29.0-48.0 U4--48.0-55.0→ |
| | GL | 26.0 | | 0.22 | 15.0 | | 0.17 | 55.2 | | 0.23 | | | | | |
| | SEL | 26.0 | | 0.22 | 15.0 | | | 55.2 | | | | | | | |
| 16 | TGW | | | | | | | 15.2 | 6.8E-05 | | 4.0 | 1.2E-05 | | 74.0-84.0 Unit 3 | U1--0.0-17.0 U2--17.0-44.0 U3--44.0-84.5 U4--84.5-114.1→ |
| | ST | | | | | | | 1.6 | | | 3.6 | | | | |
| | GL | 48.1 | | 0.24 | 12.5 | | 0.14 | 36.7 | | 0.23 | | | | 100.0-110.0 Unit 4 | |
| | SEL | 48.1 | | 0.24 | 12.5 | | | 23.3 | 6.8E-05 | | 4.0 | 1.2E-05 | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 17 | ST | | | | | | | 3.2 | | | | | | 38.0-48.0 Unit 3 | U1--0.0-16 0<br>U2--16.0-29.0<br>U3--29.0-49.0<br>U4--49.0-57.0→ |
| | GL | 38 5 | | 0.23 | 11.0 | | 0.11 | 41.3 | | | | | | | |
| | SEL | 38.5 | | 0.23 | 11.0 | | | 41.3 | | 0.22 | | | | | |
| 18 | ST | | | | | | | 21.8 | | | | | | 62.0-72.0 Unit 3 | U1--0.0-18.0<br>U2--18.0-44.0<br>U3--44.0-73.0<br>U4--73.0-83.0→ |
| | GL | 56.8 | | 0.25 | 9.1 | | 0.09 | 40.3 | | 0.23 | | | | | |
| | SEL | 56.8 | | 0.25 | 9.1 | | | 31.0 | | | | | | | |
| 19 | ST | | | | | | | 139[7](Upper)<br>32.5[7](Lower) | | | | | | 13.0-23.0 Unit 3(Upper)<br>34.5-39.5 Unit 3(Lower) | U1--0.0-5.5<br>U3--5.5-41.5 |
| | GL | 27.0 | | .22 | | | | 84.7[8] | | 0.26[8] | | | | | |
| | SEL | 27.0 | | .22 | | | | 80.0 | | | | | | | |
| 20 | TGW | 1.4 | U[8] | | | | | 11.6 | 2.3E-05 | | | | | 4.9-14.9 Units 1 &2<br>64.0-74.0 Unit 3 | U1--0.0-12.5<br>U2--12.5-59.5<br>U3--59.5-74.9<br>U4--74.9-83.0→ |
| | ST | 146.5 | | | | | | 17.7 | | | | | | | |
| | GL | 53.0 | | 0.25 | 18.6 | | 0.21 | 59.0 | | 0.24 | | | | | |
| | SEL | 53.0 | | 0.25 | 18.6 | | | 30.0 | 2.3E-05 | | | | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 21 | TGW | | | | | | | 175.7-236.2[7] (Upper)<br>265.4-356.8[7] (Lower) | 3.6E-05 (Upper)<br>5.4E-05 (Lower) | | 4.1-5.6[7] | 4.7E-06 | | 10.0-20.0 Unit 3(Upper)<br>33.0-38.0 Unit 3(Lower) | U1--0.0-7.0<br>U3--7.0-39.3<br>U4--39.3-69.7→ |
| | ST | | | | | | | 379.0 (Upper)<br>45.5 (Lower) | | | 15.0 | | | 55.3-65.3 Unit 4 | |
| | PT | | | | | | | | | | 3.2-3.4 | | | | |
| | GL | 41.9 | | 0.25 | | | | 181[9] | | 0.25[9] | | | | | |
| | SEL | 41.9 | | 0.25 | | | | 200 | 4.5E-05 | | 10.0 | 4.7E-06 | | | |
| 22 | ST | 68.0 | | | | | | 11.0 | | | | | | 8.0-13.0 Units 1&2<br>21.0-31.0 Unit 3 | U1--000-12.0<br>U2--12.0-17.0<br>U3--17.0-32.0<br>U4--32.0-40.5→ |
| | GL | 23.0 | | 0.21 | 18.0 | | .20 | 53.0 | | 0.24 | | | | | |
| | SEL | 23.0 | | 0.21 | 18.0 | | | 50.0 | | | | | | | |
| 23 | ST | **[6] | | | 19.3[6] | | | 2.3 | | | | | | 4.0-8.0 Units 1 & 2<br>34.5-44.5 Unit 3 | U1--0.0-4.5<br>U2--4.5-11.5<br>U3--11.5-45.5<br>U4--45.5-53.7→ |
| | GL | 22.5 | | 0 14 | 13.0 | | .14 | 30.0 | | 0.23 | | | | | |
| | SEL | 22.5 | | 0.14 | 13.0 | | | 30.0 | | | | | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 24 | ST | 1.5 | | | | | | 5.0 | | | | | | 9.5-19.5 Units 1& 2 | U1--0.0-18.5 U2--18.5-29.0 U3--29.0-59.8 U4--59.8-65.7 |
| | GL | 40.0 | | 0.24 | 15.0 | | 0.17 | 24.1 | | 0.23 | | | | 43.0-53.0 Unit 3 | |
| | SEL | 40 0 | | 0.24 | 15.0 | | | 24.1 | | | | | | | |
| 25 | TGW | | | | | | | 95.5-263.4 | 3.6E-06 | | 4.5-12.3 | 7 7E-06 | | 33.0-38.0 Unit 3 | U1--0.0-15.0 U2--15.0-33 0 U3--33.0-39.3 U4--39.3-68.0 |
| | ST | | | | | | | 44.0 | | | 0.1 | | | 57.0-67.0 Unit 4 | |
| | PT | | | | | | | | | | 0.02 | | | | |
| | GL | 30.3 | | 0.23 | 12.6 | | 0.14 | 67.0 | | 0.24 | | | | | |
| | SEL | 30.3 | | 0.23 | 12.6 | | | 81.0 | 3.6E-06 | | 8.4 | 7.7E-06 | | | |
| 26 | TGW | | | | | | | 1.2-1.5[6] | 7.6E-06 | | | | | 13.0-18.0 Unit 3 | U1--0.0-12.0 U3--12.0-24.0? |
| | ST | | | | | | | 0.4 | | | | | | | |
| | GL | 41.4 | | 0.24 | | | | 14.3 | | 0.16 | | | | | |
| | SEL | 41.4 | | 0.24 | | | | 14.3 | 7.6E-06 | | | | | | |
| 27 | TGW | | | | | | | 3.0-4.4 | 2.9E-05 | | | | | 45.0-52.0 Unit 3 | U1--0.0-8.0 U2--8.0-18.0 U3--18.0-53.0 U4--53.0-59.3→ |
| | ST | | | | | | | 26.5 | | | | | | | |
| | GL | 53.0 | | 0.24 | 19.6 | | .20 | 43.9 | | 0.25 | | | | | |
| | SEL | 53.0 | | 0.24 | 19.6 | | | 35.0 | 2.9E-05 | | | | | | |

| Well Cluster or Site | Method[1] for Calculating Hydraulic Conductivity (K), Storage (S), and/or Specific Yield (Sy). SEL= Selected value | Hydraulic Characteristics for the Different Hydrogeologic Units | | | | | | | | | | | | Screened Interval (ft below Land Surface) Unit | Unit Intervals - Unit 1 (U1) Unit 2 (U2) Unit 3 (U3) Unit 4 (U4) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper Sand Unit (Unit 1) | | | Silt Unit (Unit 2) | | | Till and Lower Sand Unit (Unit 3) | | | Bedrock Unit (Unit 4) | | | | |
| | | K (ft/day) | S | Sy | K (ft/da | S | Sy | K (ft/day) | S | Sy | K (ft/day) | S | Sy | | |
| 28 | TGW | | | | | | | 5.5-7.9 | 1.2E-05 | | | | | 42.0-46.0 Unit 3 | U1--0.0-8.0 U2--8.0-36.5 U3--36.5-46.5 U4--46.5--54.0→ |
| | ST | | | | | | | 5.0 | | | | | | | |
| | GL | 40.0 | | 0.22 | 13.8 | | 0.15 | 76.6 | | 0.26 | | | | | |
| | SEL | 40.0 | | 0.22 | 13.8 | | | 70.0 | 1.2E-05 | | | | | | |
| 29 | ST | | | | | | | 1.0 | | | | | | 66.5-76.5 Unit 3 | U1--0.0-8.3 U2--8.3-44.0 U3--44.0-77.5 U4--77.5-84.0→ |
| | GL | 53.0 | | 0.24 | 18.0 | | 0.20 | 34.7 | | 0.23 | | | | | |
| | SEL | 53.0 | | 0 24 | 18.0 | | | 34.7 | | | | | | | |
| 30 | ST | | | | | | | 1.2 | | | | | | 60.8-70.8 Unit 3 | U1--0.0-18.0 U2--18.0-40.8 U3--40.8-84.0 U4--84.0-91.0→ |
| | GL | 51.1 | | 0.26 | 16.0 | | 0.20 | 34.2 | | 0.22 | | | | | |
| | SEL | 51.1 | | 0.26 | 16 0 | | | 34.2 | | | | | | | |
| 31 | ST | 1.4 | | | | | | | | | | | | 14.8-24.8 Units 1 & 3 | U1--0.0-24.0 U3--24.0-26.0? |
| | GL | 30.3 | | 0.22 | | | | 19.0 | | 0.21 | | | | | |
| | SEL | 30.3 | | 0.22 | | | | 19.0 | | | | | | | |

NOTES:

1 Methods for determining K, S and Sy are:
TGW - tidal and ground-water monitoring, ST—slug test,
PT - packer test, GL—geologic log, and SEL— selected values using available results.

2 Slug tests performed by TRC Environmental Corporation.

3 Did not evaluate because tidal efficiencies were negative.

4 Did not evaluate because tidal and ground-water hydrographs did not correlate.

5 TRC could not perform slug test because of insufficient water in well.

6 Unit 1 is unsaturated.

7 Units 3 and 4 may be unconfined because Unit 2 does not exist in this area.

8 Wells are screened in upper and lower parts of Unit 3. At well site 19, K and Sy for upper screened portion of Unit 3 is 114 ft/day and 0.27, respectively, while K and Sy for the lower screened portion of Unit 3 is 20.0 ft/day and 0.20, respectively.

9 U—unconfined materials, storage (S) is not used.

10 Wells are screened in the upper and lower parts of Unit 3. At well site 21, K and Sy for upper screened portion of Unit 3 is 57.4 ft/day and 0.26, respectively, while K and Sy for the lower screened portion of Unit 3 is 600 ft/day and 0.23, respectively.

# TABLE 4-1A

## LOCATION OF PRIVATE USE GROUND-WATER WELLS NEAR SITE 07

IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Address | Property Owner | Location with respect to Site 07 |
|---|---|---|
| 11 Coolidge Ave | Rambikur, Andrew | North |
| 14 Mountainview Ave | Littlefield, Judith A. | North |
| 60 Pette Avenue | Gould, Marilyn A. | North |

NOTES: Modified from TRC Phase II RI (1994)
Ground water flow on site 07 is generally to the southeast

# TABLE 4-1B

## BACKGROUND INORGANICS CONCENTRATIONS IN GROUND WATER

IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Parameter | Background Value ($\mu$g/L) |
|---|---|
| Aluminum | 5315 |
| Antimony | 6 |
| Arsenic | 6.4 |
| Barium | 80.5 |
| Beryllium | 1.3 |
| Cadmium | 3 |
| Calcium | 13,302 |
| Chromium | 214 |
| Cobalt | 24.9 |
| Copper | 25.8 |
| Iron | 25,500 |
| Lead | 4.8 |
| Magnesium | 5,126 |
| Manganese | 3,292 |
| Mercury | ND (0.2) |
| Nickel | 154 |
| Potassium | 3843 |
| Selenium | 2.2 |
| Silver | 1 |
| Sodium | 12,346 |
| Thallium | 4.1 |
| Vanadium | 24.4 |
| Zinc | 89.9 |

NOTE: Data is from Stone & Webster's Final Background Inorganics Ground Water Study Report dated September 1996 and the finalized (December 1996) Table 7-4 from that report.

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | SB-01 | | SB-01 | | SB-02 | | SB-02 | | SB-02 | | SB-03 | | SB-03-Dup | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (15-17 ft) | | (43-44.5 ft) | | (10-12 ft) | | (28-30 ft) | | (32-34 ft) | | (10-12 ft) | | (10-12 ft) | |
| Unit Sampled | | silt | | till | | upper sand | | silt | | till | | upper sand | | upper sand | |
| Date Collected | | 07/18/95 | | 07/18/95 | | 07/18/95 | | 07/18/95 | | 07/18/95 | | 11/09/95 | | 11/09/95 | |
| Method Blank | | VBLKO6 | | VBLKO3 | | VBLKO7 | | VBLKO3 | | VBLKO7 | | VBLKCF | | VBLKCF | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Bromomethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Vinyl Chloride | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Chloroethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Methylene Chloride | 10 | 13 | U | 1500 | U | 17 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Acetone | 10 | **450** | | 1500 | U | 22 | U | 1700 | U | **660** | | **2700** | **DJ** | **1000** | **DJ** |
| Carbon Disulfide | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,1-Dichloroethene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,1-Dichloroethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,2-Dichloroethene (total) | 10 | **16** | | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Chloroform | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,2-Dichloroethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| 2-Butanone | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,1,1-Trichloroethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Carbon Tetrachloride | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Bromodichloromethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| 1,2-Dichloropropane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| cis-1,3-Dichloropropene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Trichloroethene | 10 | **53** | | **1200** | **J** | 13 | U | **8700** | | **98** | **J** | 14 | U | 13 | U |
| Dibromochloromethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * 1,1,2-Trichloroethane | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| < Benzene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| trans-1,3-Dichloropropene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Bromoform | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| 4-Methyl-2-Pentanone | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| 2-Hexanone | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Tetrachloroethene | 10 | **340** | | **680** | **J** | 13 | U | 1700 | U | **8** | **J** | 14 | U | 13 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **64** | | **12000** | | 13 | U | **17000** | | **1000** | | 14 | U | 13 | U |
| < Toluene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| * Chlorobenzene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| < Ethylbenzene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| Styrene | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| < Total Xylenes | 10 | 13 | U | 1500 | U | 13 | U | 1700 | U | 120 | U | 14 | U | 13 | U |
| DILUTION FACTOR | | 1 | | 125 | | 1 | | 125 | | 10 | | 1 | | 1 | |
| % SOLIDS | | 75 | | 85 | | 77 | | 73 | | 84 | | 74 | | 77 | |
| < Total BTEX | | 13 U | | 1500 U | | 13 U | | 1700 U | | 120 U | | 14 U | | 14 U | |
| * Total Chlorinated VOC | | 473 | | 13880 | | 13 U | | 25700 | | 1106 | | 14 U | | 14 U | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | SB-03 | | MW07-04D | | MW07-04D | | MW07-05R | | MW07-05R Dup | | MW07-05R | | MW07-05R | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (18-20 ft) | | (12-14 ft) | | (29-31 ft) | | (29-31 ft) | | (29-31 ft) | | (39-41 ft) | | (44-46 ft) | |
| Unit Sampled | | upper sand | | upper sand | | silt | | silt | | silt | | silt | | till | |
| Date Collected | | 11/09/95 | | 07/21/95 | | 07/21/95 | | 08/17/95 | | 08/17/95 | | 08/17/95 | | 08/17/95 | |
| Method Blank | | VBLKCF | | VBLKCM | | VBLKHZ | | VBLKCM | | VBLKCM | | VBLKFI | | VBLKFI | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | UJ | 12 | U | 3800 | U | 3100 | U |
| Bromomethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * Vinyl Chloride | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * Chloroethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| Methylene Chloride | 10 | 15 | U | 12 | U | 1800 | UJ | 12 | UJ | 12 | UJ | 3800 | U | 3100 | U |
| Acetone | 10 | **1800** | **D** | 34 | U | 4500 | U | **11** | **J** | **11** | **J** | 3800 | UJ | 3100 | U |
| Carbon Disulfide | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * 1,1-Dichloroethene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * 1,1-Dichloroethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * 1,2-Dichloroethene (total) | 10 | 14 | U | 12 | U | 1800 | U | **18** | **J** | **4** | **J** | 3800 | U | 3100 | U |
| * Chloroform | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * 1,2-Dichloroethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| 2-Butanone | 10 | 14 | U | 12 | U | 1900 | U | 12 | UJ | **4** | **J** | 3800 | U | **2000** | **J** |
| * 1,1,1-Trichloroethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * Carbon Tetrachloride | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| Bromodichloromethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| 1,2-Dichloropropane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| cis-1,3-Dichloropropene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * Trichloroethene | 10 | 14 | U | **7** | | **15000** | | **110** | **J** | **36** | **J** | **24000** | | **26000** | **J** |
| Dibromochloromethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * 1,1,2-Trichloroethane | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | **400** | **J** |
| < Benzene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| trans-1,3-Dichloropropene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| Bromoform | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| 4-Methyl-2-Pentanone | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | **2200** | **J** |
| 2-Hexanone | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | **2300** | **J** |
| * Tetrachloroethene | 10 | 14 | U | **7** | | 1800 | U | **2** | **J** | 12 | UJ | 3800 | U | 3100 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 14 | U | 12 | U | **19000** | | **82** | | **50** | | **28000** | | **22000** | |
| < Toluene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| * Chlorobenzene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| < Ethylbenzene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| Styrene | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| < Total Xylenes | 10 | 14 | U | 12 | U | 1800 | U | 12 | U | 12 | U | 3800 | U | 3100 | U |
| DILUTION FACTOR | | 1 | | 1 | | 125 | | 1 | | 1 | | 250 | | 250 | |
| % SOLIDS | | 72 | | 80 | | 70 | | 80 | | 80 | | 65 | | 80 | |
| < Total BTEX | | 13 U | | 12 U | | 1800 U | | 12 U | | 12 U | | 3800 U | | 3100 U | |
| * Total Chlorinated VOC | | 13 U | | 14 | | 34000 | | 212 | | 90 | | 52000 | | 48400 | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-09R | | MW07-09R | | MW07-09R | | MW07-10S | | MW07-10S | | MW07-13S | | MW07-13S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (14-16 ft) | | (48-50 ft) | | (53-55 ft) | | (0-2 ft) | | (14-16 ft) | | (4-6 ft) | | (8-10 ft) | |
| Unit Sampled | | upper sand | | lower sand | | till | | upper sand | | silt | | upper sand | | upper sand | |
| Date Collected | | 08/16/95 | | 08/18/95 | | 08/18/95 | | 08/09/95 | | 08/09/95 | | 08/15/95 | | 08/15/95 | |
| Method Blank | | VBLKCM | | VBLKCM | | VBLKCM | | VBLKBG | | VBLKBG | | VBLKBQ | | VBLKCL | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 13 | UJ | 14 | UJ | 11 | UJ | 12 | U | 14 | U | 110 | U | 120 | U |
| Bromomethane | 10 | 13 | U | 14 | U | 11 | UJ | 12 | U | 14 | U | 110 | U | 120 | U |
| * Vinyl Chloride | 10 | 13 | U | **2** | **J** | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * Chloroethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| Methylene Chloride | 10 | 13 | UJ | 14 | U | 11 | UJ | 12 | U | 14 | U | 67 | U | 76 | UJ |
| Acetone | 10 | **7100** | | 14 | U | **230** | | 12 | U | 32 | U | **5500** | | **4900** | |
| Carbon Disulfide | 10 | **8** | **J** | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,1-Dichloroethene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,1-Dichloroethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,2-Dichloroethene (total) | 10 | 13 | U | **590** | | **71** | | 12 | U | **15** | | 110 | U | 120 | U |
| * Chloroform | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,2-Dichloroethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| 2-Butanone | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,1,1-Trichloroethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * Carbon Tetrachloride | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| Bromodichloromethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| 1,2-Dichloropropane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| cis-1,3-Dichloropropene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * Trichloroethene | 10 | 13 | U | **680** | | **780** | | 12 | U | **130** | | 110 | U | 120 | U |
| Dibromochloromethane | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,1,2-Trichloroethane | 10 | 13 | U | **42** | | **8** | **J** | 12 | U | 14 | U | 110 | U | 120 | U |
| < Benzene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | **5** | **J** | 110 | U | 120 | U |
| trans-1,3-Dichloropropene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| Bromoform | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| 4-Methyl-2-Pentanone | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| 2-Hexanone | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * Tetrachloroethene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 13 | U | **260** | | **71** | | 12 | U | **59** | | 110 | U | 120 | U |
| < Toluene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| * Chlorobenzene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| < Ethylbenzene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| Styrene | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| < Total Xylenes | 10 | 13 | U | 14 | U | 11 | U | 12 | U | 14 | U | 110 | U | 120 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 1 | | 1 | | 10 | | 10 | |
| % SOLIDS | | 76 | | 71 | | 88 | | 86 | | 73 | | 89 | | 80 | |
| < Total BTEX | | 13 U | | 14 U | | 11 U | | 12 U | | 5 | | 110 U | | 120 U | |
| * Total Chlorinated VOC | | 13 U | | 1574 | | 930 | | 12 U | | 204 | | 110 U | | 120 U | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg)

CRQL = contract required quantitation limit
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U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-14D | | MW07-14D | | MW07-15D | | MW07-15D | | MW07-16D | | MW07-16D | | MW07-17D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (12-14 ft) | | (22-24 ft) | | (18-20 ft) | | (44-46 ft) | | (10-12 ft) | | (59-61 ft) | | (14-16 ft) | |
| Unit Sampled | | upper sand | | silt | | silt | | till | | upper sand | | till | | upper sand | |
| Date Collected | | 07/19/95 | | 07/19/95 | | 07/19/95 | | 07/19/95 | | 07/25/95 | | 07/25/95 | | 07/21/95 | |
| Method Blank | | VBLKO3 | | VBLKO3 | | VBLKO2 | | VBLKO1 | | VBLKCN | | VBLKCN | | VBLKCN | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Bromomethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * Vinyl Chloride | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | **2** | |
| * Chloroethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Methylene Chloride | 10 | 1500 | U | 1600 | U | 58 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Acetone | 10 | 1500 | U | 1600 | U | **170** | | 1400 | U | **120** | | **76** | | **89** | |
| Carbon Disulfide | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | **5** | | 12 | U | 17 | U |
| * 1,1-Dichloroethene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * 1,1-Dichloroethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * 1,2-Dichloroethene (total) | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * Chloroform | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * 1,2-Dichloroethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| 2-Butanone | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | **9** | | 12 | U | 17 | U |
| * 1,1,1-Trichloroethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * Carbon Tetrachloride | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Bromodichloromethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| 1,2-Dichloropropane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| cis-1,3-Dichloropropene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * Trichloroethene | 10 | **1200** | **J** | **4200** | | **40** | | **180** | | 12 | U | 12 | U | 17 | U |
| Dibromochloromethane | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * 1,1,2-Trichloroethane | 10 | 1500 | U | **190** | **J** | 14 | U | **22** | | 12 | U | 12 | U | 17 | U |
| < Benzene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| trans-1,3-Dichloropropene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Bromoform | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| 4-Methyl-2-Pentanone | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| 2-Hexanone | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| * Tetrachloroethene | 10 | **310** | **J** | 1600 | U | **65** | | **19** | | 12 | U | 12 | U | 17 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **38000** | | **12000** | | **54** | | **1800** | | 12 | U | 12 | U | 17 | U |
| < Toluene | 10 | 1500 | U | 1600 | U | **3** | **J** | 11 | U | 12 | U | 12 | U | 17 | U |
| * Chlorobenzene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| < Ethylbenzene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| Styrene | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| < Total Xylenes | 10 | 1500 | U | 1600 | U | 14 | U | 11 | U | 12 | U | 12 | U | 17 | U |
| DILUTION FACTOR | | 125 | | 125 | | 1 | | 1 | | 1 | | 1 | | 1 | |
| % SOLIDS | | 84 | | 78 | | 72 | | 87 | | 82 | | 83 | | 59 | |
| < Total BTEX | | 1500 U | | 1600 U | | 3 | | 11 U | | 12 U | | 12 U | | 17 U | |
| * Total Chlorinated VOC | | 39510 | | 16390 | | 159 | | 2021 | | 12 U | | 12 U | | 2 | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-17D | | MW07-18D | | MW07-18D | | MW07-19S | | MW07-19S | | MW07-19S Dup | | MW07-19D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (44-46 ft) | | (18-20 ft) | | (44-46 ft) | | (12-14 ft) | | (16-18 ft) | | (16-18 ft) | | (26-28 ft) | |
| Unit Sampled | | till | | silt | | lower sand | | till | | till | | till | | till | |
| Date Collected | | 07/25/95 | | 07/25/95 | | 07/25/95 | | 08/01/95 | | 08/01/95 | | 08/01/95 | | 07/28/95 | |
| Method Blank | | VBLKHZ | | VBLKO1 | | VBLKO1 | | VBLKO1 | | VBLKO2 | | VBLKO2 | | VBLKO1 | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| Bromomethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * Vinyl Chloride | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * Chloroethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| Methylene Chloride | 10 | 1500 | UJ | 14 | U | 13 | U | 18 | U | 13 | U | 13 | U | 15 | U |
| Acetone | 10 | 1500 | U | **27** | | **1800** | | **46** | | **150** | | **110** | | **1300** | |
| Carbon Disulfide | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,1-Dichloroethene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,1-Dichloroethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,2-Dichloroethene (total) | 10 | 1500 | U | 14 | U | 13 | U | **5** | **J** | 11 | U | 11 | U | **27** | |
| * Chloroform | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,2-Dichloroethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| 2-Butanone | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,1,1-Trichloroethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * Carbon Tetrachloride | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| Bromodichloromethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| 1,2-Dichloropropane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| cis-1,3-Dichloropropene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * Trichloroethene | 10 | **4100** | | 14 | U | 13 | U | **19** | | **44** | **J** | **22** | **J** | **60** | |
| Dibromochloromethane | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,1,2-Trichloroethane | 10 | 1500 | U | 14 | U | 13 | U | **6** | **J** | 11 | U | 11 | U | 12 | U |
| < Benzene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| trans-1,3-Dichloropropene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| Bromoform | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| 4-Methyl-2-Pentanone | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| 2-Hexanone | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * Tetrachloroethene | 10 | **160** | | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **8700** | | 14 | U | 13 | U | **90** | | **94** | | **58** | | 12 | U |
| < Toluene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | **1** | **J** | 11 | U | 12 | U |
| * Chlorobenzene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| < Ethylbenzene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| Styrene | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| < Total Xylenes | 10 | 1500 | U | 14 | U | 13 | U | 11 | U | 11 | U | 11 | U | 12 | U |
| DILUTION FACTOR | | 125 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |
| % SOLIDS | | 82 | | 69 | | 79 | | 90 | | 89 | | 89 | | 83 | |
| < Total BTEX | | 1500 U | | 14 U | | 13 U | | 11 U | | 1 | | 11 U | | 12 U | |
| * Total Chlorinated VOC | | 12960 | | 14 U | | 13 U | | 120 | | 138 | | 80 | | 87 | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg)

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-19D | | MW07-20S | | MW07-20S Dup | | MW07-20D | | MW07-20D | | MW07-20D | | MW07-21D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (38-38.5 ft) | | (4-6 ft) | | (4-6 ft) | | (14-16 ft) | | (49-51 ft) | | (64-66 ft) | | (0-2 ft) | |
| Unit Sampled | | till | | upper sand | | upper sand | | silt | | silt | | till | | upper sand | |
| Date Collected | | 07/31/95 | | 07/28/95 | | 07/28/95 | | 07/28/95 | | 07/31/95 | | 07/31/95 | | 08/02/95 | |
| Method Blank | | VBLKO3 | | VBLKO2 | | VBLKO2 | | VBLKO1 | | VBLKO1 | | VBLKO1 | | VBLKBB | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Bromomethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Vinyl Chloride | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Chloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Methylene Chloride | 10 | **80** | | 12 | U | 14 | U | 19 | U | 20 | U | 13 | U | 12 | U |
| Acetone | 10 | **450** | | **1700** | | **6100** | | **15** | | **49** | | **39** | | 180 | U |
| Carbon Disulfide | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,1-Dichloroethene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,1-Dichloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,2-Dichloroethene (total) | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Chloroform | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,2-Dichloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| 2-Butanone | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,1,1-Trichloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Carbon Tetrachloride | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Bromodichloromethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| 1,2-Dichloropropane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| cis-1,3-Dichloropropene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Trichloroethene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Dibromochloromethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,1,2-Trichloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| < Benzene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| trans-1,3-Dichloropropene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Bromoform | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| 4-Methyl-2-Pentanone | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| 2-Hexanone | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * Tetrachloroethene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| < Toluene | 10 | 57 | U | 12 | U | **1** | **J** | 14 | U | 15 | U | 10 | U | 12 | U |
| * Chlorobenzene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| < Ethylbenzene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| Styrene | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| < Total Xylenes | 10 | 57 | U | 12 | U | 12 | U | 14 | U | 15 | U | 10 | U | 12 | U |
| DILUTION FACTOR | | 5 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |
| % SOLIDS | | 88 | | 83 | | 84 | | 69 | | 68 | | 96 | | 81 | |
| < Total BTEX | | 57 U | | 12 U | | 1 | | 14 U | | 15 U | | 10 U | | 12 U | |
| * Total Chlorinated VOC | | 57 U | | 12 U | | 12 | U | 14 U | | 15 U | | 10 U | | 12 U | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis [illegible] secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-21D | | MW07-21D | | MW07-21D | | MW07-21R | | MW07-22S | | MW07-22S | | MW07-22S Dup | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (10-12 ft) | | (16-18 ft) | | (24-26 ft) | | (37-39 ft) | | (2-4 ft) | | (10-12 ft) | | (10-12 ft) | |
| Unit Sampled | | till | | till | | till | | till | | upper sand | | upper sand | | upper sand | |
| Date Collected | | 08/02/95 | | 08/02/95 | | 08/02/95 | | 10/20/95 | | 08/03/95 | | 08/03/95 | | 08/03/95 | |
| Method Blank | | VBLKBB | | VBLKBB | | VBLKBI | | VBLKCM | | VBLKBB | | VBLKBB | | VBLKBF | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| Bromomethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * Vinyl Chloride | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * Chloroethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| Methylene Chloride | 10 | 12 | U | 15 | U | 14 | U | 11 | U | 23 | U | 23 | U | 13 | U |
| Acetone | 10 | 710 | U | 310 | U | 510 | U | **280** | **D** | 19 | U | 26 | U | 44 | U |
| Carbon Disulfide | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,1-Dichloroethene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,1-Dichloroethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,2-Dichloroethene (total) | 10 | **15** | | **14** | | **47** | | 11 | U | 10 | U | 13 | U | 13 | U |
| * Chloroform | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,2-Dichloroethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| 2-Butanone | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,1,1-Trichloroethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * Carbon Tetrachloride | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| Bromodichloromethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| 1,2-Dichloropropane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| cis-1,3-Dichloropropene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * Trichloroethene | 10 | **13** | | **16** | | **32** | | 11 | U | 10 | U | 13 | U | 13 | U |
| Dibromochloromethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,1,2-Trichloroethane | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| < Benzene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| trans-1,3-Dichloropropene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| Bromoform | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| 4-Methyl-2-Pentanone | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| 2-Hexanone | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * Tetrachloroethene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **12** | | **16** | | **14** | **J** | 11 | U | 10 | U | 13 | U | 13 | U |
| < Toluene | 10 | 12 | U | 12 | U | 14 | U | **2** | | 10 | U | 13 | U | 13 | U |
| * Chlorobenzene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| < Ethylbenzene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| Styrene | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| < Total Xylenes | 10 | 12 | U | 12 | U | 14 | U | 11 | U | 10 | U | 13 | U | 13 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |
| % SOLIDS | | 82 | | 86 | | 70 | | 90 | | 97 | | 77 | | 75 | |
| < Total BTEX | | 12 U | | 12 U | | 14 U | | 2 | | 10 U | | 13 U | | 13 U | |
| * Total Chlorinated VOC | | 40 | | 46 | | 93 | | 11 | U | 10 U | | 13 U | | 13 U | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg)

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-22D | | MW07-22D | | MW07-23D | | MW07-23D | | MW07-23D | | MW07-23D | | MW07-24D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (14-16 ft) | | (18-20 ft) | | (0-2 ft) | | (18-20 ft) | | (28-30 ft) | | (44-46 ft) | | (4-6 ft) | |
| Unit Sampled | | silt | | till | | upper sand | | till | | till | | till | | upper sand | |
| Date Collected | | 08/03/95 | | 08/03/95 | | 08/04/95 | | 08/07/95 | | 08/07/95 | | 08/07/95 | | 08/22/95 | |
| Method Blank | | VBLKBB | | VBLKBB | | VBLKBH | | VBLKBG | | VBLKBG | | VBLKBG | | VBLKO2 | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| Bromomethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Vinyl Chloride | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Chloroethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| Methylene Chloride | 10 | 19 | U | 20 | U | 62 | UJ | 12 | U | 11 | U | 12 | U | 130 | U |
| Acetone | 10 | 27 | U | 220 | U | 87 | U | 1600 | U | 630 | U | 190 | U | 1200 | U |
| Carbon Disulfide | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,1-Dichloroethene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,1-Dichloroethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,2-Dichloroethene (total) | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Chloroform | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,2-Dichloroethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| 2-Butanone | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,1,1-Trichloroethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Carbon Tetrachloride | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| Bromodichloromethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| 1,2-Dichloropropane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| cis-1,3-Dichloropropene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Trichloroethene | 10 | 12 | U | 11 | U | 12 | U | **3** | **J** | 11 | U | **150** | | 120 | U |
| Dibromochloromethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,1,2-Trichloroethane | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| < Benzene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| trans-1,3-Dichloropropene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| Bromoform | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| 4-Methyl-2-Pentanone | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| 2-Hexanone | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Tetrachloroethene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 12 | U | 11 | U | 12 | U | **7** | **J** | 11 | U | **140** | | 120 | U |
| < Toluene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| * Chlorobenzene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| < Ethylbenzene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| Styrene | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| < Total Xylenes | 10 | 12 | U | 11 | U | 12 | U | 12 | U | 11 | U | 11 | U | 120 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 10 | |
| % SOLIDS | | 80 | | 87 | | 80 | | 86 | | 89 | | 89 | | 86 | |
| < Total BTEX | | 12 U | | 11 U | | 12 U | | 12 U | | 11 U | | 11 U | | 120 U | |
| * Total Chlorinated VOC | | 12 U | | 11 U | | 12 U | | 10 | | 11 U | | 290 | | 120 U | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis [illegible] secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-24D | MW07-24D | MW07-24D | MW07-24D Dup | MW07-25D | MW07-25D | MW07-26S |
|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (8-10 ft) | (29-31 ft) | (54-56 ft) | (54-56 ft) | (6-8 ft) | (34-36 ft) | (10-12 ft) |
| Unit Sampled | | upper sand | till | till | till | upper sand | till | upper sand |
| Date Collected | | 08/22/95 | 08/23/95 | 08/23/95 | 08/23/95 | 10/24/95 | 10/24/95 | 08/09/95 |
| Method Blank | | VBLKO3 | VBLKO3 | VBLKO6 | VBLKO3 | VBLKED | VBLKED | VBLKBQ |
| **ANALYTE** | **CRQL** | | | | | | | |
| * Chloromethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| Bromomethane | 10 | 58 UJ | 12 U | 12 UJ | 12 U | 15 U | 14 U | 11 U |
| * Vinyl Chloride | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * Chloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| Methylene Chloride | 10 | 58 UJ | 12 U | 12 U | 12 UJ | 15 U | 14 U | 15 U |
| Acetone | 10 | 4300 U | 4000 U | 60 UJ | 130 UJ | **170** | **85** | **280** |
| Carbon Disulfide | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,1-Dichloroethene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,1-Dichloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,2-Dichloroethene (total) | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * Chloroform | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,2-Dichloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| 2-Butanone | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,1,1-Trichloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * Carbon Tetrachloride | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| Bromodichloromethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| 1,2-Dichloropropane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| cis-1,3-Dichloropropene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * Trichloroethene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | **19** | 11 U |
| Dibromochloromethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * 1,1,2-Trichloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| < Benzene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| trans-1,3-Dichloropropene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| Bromoform | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| 4-Methyl-2-Pentanone | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| 2-Hexanone | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| * Tetrachloroethene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | **7** | 11 U |
| * 1,1,2,2-Tetrachloroethane | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | **200** | 11 U |
| < Toluene | 10 | 58 U | 12 U | 12 U | **1 J** | 15 U | 14 U | 11 U |
| * Chlorobenzene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| < Ethylbenzene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| Styrene | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| < Total Xylenes | 10 | 58 U | 12 U | 12 U | 12 U | 15 U | 14 U | 11 U |
| DILUTION FACTOR | | 5 | 1 | 1 | 1 | 1 | 1 | 1 |
| % SOLIDS | | 86 | 86 | 84 | 83 | 68 | 74 | 89 |
| < Total BTEX | | 58 U | 12 U | 12 U | 1 | 15 U | 14 U | 11 U |
| * Total Chlorinated VOC | | 58 U | 12 U | 12 U | 12 U | 15 U | 226 | 11 U |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg)

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-26S | MW07-27D | MW07-27D | MW07-27D | MW07-28D | MW07-28D | MW07-29D |
|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (16-18 ft) | (18-20 ft) | (24-26 ft) | (34-36 ft) | (20-22 ft) | (44-45 ft) | (49-51 ft) |
| Unit Sampled | | till | till | till | till | silt | till | lower sand |
| Date Collected | | 08/09/95 | 08/10/95 | 08/10/95 | 08/11/95 | 10/16/95 | 10/17/95 | 10/25/95 |
| Method Blank | | VBLKCL | VBLKBG | VBLKBH | VBLKBI | VBLKCL | VBLKCM | VBLKED |
| **ANALYTE** | **CRQL** | | | | | | | |
| * Chloromethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| Bromomethane | 10 | **1 J** | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Vinyl Chloride | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Chloroethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| Methylene Chloride | 10 | 35 UJ | 12 U | 450 UJ | 16 UJ | 12 U | 11 U | 13 U |
| Acetone | 10 | **12000** | 84 U | 140 U | 13 U | **520 J** | 44 U | 49 U |
| Carbon Disulfide | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,1-Dichloroethene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,1-Dichloroethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,2-Dichloroethene (total) | 10 | **10 J** | **240** | 110 U | **9 J** | 12 U | 11 U | 13 U |
| * Chloroform | 10 | 11 U | **2 J** | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,2-Dichloroethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| 2-Butanone | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,1,1-Trichloroethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Carbon Tetrachloride | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| Bromodichloromethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| 1,2-Dichloropropane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| cis-1,3-Dichloropropene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Trichloroethene | 10 | **3 J** | **340** | **230** | **21** | 12 U | 11 U | 13 U |
| Dibromochloromethane | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,1,2-Trichloroethane | 10 | **2 J** | **60** | 110 U | 12 U | 12 U | 11 U | 13 U |
| < Benzene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| trans-1,3-Dichloropropene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| Bromoform | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| 4-Methyl-2-Pentanone | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| 2-Hexanone | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Tetrachloroethene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * 1,1,2,2-Tetrachloroethane | 10 | 11 U | **1100** | **770** | **92** | 12 U | 11 U | 13 U |
| < Toluene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Chlorobenzene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | **1** | 13 U |
| < Ethylbenzene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| Styrene | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| < Total Xylenes | 10 | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| DILUTION FACTOR | | 1 | 1 | 10 | 1 | 1 | 1 | 1 |
| % SOLIDS | | 88 | 80 | 88 | 86 | 80 | 91 | 75 |
| < Total BTEX | | 11 U | 12 U | 110 U | 12 U | 12 U | 11 U | 13 U |
| * Total Chlorinated VOC | | 15 | 1742 | 1000 | 122 | 12 U | 1 | 13 U |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg)
CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis a[illegible]condary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-29D | MW07-30D | MW07-30D Dup | MW07-30D | MW07-31I | MW07-31I | MW07-31I |
|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | (69-71) | (49-51 ft) | (49-51 ft) | (64-66 ft) | (6-8 ft) | (18-20 ft) | (24-25 ft) |
| Unit Sampled | | till | lower sand | lower sand | lower sand | upper sand | silt (sandy) | till |
| Date Collected | | 10/25/95 | 10/30/95 | 10/30/95 | 10/30/95 | 11/10/95 | 11/10/95 | 11/13/95 |
| Method Blank | | VBLKED | VBLKCW | VBLKCB | VBLKCW | VBLKCI | VBLKCI | VBLKCI |
| **ANALYTE** | **CRQL** | | | | | | | |
| * Chloromethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| Bromomethane | 10 | 11 U | 13 U | 13 UJ | 13 U | 13 U | 15 U | 12 U |
| * Vinyl Chloride | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Chloroethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 UJ | 15 UJ | 12 UJ |
| Methylene Chloride | 10 | 11 U | 30 U | 20 U | 26 U | 13 U | 15 U | 12 U |
| Acetone | 10 | **92** | **160 J** | 65 U | **150** | **600 J** | **75** | **190** |
| Carbon Disulfide | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * 1,1-Dichloroethene | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * 1,1-Dichloroethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * 1,2-Dichloroethene (total) | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | **43 J** |
| * Chloroform | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | **6** |
| * 1,2-Dichloroethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| 2-Butanone | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * 1,1,1-Trichloroethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Carbon Tetrachloride | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| Bromodichloromethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| 1,2-Dichloropropane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| cis-1,3-Dichloropropene | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Trichloroethene | 10 | 11 U | 13 U | 13 U | 13 U | **18** | **100** | **2800 J** |
| Dibromochloromethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * 1,1,2-Trichloroethane | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | **16** | **180** |
| < Benzene | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| trans-1,3-Dichloropropene | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| Bromoform | 10 | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| 4-Methyl-2-Pentanone | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| 2-Hexanone | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Tetrachloroethene | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | **39** | **230** |
| * 1,1,2,2-Tetrachloroethane | 10 | 11 UJ | 13 U | 13 U | 13 U | **15** | **5000 D** | **18000 D** |
| < Toluene | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Chlorobenzene | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| < Ethylbenzene | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| Styrene | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| < Total Xylenes | 10 | 11 UJ | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| DILUTION FACTOR | | 1 | 1 | 1 | 1 | | 1 | 1 |
| % SOLIDS | | 91 | 77 | 75 | 79 | | 66 | 86 |
| < Total BTEX | | 11 U | 13 U | 13 U | 13 U | 13 U | 15 U | 12 U |
| * Total Chlorinated VOC | | 11 U | 13 U | 13 U | 13 U | 33 | 5155 | 21259 |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).
CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | Source | Source | Source | MW07-32R | MW07-32R | MW07-32R | SB09-16 | SB09-16 | SB09-16 |
|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | Water #1 | Water #2 | Water #3 | 04-06 | 22-24 | 24-26 | 5-6.5 | 7.5-9.5 | 9.5-11 |
| Unit Sampled | | | | | | | | | | |
| Date Collected | | 07/25/95 | 08/10/95 | 08/24/95 | 12/12/97 | 12/12/97 | 12/12/97 | 11/12/97 | 11/13/97 | 11/13/97 |
| Method Blank | | VBLKHY | VBLKCE | VBLKO4 | | | | | | |
| **ANALYTE** | **CRQL** | | | | | | | | | |
| * Chloromethane | 10 | 10 U | 10 U | 10 U | 2 UJ | 2 UJ | 2 UJ | 3 U | 2 U | 3 U |
| Bromomethane | 10 | 10 U | 10 U | 10 U | 1 UJ | 1 UJ | 1 UJ | 1 U | 1 U | 1 U |
| * Vinyl Chloride | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * Chloroethane | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| Methylene Chloride | 10 | 10 UJ | 9 BJ | 17 BJ | 12 U | 12 U | 14 U | **10** | 2 U | 3 U |
| Acetone | 10 | 11 U | **6 J** | 10 U | 1 U | 86 U | 1 U | **79 J** | 62 J | 1 UJ |
| Carbon Disulfide | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * 1,1-Dichloroethene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * 1,1-Dichloroethane | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethene (total) | 10 | 10 U | 10 U | 10 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| * Chloroform | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethane | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| 2-Butanone | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,1-Trichloroethane | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * Carbon Tetrachloride | 10 | 10 U | 10 U | 10 U | 3 U | 4 U | 4 U | 4 U | 4 U | 4 U |
| Bromodichloromethane | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,3-Dichloropropene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * Trichloroethene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| Dibromochloromethane | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,2-Trichloroethane | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| < Benzene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| trans-1,3-Dichloropropene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| Bromoform | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 4-Methyl-2-Pentanone | 10 | 10 U | 10 U | 10 U | 3 U | 4 U | 4 U | 4 UJ | 4 UJ | 4 UJ |
| 2-Hexanone | 10 | 10 U | 10 U | 10 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * Tetrachloroethene | 10 | 10 U | 10 U | **1 J** | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * 1,1,2,2-Tetrachloroethane | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| < Toluene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| * Chlorobenzene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| < Ethylbenzene | 10 | 10 U | 10 U | 10 U | 6 U | 6 U | 6 U | 7 U | 6 U | 6 U |
| Styrene | 10 | 10 U | 10 U | 10 U | 2 U | 2 U | 2 U | 3 U | 2 U | 3 U |
| < Total Xylenes | 10 | 10 U | 10 U | 10 U | 7 U | 7 U | 7 U | 8 U | 7 U | 8 U |
| DILUTION FACTOR | | 1 | 1 | 1 | | | | | | |
| % SOLIDS | | | | | | | | | | |
| < Total BTEX | | 10 U | 10 U | 10 U | ND | ND | ND | ND | ND | ND |
| * Total Chlorinated VOC | | 10 U | 10 U | 1 | ND | ND | ND | ND | ND | ND |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).
CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | SB09-16 | SB09-16 | SB09-16 | SB09-17 | SB09-17 | SB09-17 | SB09-17 | SB09 | SB09-17 | SB09-17 | SB09-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (below ground surface) | | 17-19 | 30-32 | 41-43 | 07-09 | 13-15 | 15-17 | 17-19 | -DUP5 | 30-32 | 32-34 | 34-36 |
| Unit Sampled | | | | | | | | | | | | |
| Date Collected | | 11/24/97 | 11/12/97 | 11/17/97 | 11/21/97 | 11/21/97 | 11/24/97 | 11/24/97 | 11/24/97 | 11/24/97 | 11/25/97 | 11/25/97 |
| Method Blank | | | | | | | | | | | | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | |
| * Chloromethane | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| Bromomethane | 10 | 1 U | 1 U | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 U | 1 U |
| * Vinyl Chloride | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * Chloroethane | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| Methylene Chloride | 10 | 2 U | 4 | 2 U | 3 U | 4 | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| Acetone | 10 | 75 J | 1 UJ | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 UJ | 1 U | 22 J |
| Carbon Disulfide | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * 1,1-Dichloroethene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * 1,1-Dichloroethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethene (total) | 10 | 5 U | 5 U | 4 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| * Chloroform | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethane | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| 2-Butanone | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,1-Trichloroethane | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * Carbon Tetrachloride | 10 | 4 U | 4 U | 3 U | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U |
| Bromodichloromethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,3-Dichloropropene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * Trichloroethene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| Dibromochloromethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,2-Trichloroethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| < Benzene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| trans-1,3-Dichloropropene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| Bromoform | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 4-Methyl-2-Pentanone | 10 | 4 UJ | 4 UJ | 3 UJ | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U |
| 2-Hexanone | 10 | 1 U | 1 U | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ |
| * Tetrachloroethene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * 1,1,2,2-Tetrachloroethane | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| < Toluene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| * Chlorobenzene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| < Ethylbenzene | 10 | 6 U | 7 U | 6 U | 6 U | 7 U | 7 U | 6 U | 6 U | 6 U | 6 U | 6 U |
| Styrene | 10 | 2 U | 3 U | 2 U | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U | 2 U | 2 U |
| < Total Xylenes | 10 | 7 U | 8 U | 7 U | 8 U | 8 U | 8 U | 8 U | 8 U | 8 U | 7 U | 7 U |
| DILUTION FACTOR | | | | | | | | | | | | |
| % SOLIDS | | | | | | | | | | | | |
| < Total BTEX | | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| * Total Chlorinated VOC | | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution factor

# Summary of Volatile Organic Compounds in Soil (ug/kg)

**Table 4-2**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | SB09-17 | SB09-17 | SB09-17 | SB09-17 | SB09-17 |
|---|---|---|---|---|---|---|
| Depth (below ground surface) | | 46-47 | 48-50 | 55-57 | 57-59 | 59-60 |
| Unit Sampled | | | | | | |
| Date Collected | | 11/25/97 | 11/26/97 | 11/26/97 | 11/26/97 | 11/26/97 |
| Method Blank | | | | | | |
| **ANALYTE** | **CRQL** | | | | | |
| * Chloromethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| Bromomethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| * Vinyl Chloride | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * Chloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| Methylene Chloride | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| Acetone | 10 | 1 UJ | 1 U | **21** | 1 U | 1 U |
| Carbon Disulfide | 10 | 2 U | 2 UJ | 2 UJ | 2 UJ | 2 UJ |
| * 1,1-Dichloroethene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * 1,1-Dichloroethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethene (total) | 10 | 5 U | 4 U | 5 U | 5 U | 4 U |
| * Chloroform | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,2-Dichloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| 2-Butanone | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,1-Trichloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * Carbon Tetrachloride | 10 | 3 U | 3 U | 4 U | 3 U | 3 U |
| Bromodichloromethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| 1,2-Dichloropropane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,3-Dichloropropene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * Trichloroethene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| Dibromochloromethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| * 1,1,2-Trichloroethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U |
| < Benzene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| trans-1,3-Dichloropropene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| Bromoform | 10 | 1 U | 1 UJ | 1 UJ | 1 UJ | 1 UJ |
| 4-Methyl-2-Pentanone | 10 | 3 U | 3 UJ | 4 UJ | 3 UJ | 3 UJ |
| 2-Hexanone | 10 | 1 UJ | 1 UJ | 1 UJ | 1 UJ | 1 UJ |
| * Tetrachloroethene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * 1,1,2,2-Tetrachloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| < Toluene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| * Chlorobenzene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| < Ethylbenzene | 10 | 6 U | 6 U | 6 U | 6 U | 6 U |
| Styrene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U |
| < Total Xylenes | 10 | 7 U | 7 U | 7 U | 7 U | 7 U |
| DILUTION FACTOR | | | | | | |
| % SOLIDS | | | | | | |
| < Total BTEX | | ND | ND | ND | ND | ND |
| * Total Chlorinated VOC | | ND | ND | ND | ND | ND |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per kilograms (ug/kg).

CRQL = contract required quantitation limit
UJ = estimated value (below laboratory detection limit)
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
BJ = estimated value below SQL where analyte is detected in method blank and sample
D = analysis at a secondary dilution fa

# TABLE 4-2A
## Site 07, NCBC Davisville, R.I.
## WETLANDS SEDIMENT SAMPLES

| VOC ANALYSIS: (ug/Kg) | | |
|---|---|---|
| **Sample I.D.** | SD2MW19 | SD8SMW13 |
| **Date Collected** | 12/04/97 | 12/04/97 |
| **ANALYTE** | | |
| * Chloromethane | 6U | 8U |
| * Vinyl Chloride | 6U | 8U |
| Bromomethane | 6U | 8U |
| * Chloroethane | 6U | 8U |
| Acetone | 13U | 17U |
| * 1,1-Dichloroethene | 6U | 8U |
| Methylene Chloride | 6U | 8U |
| Carbon Disulfide | 6U | 8U |
| * 1,2-Dichloroethene (total) | 6U | 8U |
| * 1,1-Dichloroethane | 6U | 8U |
| 2-Butanone | 13U | 17U |
| * Chloroform | 6U | 8U |
| * 1,1,1-Trichloroethane | 6U | 8U |
| * Carbon Tetrachloride | 6U | 8U |
| * 1,2-Dichloroethane | 6U | 8U |
| < Benzene | 6U | 8U |
| * Trichloroethene | 6U | 8U |
| 1,2-Dichloropropane | 6U | 8U |
| Bromodichloromethane | 6U | 8U |
| 4-Methyl-2-Pentanone | 13U | 17U |
| cis-1,3-Dichloropropene | 6U | 8U |
| < Toluene | 6U | 8U |
| trans-1,3-Dichloropropene | 6U | 8U |
| * 1,1,2-Trichloroethane | 6U | 8U |
| 2-Hexanone | 13U | 17U |
| * Tetrachloroethene | 6U | 8U |
| Chlorodibromomethane | 6U | 8U |
| * Chlorobenzene | 6U | 8U |
| < Ethylbenzene | 6U | 8U |
| < Total Xylenes | 6U | 8U |
| Styrene | 6U | 8U |
| Bromoform | 6U | 8U |
| * 1,1,2,2-Tetrachloroethane | 6U | 8U |
| < Total BTEX | | |
| * Total Chlorinated VOC | | |

| METALS ANALYSIS: (mg/Kg) | | |
|---|---|---|
| **Sample I.D.** | SD2MW19 | SD8SMW13 |
| **Date Collected** | 12/04/97 | 12/04/97 |
| **ANALYTE** | | |
| arsenic | 4.2 | 8.8 |
| copper | 10.8E | 27.8E |
| iron | 11300 | 23100 |
| manganese | 49.4 | 96.4 |
| nickel | 3.2B | 7.6 |
| zinc | 17.4 | 300.7 |

# TABLE 4-3

## Summary of Total Organic Carbon Detected in Soil Samples

**IR Program Site 07, Calf Pasture Point**

NCBC Davisville, R.I.

| Well/Boring Designation | Date Sample Collected | Sample Depth (ft bgs) | Geologic Unit | TOC (mg/Kg) |
|---|---|---|---|---|
| SB07-02 | 07/18/95 | 28-30 | silt | 11400 |
| MW07-17D | 07/25/95 | 44-46 | till | 4500 |
| MW07-19S | 08/01/95 | 12-14 | till | 7490 |
| MW07-13S | 08/15/95 | 16-18 | silt | 7290 |
| MW07-24D | 08/23/95 | 34-36 | lower sand | 7670 |
| MW07-21R | 10/20/95 | 37-39 | till | 10100 |
| MW07-29D | 10/25/95 | 44-46 | lower sand | 6070 |
| MW07-30D | 10/30/95 | 54-56 | lower sand | 8000 |
| SB09-16 | 11/12/97 | 5.0-6.5 | organic silt, fine sand | 21700 |
| SB09-16 | 11/13/97 | 7.5-9.5 | fine sand and silt | 17500 |
| SB09-16 | 11/13/97 | 9.5-11 | silt | 17500 |
| SB09-16 | 11/24/97 | 17-19 | silt | 17500 |
| SB09-16 | 11/12/97 | 30-32 | silt | 17500 |
| SB09-16 | 11/17/97 | 41-43 | till | 7000 |
| SB09-17 | 11/21/97 | 7-9 | silt | 12800 |
| SB09-17 | 11/21/97 | 13-15 | silt | 14600 |
| SB09-17 | 11/24/97 | 15-17 | silt | 17300 |
| SB09-17 | 11/24/97 | 17-19 | silt | 13900 |
| SB09-DUP5 | 11/24/97 | 17-19 | silt | 18100 |
| SB09-17 | 11/24/97 | 30-32 | silt | 18400 |
| SB09-17 | 11/25/97 | 32-34 | till | 12700 |
| SB09-17 | 11/25/97 | 34-36 | till | 14100 |
| SB09-17 | 11/25/97 | 46-47 | till | 8630 |
| SB09-17 | 11/26/97 | 48-50 | till | 5060 |
| SB09-17 | 11/26/97 | 55-57 | till | 8010 |
| SB09-17 | 11/26/97 | 57-59 | till | 7180 |
| SB09-17 | 11/26/97 | 59-59.8 | till | 5460 |

**NOTES:**

TOC = total organic carbon

mg/Kg = milligrams per kilogram

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

## TABLE 4-4
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-NB1 | | NCBC-AH1 | | MW07-01S | | MW07-02S | | MW07-03S | | MW07-03D | | MW07-04S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 12/22/95 | | 12/21/95 | | 12/27/95 | | 12/27/95 | | 12/28/95 | | 05/22/96 | | 12/27/95 | |
| **Method Blank** | | VBLKGA | | VBLKGA | | VBLKHG | | VBLKFC | | VBLKGA | | VBLKEM | | VBLKEZ | |
| **ANALYTE** | **CRQL** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromomethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Vinyl Chloride | 10 | 10 | UJ | 10 | UJ | **23** | | 10 | U | 10 | U | **31** | **J** | 10 | U |
| * Chloroethane | 10 | 10 | UJ | 10 | UJ | 10 | U | 10 | U | 10 | U | 10 | UJ | 10 | U |
| Methylene Chloride | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | UJ | 10 | U | 10 | UJ |
| Acetone | 10 | 10 | U | 11 | U | 10 | U | 13 | UJ | 14 | UJ | 16 | U | **200** | **J** |
| Carbon Disulfide | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | **230** | | 10 | U |
| * Chloroform | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 2-Butanone | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | UJ | 10 | U | 10 | UJ |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromodichloromethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Trichloroethene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | **65** | **J** | 10 | U |
| Dibromochloromethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | **5** | **J** | 10 | U |
| < Benzene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromoform | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 2-Hexanone | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Tetrachloroethene | 10 | 10 | U | 10 | U | 10 | U | **1** | | 10 | U | 10 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 10 | U | 10 | U | 10 | U | 10 | UJ | 10 | U | **8** | **J** | 10 | U |
| < Toluene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Chlorobenzene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| < Ethylbenzene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Styrene | 10 | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| < Total Xylenes | 10 | 10 | U | **4** | **J** | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |
| < Total BTEX | | 10 | U | 4 | | 10 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Total Chlorinated VOC | | 10 | U | 10 | U | 23 | | 1 | | 10 | U | 339 | | 10 | U |

**All data is VALIDATED**

NOTES: All values reported in micrograms per liter (ug/L)

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

## TABLE 4-4
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | MW07-04D | | MW07-05S | | MW07-05D | | MW07-05D/dup | | MW07-05R | | MW07-06S | | MW07-07S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 05/28/96 | | 12/26/95 | | 05/23/96 | | 05/23/96 | | 05/23/96 | | 12/14/95 | | 12/21/95 | |
| **Method Blank** | | VBLKER | | VBLKFB | | VBLKGE | | VBLKEO<br>VBLKEP | | VBLKEM | | VBLKEP | | VBLKHP | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 5000 | U | 10 | U | 1000 | U | **98** | **J** | 10 | U | 10 | U | 10 | U |
| Bromomethane | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| * Vinyl Chloride | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | **17** | | 10 | U | 10 | U |
| * Chloroethane | 10 | 5000 | U | 10 | U | 1000 | UJ | 500 | U | 10 | U | 10 | U | 10 | U |
| Methylene Chloride | 10 | 5800 | U | 14 | U | 1000 | UJ | 700 | UJ | 10 | U | 10 | U | 10 | UJ |
| Acetone | 10 | 5000 | U | 35 | UJ | 1000 | UJ | 500 | U | 22 | U | 10 | U | 10 | U |
| Carbon Disulfide | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | **2** | **J** | 10 | U | 10 | U |
| * 1,1-Dichloroethene | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | **21** | | 10 | U | 10 | U |
| * 1,1-Dichloroethane | 10 | 5000 | U | 10 | U | 1000 | U | **74** | **J** | 10 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | 5000 | U | 10 | U | **520** | **J** | **790** | | **2200** | | 10 | U | 10 | U |
| * Chloroform | 10 | 5000 | U | 10 | U | **130** | **J** | **240** | **J** | **48** | | 10 | U | 10 | U |
| * 1,2-Dichloroethane | 10 | 5000 | U | 10 | U | 1000 | U | **120** | **J** | **1** | **J** | 10 | U | 10 | U |
| 2-Butanone | 10 | 5000 | U | 10 | U | 1000 | UJ | 500 | U | 10 | U | **5** | **J** | 10 | U |
| * 1,1,1-Trichloroethane | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| Bromodichloromethane | 10 | 5000 | U | 10 | U | 1000 | U | **78** | **J** | 10 | U | 10 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 5000 | U | 10 | U | 1000 | U | **98** | **J** | 10 | U | 10 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 5000 | U | 10 | U | 1000 | U | **66** | **J** | 10 | U | 10 | U | 10 | U |
| * Trichloroethene | 10 | **46000** | | 10 | U | **47000** | **J** | **46000** | | **27000** | | 10 | U | 10 | U |
| Dibromochloromethane | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | 5000 | U | 10 | U | **390** | **J** | 500 | U | **390** | **J** | 10 | U | 10 | U |
| < Benzene | 10 | 5000 | U | 10 | U | 1000 | U | **550** | | 10 | U | 10 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| Bromoform | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 5000 | U | 10 | U | 1000 | UJ | 500 | U | 10 | U | 10 | U | 10 | U |
| 2-Hexanone | 10 | 5000 | U | 10 | U | 1000 | UJ | 500 | U | 10 | U | 10 | U | 10 | U |
| * Tetrachloroethene | 10 | 5000 | U | 10 | U | **710** | **J** | **760** | | **51** | | 10 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **77000** | | 10 | U | **48000** | **J** | **28000** | **J** | **12000** | | 10 | U | 10 | U |
| < Toluene | 10 | 5000 | U | 10 | U | 1000 | U | **96** | **J** | 10 | U | 10 | U | 10 | U |
| * Chlorobenzene | 10 | 5000 | U | 10 | U | 1000 | U | **100** | **J** | 10 | U | 10 | U | 10 | U |
| < Ethylbenzene | 10 | 5000 | U | 10 | U | 1000 | U | 500 | U | 10 | U | 10 | U | 10 | U |
| Styrene | 10 | 5000 | U | 10 | U | 1000 | U | **72** | **J** | 10 | U | 10 | U | 10 | U |
| < Total Xylenes | 10 | 5000 | U | 10 | U | 1000 | U | **220** | **J** | 10 | U | 10 | U | 10 | U |
| DILUTION FACTOR | | 500 | | 1 | | 100 | | 50 | | 1 | | 1 | | 1 | |
| < Total BTEX | | 5000 | U | 10 | U | 1000 | U | 866 | | 10 | U | 10 | U | 10 | U |
| * Total Chlorinated VOC | | 123000 | | 10 | U | 96750 | | 77362 | | 41730 | | 10 | U | 10 | U |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

**TABLE 4-4**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-08S | | MW07-09D | | MW07-09D/dup | | MW07-09R | | MW07-10S | | MW07-10D | | MW07-11D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 12/20/95 | | 05/22/96 | | 05/22/96 | | 12/20/95 | | 12/22/95 | | 05/23/96 | | 12/19/95 | |
| **Method Blank** | | VBLKBJ | | VBLKGE | | VBLKGE | | VBLKBJ | | VBLKHP | | VBLKEO | | VBLKEQ | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| Bromomethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Vinyl Chloride | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Chloroethane | 10 | 10 | U | 500 | UJ | 500 | UJ | 10 | U | 10 | U | 100 | U | 10 | U |
| Methylene Chloride | 10 | 25 | UJ | 520 | UJ | 500 | UJ | 22 | UJ | 10 | UJ | 150 | UJ | 28 | UJ |
| Acetone | 10 | 17 | UJ | 500 | UJ | 500 | UJ | 21 | UJ | 10 | U | 100 | U | 32 | UJ |
| Carbon Disulfide | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,1-Dichloroethene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,1-Dichloroethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | 10 | U | **3700** | | **3500** | | 10 | U | 10 | U | **29** | **J** | 10 | U |
| * Chloroform | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,2-Dichloroethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| 2-Butanone | 10 | 10 | U | 500 | UJ | 500 | UJ | 10 | U | 10 | U | 100 | U | 4 | UJ |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| Bromodichloromethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Trichloroethene | 10 | 10 | U | **5500** | | **5500** | | 10 | U | 10 | U | **860** | **J** | 10 | U |
| Dibromochloromethane | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | 10 | U | **310** | **J** | **320** | **J** | 10 | U | 10 | U | **40** | **J** | **2** | **J** |
| < Benzene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| Bromoform | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 500 | UJ | 500 | UJ | 10 | U | 10 | U | 100 | U | 10 | U |
| 2-Hexanone | 10 | 10 | U | 500 | UJ | 500 | UJ | 10 | U | 10 | U | 100 | U | 10 | U |
| * Tetrachloroethene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 10 | U | **2000** | **J** | **2100** | **J** | 10 | U | 10 | U | **1500** | | 10 | U |
| < Toluene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Chlorobenzene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| < Ethylbenzene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| Styrene | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| < Total Xylenes | 10 | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| DILUTION FACTOR | | 1 | | 50 | | 50 | | 1 | | 1 | | 10 | | 1 | |
| < Total BTEX | | 10 | U | 500 | U | 500 | U | 10 | U | 10 | U | 100 | U | 10 | U |
| * Total Chlorinated VOC | | 10 | U | 11510 | | 11420 | | 10 | U | 10 | U | 2429 | | 2 | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

## Summary of Volatile Organic Compounds in Ground Water (ug/L)

**TABLE 4-4**
**Site 07, NCBC Davisville, R.I.**

| **Sample I.D.** | | MW07-12D | | MW07-13S | | MW07-13D | | MW07-14D | | MW07-15D | | MW07-16D | | MW07-16R | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 05/29/96 | | 12/18/95 | | 12/18/95 | | 05/30/96 | | 05/24/96 | | 12/14/95 | | 12/15/95 | |
| **Method Blank** | | VBLKCI | | VBLKHB | | VBLKBJ | | VBLKET | | VBLKGE | | VBLKHV | | VBLKHV | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| Bromomethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Vinyl Chloride | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Chloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| Methylene Chloride | 10 | 14 | U | 10 | UJ | 10 | U | 840 | U | 1000 | U | 10 | U | 10 | U |
| Acetone | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 19 | U | 22 | U |
| Carbon Disulfide | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | **36** | | 10 | U | **18** | | 500 | U | **890** | **J** | 10 | U | 10 | U |
| * Chloroform | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| 2-Butanone | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| Bromodichloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Trichloroethene | 10 | **2** | **J** | 10 | U | **26** | | **6500** | | **47000** | | 10 | U | 10 | U |
| Dibromochloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | **190** | **J** | 1000 | U | 10 | U | 10 | U |
| < Benzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| Bromoform | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| 2-Hexanone | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Tetrachloroethene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | **1000** | | 10 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **61** | | 10 | U | 10 | U | **7800** | | **45000** | | 10 | U | 10 | U |
| < Toluene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Chlorobenzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| < Ethylbenzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| Styrene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| < Total Xylenes | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 50 | | 100 | | 1 | | 1 | |
| < Total BTEX | | 10 | U | 10 | U | 10 | U | 500 | U | 1000 | U | 10 | U | 10 | U |
| * Total Chlorinated VOC | | 99 | | 10 | U | 44 | | 14490 | | 93890 | | 10 | U | 10 | U |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

**TABLE 4-4**
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | MW07-17D | | MW07-18D | | MW07-19S | | MW07-19D | | MW07-20S | | MW07-20D | | MW07-20D/Dup | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 05/22/96 | | 12/14/95 | | 05/29/96 | | 12/19/95 | | 12/14/95 | | 12/14/95 | | 12/14/95 | |
| **Method Blank** | | VBLKEN | | VBLKBF | | VBLKER | | VBLKEQ | | VBLKHV | | VBLKBF | | VBLKBF | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromomethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Vinyl Chloride | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Chloroethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Methylene Chloride | 10 | 1400 | U | 10 | U | 520 | U | 28 | UJ | 10 | U | 10 | U | 10 | U |
| Acetone | 10 | 1000 | U | 25 | U | 500 | U | 38 | UJ | 16 | U | 10 | U | 10 | U |
| Carbon Disulfide | 10 | 1000 | U | 10 | U | 500 | U | **4** | **J** | 10 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1-Dichloroethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | **5700** | | 10 | U | **920** | | **3** | **J** | 10 | U | 10 | U | 10 | U |
| * Chloroform | 10 | **110** | **J** | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,2-Dichloroethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 2-Butanone | 10 | 1000 | U | 10 | U | 500 | U | 10 | UJ | 10 | U | 10 | U | 10 | U |
| * 1,1,1-Trichloroethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromodichloromethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Trichloroethene | 10 | **120000** | | 10 | U | **3400** | | 10 | U | 10 | U | 10 | U | 10 | U |
| Dibromochloromethane | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | **1200** | | 10 | U | **130** | **J** | 10 | U | 10 | U | 10 | U | 10 | U |
| < Benzene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Bromoform | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| 2-Hexanone | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Tetrachloroethene | 10 | **670** | **J** | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **66000** | **J** | 10 | U | **1500** | | 10 | U | 10 | U | 10 | U | 10 | U |
| < Toluene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Chlorobenzene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| < Ethylbenzene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| Styrene | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| < Total Xylenes | 10 | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| DILUTION FACTOR | | 100 | | 1 | | 50 | | 1 | | 1 | | 1 | | 1 | |
| < Total BTEX | | 1000 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 10 | U |
| * Total Chlorinated VOC | | 193680 | | 10 | U | 5950 | | 3 | | 10 | U | 10 | U | 10 | U |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

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J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

## TABLE 4-4
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | MW07-21S | | MW07-21D | | MW07-21R | | MW07-22S | | MW07-22D | | MW07-23S | | MW07-23D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 12/18/95 | | 05/24/96 | | 05/24/96 | | 12/07/95 | | 12/08/95 | | 12/20/95 | | 05/29/96 | |
| **Method Blank** | | VBLKHB | | VBLKGG | | VBLKEO | | | | | | VBLKET | | VBLKER | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| Bromomethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Vinyl Chloride | 10 | 10 | U | **1** | **J** | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Chloroethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| Methylene Chloride | 10 | 10 | U | 10 | U | 700 | U | 15 | U | 13 | U | 10 | U | 50 | U |
| Acetone | 10 | 10 | U | 15 | U | 500 | U | **28** | | 10 | U | **200** | **J** | 76 | U |
| Carbon Disulfide | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,1-Dichloroethene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,1-Dichloroethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,2-Dichloroethene (total) | 10 | **540** | | **35** | | **890** | | 10 | U | 10 | U | 10 | U | **170** | |
| * Chloroform | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,2-Dichloroethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| 2-Butanone | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Carbon Tetrachloride | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| Bromodichloromethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| 1,2-Dichloropropane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Trichloroethene | 10 | **590** | | **82** | | **5800** | | 10 | U | 10 | U | 10 | U | **460** | |
| Dibromochloromethane | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,1,2-Trichloroethane | 10 | **41** | | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | **22** | **J** |
| < Benzene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| Bromoform | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| 2-Hexanone | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Tetrachloroethene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | **310** | | **22** | | **1700** | | 10 | U | 10 | U | 10 | U | **370** | |
| < Toluene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Chlorobenzene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| < Ethylbenzene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| Styrene | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| < Total Xylenes | 10 | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| DILUTION FACTOR | | 1 | | 1 | | 50 | | 1 | | 1 | | 1 | | 5 | |
| < Total BTEX | | 10 | U | 10 | U | 500 | U | 10 | U | 10 | U | 10 | U | 50 | U |
| * Total Chlorinated VOC | | 1481 | | 140 | | 8390 | | 10 | U | 10 | U | 10 | U | 1022 | |

**All data is VALIDATED**

**NOTES:**
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

## TABLE 4-4
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | MW07-24S | | MW07-24D | | MW07-24D/Dup | | MW07-25D | | MW07-25R | | MW07-26S | | MW07-27D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 12/13/95 | | 12/12/95 | | 12/12/95 | | 05/22/96 | | 05/21/96 | | 05/28/96 | | 12/19/95 | |
| **Method Blank** | | VBLKBF | | VBLKHU | | VBLKBF | | VBLKGE | | VBLKGE | | VBLKER | | VBLKEQ | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| Bromomethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * Vinyl Chloride | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | **13** | |
| * Chloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | UJ | 250 | UJ | 100 | U | 10 | U |
| Methylene Chloride | 10 | 10 | U | 24 | UJ | 10 | U | 500 | UJ | 250 | UJ | 120 | U | 29 | UJ |
| Acetone | 10 | 10 | U | 23 | U | 27 | U | 500 | UJ | 270 | UJ | **1800** | | 59 | UJ |
| Carbon Disulfide | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | **3** | **J** |
| * 1,1-Dichloroethene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | **16** | |
| * 1,1-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * 1,2-Dichloroethene (total) | 10 | 10 | U | 10 | U | 10 | U | **61** | **J** | **990** | | **1400** | | **2100** | |
| * Chloroform | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | **17** | |
| * 1,2-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | **30** | **J** | **4** | **J** |
| 2-Butanone | 10 | 10 | U | 10 | U | 10 | U | 500 | UJ | 250 | UJ | 100 | U | 10 | U |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * Carbon Tetrachloride | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| Bromodichloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| 1,2-Dichloropropane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * Trichloroethene | 10 | 10 | U | 10 | U | 10 | U | **3000** | | **2900** | | **23** | **J** | **10000** | |
| Dibromochloromethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * 1,1,2-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | **30** | **J** | **240** | **J** |
| < Benzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| Bromoform | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 10 | U | 10 | U | 500 | UJ | 250 | UJ | 100 | U | 10 | U |
| 2-Hexanone | 10 | 10 | U | 10 | U | 10 | U | 500 | UJ | 250 | UJ | 100 | U | 10 | U |
| * Tetrachloroethene | 10 | 10 | U | 10 | U | 10 | U | **84** | **J** | 250 | U | 100 | U | 10 | U |
| * 1,1,2,2-Tetrachloroethane | 10 | 10 | U | 10 | U | 10 | U | **3600** | **J** | **510** | **J** | 100 | U | **2600** | |
| < Toluene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * Chlorobenzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| < Ethylbenzene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| Styrene | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| < Total Xylenes | 10 | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 50 | | 25 | | 10 | | 1 | |
| < Total BTEX | | 10 | U | 10 | U | 10 | U | 500 | U | 250 | U | 100 | U | 10 | U |
| * Total Chlorinated VOC | | 10 | U | 10 | U | 10 | U | 6745 | | 4400 | | 1483 | | 14990 | |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
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J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

## TABLE 4-4
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | MW07-28D | | MW07-29D | | MW07-29D/Dup | | MW07-30D | | MW07-31I | | Source water | | MW07-32D | MW07-32R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Date Collected** | | 12/19/95 | | 12/14/95 | | 12/14/95 | | 12/20/95 | | 05/30/96 | | | | 02/02/98 | 01/28/98 |
| **Method Blank** | | VBLKEQ | | VBLKBF | | VBLKBF | | VBLKBJ | | VBLKCI | | VBLKHG | | | |
| **ANALYTE** | **CR** | | | | | | | | | | | | | | |
| * Chloromethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| Bromomethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 4U | 4U |
| * Vinyl Chloride | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 3U | 3U |
| * Chloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| Methylene Chloride | 10 | 28 | UJ | 10 | U | 10 | U | 120 | UJ | 1600 | U | 10 | U | 4U | 4U |
| Acetone | 10 | 96 | UJ | **190** | | 150 | U | 280 | UJ | 1000 | U | 10 | U | 6UJ | 6UJ |
| Carbon Disulfide | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 4U | 4U |
| * 1,1-Dichloroethene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 3U | 3U |
| * 1,1-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| * 1,2-Dichloroethene (total) | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 5U | 5U |
| * Chloroform | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| * 1,2-Dichloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| 2-Butanone | 10 | **34** | **J** | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 3U | 3U |
| * 1,1,1-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| * Carbon Tetrachloride | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| Bromodichloromethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| 1,2-Dichloropropane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| cis-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| * Trichloroethene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | **2800** | | 10 | U | 2U | 2U |
| Dibromochloromethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| * 1,1,2-Trichloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| < Benzene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| trans-1,3-Dichloropropene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| Bromoform | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| 4-Methyl-2-Pentanone | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| 2-Hexanone | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| * Tetrachloroethene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | **390** | **J** | 10 | U | 2U | 2U |
| * 1,1,2,2-Tetrachloroethane | 10 | 10 | U | 10 | U | 10 | U | 50 | U | **12000** | | 10 | U | 1U | 1U |
| < Toluene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | **8** |
| * Chlorobenzene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 1U | 1U |
| < Ethylbenzene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| Styrene | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 2U | 2U |
| < Total Xylenes | 10 | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | 6U | 6U |
| DILUTION FACTOR | | 1 | | 1 | | 1 | | 5 | | 100 | | 1 | | | |
| < Total BTEX | | 10 | U | 10 | U | 10 | U | 50 | U | 1000 | U | 10 | U | ND | 8 |
| * Total Chlorinated VOC | | 10 | U | 10 | U | 10 | U | 50 | U | 15190 | | 10 | U | ND | ND |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Volatile Organic Compounds in Ground Water (ug/L)

**TABLE 4-4**
**Site 07, NCBC Davisville, R.I.**

| Sample I.D. | | GW09-16-7 5-9 5 | GW09-16-30-32 | GW09-16B-41-43 | GW09-17A-7-9 | GW09-17A-30-32 | GW09-17A-48-50 |
|---|---|---|---|---|---|---|---|
| **Date Collected** | | 11/13/97 | 11/10/97 | 11/14/97 | 11/21/97 | 11/24/97 | 11/26/97 |
| **Method Blank** | | | | | | | |
| **ANALYTE** | **CR** | | | | | | |
| * Chloromethane | 10 | NA | NA | NA | NA | NA | NA |
| Bromomethane | 10 | NA | NA | NA | NA | NA | NA |
| * Vinyl Chloride | 10 | 3 U | 3 U | 3 UJ | 3 U | 3 U | 3 U |
| * Chloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| Methylene Chloride | 10 | 4 U | 4 U | 4 U | 4 U | 4 U | 4 U |
| Acetone | 10 | **73 J** | **51 J** | 6 UJ | 6 U | **17** | **7** |
| Carbon Disulfide | 10 | NA | NA | NA | NA | NA | NA |
| * 1,1-Dichloroethene | 10 | NA | NA | NA | NA | NA | NA |
| * 1,1-Dichloroethane | 10 | NA | NA | NA | NA | NA | NA |
| * 1,2-Dichloroethene (total) | 10 | 5 U | 5 U | 5 U | 5 U | 5 U | 5 U |
| * Chloroform | 10 | NA | NA | NA | NA | NA | NA |
| * 1,2-Dichloroethane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| 2-Butanone | 10 | 3 U | 3 U | 3 U | 3 U | 3 U | 3 U |
| * 1,1,1-Trichloroethane | 10 | NA | NA | NA | NA | NA | NA |
| * Carbon Tetrachloride | 10 | NA | NA | NA | NA | NA | NA |
| Bromodichloromethane | 10 | NA | NA | NA | NA | NA | NA |
| 1,2-Dichloropropane | 10 | 1 U | 1 U | 1 U | 1 U | 1 U | 1 U |
| cis-1,3-Dichloropropene | 10 | NA | NA | NA | NA | NA | NA |
| * Trichloroethene | 10 | **2** | **3** | 2 U | 2 U | 2 U | 2 U |
| Dibromochloromethane | 10 | NA | NA | NA | NA | NA | NA |
| * 1,1,2-Trichloroethane | 10 | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| < Benzene | 10 | 2 U | 2 U | 2 U | 2 R | 2 UJ | 2 U |
| trans-1,3-Dichloropropene | 10 | NA | NA | NA | NA | NA | NA |
| Bromoform | 10 | NA | NA | NA | NA | NA | NA |
| 4-Methyl-2-Pentanone | 10 | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| 2-Hexanone | 10 | NA | NA | NA | NA | NA | NA |
| * Tetrachloroethene | 10 | 2 U | 2 U | 2 U | 2 U | 2 U | 2 U |
| * 1,1,2,2-Tetrachloroethane | 10 | **4** | **5** | 1 U | 1 U | 1 U | 1 U |
| < Toluene | 10 | 2 U | 2 U | 2 U | 2 R | 2 UJ | 2 U |
| * Chlorobenzene | 10 | 1 U | 1 U | 1 U | 1 R | 1 UJ | 1 U |
| < Ethylbenzene | 10 | 2 U | 2 U | 2 U | 2 R | 2 UJ | 2 U |
| Styrene | 10 | NA | NA | NA | NA | NA | NA |
| < Total Xylenes | 10 | 6 U | 6 U | 6 U | 6 R | 6 UJ | 6 U |
| DILUTION FACTOR | | | | | | | |
| < Total BTEX | | ND | ND | ND | ND | ND | ND |
| * Total Chlorinated VOC | | 6 | 8 | ND | ND | ND | ND |

**All data is VALIDATED**

**NOTES:** All values reported in micrograms per liter (ug/L).

CRQL = contract required quantitation limit
D = analysis at a secondary dilution factor
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
NA = Not included in site specific parameter lits
Refer to IR Program Site 09 Offshore Investigation Report, April 1998.

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | NCBC-NB1 | | NCBC-AH1 | | MW07-01S | | MW07-02S | | MW07-03S | | MW07-03D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/22/95 | | 12/21/95 | | 12/27/95 | | 12/27/95 | | 12/28/95 | | 12/21/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 58.4 | UJ | 20.8 | UJ | 18 | U | 20.7 | U | 20.7 | U | 32.6 | UJ |
| Antimony | 60 | 42 | 42 | U | 42 | U | 42 | UJ | 42 | U | 42 | U | 42 | U |
| Arsenic | 10 | 2 | 4.2 | U | 2 | U | 2 | UJ | 2 | UJ | 5 | U | 2 | U |
| Barium | 200 | 1 | 5.9 | UJ | 6.9 | UJ | 6.1 | U | 25 | U | 9.5 | U | 21.2 | J |
| Beryllium | 5 | 1 | 1 | UJ | 1 | UJ | 1 | U | 1 | U | 1 | U | 1 | UJ |
| Cadmium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | U | 3 | U | 3 | U | 3 | UJ |
| Calcium | 5000 | 11 | 221000 | | 242000 | | 66100 | | 107000 | | 62300 | | 24600 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 8 | U | 8 | U | 8 | U | 8 | UJ |
| Cobalt | 50 | 3 | 3 | UJ | 3 | UJ | 3 | U | 5.6 | U | 3 | U | 3 | UJ |
| Copper | 25 | 4 | 4 | U | 4 | U | 4 | U | 4.7 | U | 4 | U | 5 | U |
| Iron | 100 | 3 | 32 | UJ | 30.8 | UJ | 457 | U | 1330 | J | 17 | U | 2100 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 780000 | | 928000 | | 1000 | U | 1050 | U | 1070 | U | 8070 | |
| Manganese | 15 | 1 | 5.8 | UJ | 1 | UJ | 25.7 | U | 70.5 | | 6.3 | U | 588 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.2 | U | 0.13 | U | 0.13 | U | 0.14 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 12 | U | 12 | U | 12 | U | 12 | UJ |
| Potassium | 5000 | 96 | 259000 | | 286000 | | 1890 | | 2140 | | 2490 | | 7030 | |
| Selenium | 5 | 3 | 3 | UJ | 3.8 | J | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | UJ | 4 | UJ | 4 | U | 4 | U | 4 | U | 4 | UJ |
| Sodium | 5000 | 39 | 6820000 | | 7790000 | | 4750 | | 4370 | | 5470 | | 127000 | |
| Thallium | 10 | 3 | 31.6 | | 32 | | 3 | UJ | 3.2 | U | 3 | UJ | 3 | U |
| Vanadium | 50 | 2 | 2 | UJ | 2 | UJ | 2 | U | 2 | U | 2 | U | 2 | UJ |
| Zinc | 20 | 3 | 7.6 | U | 7 | U | 3.4 | U | 71.5 | | 3 | U | 7.3 | U |
| DILUTION FACTOR | | | 50 | | 50 | | | | | | | | 1 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 27.6 | | 30.7 | | 0.5 | U | 0.5 | U | 0.5 | U | 0.5 | U |
| Total Dissolved Solids | | 1 | 24500 | | 27200 | J | 244 | | 380 | | 244 | | 506 | J |
| Chloride | | 5 | 19400 | | 19400 | | 5.2 | | 70 | | 6.3 | | 87.4 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated
All values reported in micrograms per liter (ug/L)
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-04S | | MW07-04D/Dup | | MW07-04D | | MW07-05S | | MW07-05D | | MW07-05R | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/27/95 | | 12/27/95 | | 12/27/95 | | 12/26/95 | | 12/26/95 | | 12/26/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18 | U | 44.1 | U | 29.5 | U | 40.9 | U | 22.7 | U | 18 | U |
| Antimony | 60 | 42 | 42 | UJ | 42 | UJ | 42 | UJ | 42 | UJ | 42 | UJ | 42 | UJ |
| Arsenic | 10 | 2 | 3.2 | U | 2 | UJ | 2.3 | U | 2 | UJ | 2.7 | U | 3.6 | U |
| Barium | 200 | 1 | 3.5 | U | 20.2 | U | 23.1 | U | 9.4 | U | 14.6 | U | 15.2 | U |
| Beryllium | 5 | 1 | 3.5 | | 1 | U | 1 | U | 1 | U | 1 | U | 1 | U |
| Cadmium | 5 | 3 | 3 | U | 3 | U | 3 | U | 3 | U | 3 | U | 3 | U |
| Calcium | 5000 | 11 | 109000 | | 13100 | | 14400 | | 104000 | | 18400 | | 64400 | |
| Chromium | 10 | 8 | 8 | U | 8 | U | 8 | U | 8 | U | 8 | U | 8 | U |
| Cobalt | 50 | 3 | 3 | U | 6 | U | 6.3 | U | 3 | U | 12.8 | U | 7 | U |
| Copper | 25 | 4 | 4.3 | U | 4 | U | 6.9 | U | 4 | U | 4 | U | 4.8 | U |
| Iron | 100 | 3 | 21.4 | U | 368 | U | 398 | U | 2220 | J | 290 | U | 1360 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 1260 | U | 3600 | U | 4010 | U | 1690 | U | 7392 | U | 23100 | |
| Manganese | 15 | 1 | 3.3 | U | 379 | | 423 | | 41.4 | | 775 | | 808 | |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.14 | U | 0.13 | U | 0.13 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | U | 12 | U | 12.5 | U | 12 | U | 15.7 | U | 12 | U |
| Potassium | 5000 | 96 | 3040 | | 1940 | | 2210 | | 7330 | | 3150 | | 8890 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | U | 4 | U | 4 | U | 4 | U | 4 | U |
| Sodium | 5000 | 39 | 5790 | | 192000 | | 210000 | | 9960 | | 96100 | | 295000 | |
| Thallium | 10 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Vanadium | 50 | 2 | 2 | U | 2 | U | 2.5 | U | 2 | U | 2 | U | 2 | U |
| Zinc | 20 | 3 | 3 | U | 3 | U | 7.1 | U | 4.1 | U | 7.6 | U | 19.9 | U |
| DILUTION FACTOR | | | | | | | | | | | | | | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 0.5 | U | 0.59 | | 0.58 | | 0.5 | U | 0.5 | | 1.06 | |
| Total Dissolved Solids | | 1 | 415 | | 709 | | 709 | | 386 | | 405 | | 1170 | |
| Chloride | | 5 | 11 | | 300 | | 297 | | 13 | | 123 | | 505 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated
All values reported in micrograms per liter (ug/L)
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-06S | | MW07-07S | | MW07-08S | | MW07-09D | | MW07-09R | | MW07-10S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/14/95 | | 12/21/95 | | 12/20/95 | | 12/21/95 | | 12/20/95 | | 12/22/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18 | U | 91.1 | UJ | 52.3 | UJ | 18 | UJ | 48.6 | UJ | 32 | UJ |
| Antimony | 60 | 42 | 42 | UJ | 42 | U | 42 | U | 42 | U | 42 | U | 42 | U |
| Arsenic | 10 | 2 | 2.1 | J | 2 | U | 2 | U | 2.5 | U | 2.4 | U | 2.2 | U |
| Barium | 200 | 1 | 16.4 | J | 6.2 | UJ | 11.6 | UJ | 32.2 | J | 32 | J | 3.6 | UJ |
| Beryllium | 5 | 1 | 1 | U | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Cadmium | 5 | 3 | 3 | U | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Calcium | 5000 | 11 | 81600 | | 5340 | | 71900 | | 68200 | | 118000 | | 247000 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ |
| Cobalt | 50 | 3 | 3 | U | 3 | UJ | 3 | UJ | 4.1 | J | 151 | J | 3 | UJ |
| Copper | 25 | 4 | 4.5 | J | 4 | U | 7.5 | U | 4 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 1410 | | 46.4 | UJ | 272 | J | 7520 | J | 15500 | J | 716 | J |
| Lead | 3 | 1 | 1 | UJ | 1.3 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 1730 | J | 1100 | J | 1720 | J | 160000 | | 355000 | | 8770 | |
| Manganese | 15 | 1 | 74.4 | J | 7.1 | J | 7.9 | J | 595 | J | 767 | J | 171 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.14 | U | 0.13 | U | 0.13 | U | 0.14 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ |
| Potassium | 5000 | 96 | 3590 | J | 1340 | U | 3800 | J | 60700 | | 154000 | | 10000 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | UJ | 4 | UJ | 4 | UJ | 4 | UJ | 4 | UJ |
| Sodium | 5000 | 39 | 8090 | | 6540 | | 8880 | | 1520000 | | 4530000 | | 29900 | |
| Thallium | 10 | 3 | 3.9 | J | 3 | U | 3 | U | 7.4 | J | 16 | | 3 | U |
| Vanadium | 50 | 2 | 2 | U | 2 | UJ | 2 | UJ | 2 | UJ | 2 | UJ | 2 | UJ |
| Zinc | 20 | 3 | 8.1 | U | 5 | U | 6.4 | U | 9.6 | U | 56.9 | | 4.7 | U |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 50 | | 50 | | 1 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 0.5 | U | 0.5 | U | 0.5 | U | 5.38 | | 15.2 | | 0.58 | |
| Total Dissolved Solids | | 1 | 350 | | 10 | UJ | 185 | | 5700 | J | 16400 | | 819 | |
| Chloride | | 5 | 8.2 | | 9.8 | | 3.7 | | 2940 | | 9140 | | 31.4 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-10D | | MW07-11D | | MW07-12D | | MW07-13S | | MW07-13D | | MW07-14D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/27/95 | | 12/19/95 | | 12/20/95 | | 12/18/95 | | 12/18/95 | | 12/26/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18.8 | U | 40.8 | UJ | 31.4 | UJ | 18 | U | 18 | U | 24.3 | U |
| Antimony | 60 | 42 | 42 | UJ | 42 | U | 42 | U | 42 | UJ | 42 | UJ | 42 | UJ |
| Arsenic | 10 | 2 | 3.1 | U | 4.4 | U | 5.8 | U | 8 | J | 2 | U | 4.3 | U |
| Barium | 200 | 1 | 19.1 | U | 19.8 | J | 30.1 | J | 2.4 | U | 12.7 | U | 11.1 | U |
| Beryllium | 5 | 1 | 1 | U | 1 | UJ | 1 | UJ | 1 | U | 1 | U | 1 | U |
| Cadmium | 5 | 3 | 3 | U | 3 | UJ | 3 | UJ | 3 | U | 3 | U | 3 | U |
| Calcium | 5000 | 11 | 6230 | | 125000 | | 89600 | | 245000 | | 54500 | | 15600 | |
| Chromium | 10 | 8 | 8 | U | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | U |
| Cobalt | 50 | 3 | 8.7 | U | 5.5 | J | 32.1 | J | 3 | U | 3 | U | 7.5 | U |
| Copper | 25 | 4 | 4 | U | 4 | U | 4.5 | U | 4 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 1420 | J | 10000 | J | 46300 | J | 22900 | | 302 | U | 5720 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 10200 | | 378000 | | 176000 | | 16300 | | 31200 | | 4120 | U |
| Manganese | 15 | 1 | 244 | | 553 | J | 2890 | J | 1270 | J | 1550 | J | 766 | |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.15 | J | 0.13 | U | 0.13 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | U | 12.4 | UJ | 56 | UJ | 12 | UJ | 12 | UJ | 12 | U |
| Potassium | 5000 | 96 | 7770 | | 141000 | | 37000 | | 9650 | | 29300 | | 3290 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | UJ | 4 | UJ | 4 | U | 4 | U | 4 | U |
| Sodium | 5000 | 39 | 191000 | | 3590000 | | 945000 | | 61800 | | 356000 | | 34500 | |
| Thallium | 10 | 3 | 3 | UJ | 17.6 | | 3 | U | 3 | U | 3 | U | 3 | UJ |
| Vanadium | 50 | 2 | 2 | U | 2 | UJ | 2 | UJ | 2 | U | 2 | U | 2 | U |
| Zinc | 20 | 3 | 16.8 | U | 16.5 | U | 79.5 | | 4.3 | U | 3 | U | 3 | U |
| DILUTION FACTOR | | | | | 50 | | 50 | | 1 | | 50 | | | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 0.61 | | 13.1 | | 3.67 | | 0.77 | | 1.39 | | 0.5 | U |
| Total Dissolved Solids | | 1 | 776 | | 13500 | | 3820 | | 1220 | J | 1610 | J | 162 | |
| Chloride | | 5 | 176 | | 7470 | | 1670 | | 74.1 | | 404 | | 34.6 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:** All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-15D | | MW07-15D/Dup | | MW07-16D | | MW07-16R | | MW07-17D | | MW07-18D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/28/95 | | 12/28/95 | | 12/14/95 | | 12/15/95 | | 12/28/95 | | 12/14/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18 | U | 18 | U | 18 | U | 18 | U | 20.2 | U | 18 | U |
| Antimony | 60 | 42 | 42 | U | 42 | U | 42 | UJ | 42 | UJ | 42 | U | 42 | UJ |
| Arsenic | 10 | 2 | 2 | UJ | 3.4 | U | 2 | U | 4.2 | J | 2 | UJ | 2 | U |
| Barium | 200 | 1 | 16.5 | U | 17.6 | U | 34 | J | 123 | J | 23.9 | U | 36.7 | J |
| Beryllium | 5 | 1 | 1 | U | 1 | U | 1 | U | 1 | U | 1 | U | 1 | U |
| Cadmium | 5 | 3 | 3 | U | 3 | U | 3 | U | 3 | U | 3 | U | 3 | U |
| Calcium | 5000 | 11 | 18400 | | 19500 | | 266000 | | 275000 | | 37800 | | 237000 | |
| Chromium | 10 | 8 | 8 | U | 8 | U | 8 | UJ | 8 | UJ | 8 | U | 8 | UJ |
| Cobalt | 50 | 3 | 13.9 | U | 13.7 | U | 3 | U | 8 | J | 4.6 | U | 3 | U |
| Copper | 25 | 4 | 4 | U | 4 | U | 7.2 | J | 4 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 2270 | J | 2450 | J | 7410 | | 1290 | | 7180 | J | 40900 | |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 6940 | U | 7343 | U | | | 753000 | | 16700 | | 670000 | |
| Manganese | 15 | 1 | 1280 | | 1360 | | 3510 | J | 15500 | J | 1080 | | 1600 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.13 | U | 0.14 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 14.5 | U | 13.9 | U | 12 | UJ | 12 | UJ | 12 | U | 12 | UJ |
| Potassium | 5000 | 96 | 3880 | | 4110 | | 262000 | | 203000 | | 7370 | | 199000 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 5.2 | J | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | U | 4 | U | 4 | U | 4.4 | U | 4 | U |
| Sodium | 5000 | 39 | 78200 | | 83100 | | 8240000 | | 7730000 | | 233000 | | 6560000 | |
| Thallium | 10 | 3 | 3 | UJ | 3 | UJ | 27.8 | | 29 | | 3 | UJ | 20.1 | |
| Vanadium | 50 | 2 | 2 | U | 2 | U | 2 | U | 2 | U | 2 | U | 2 | U |
| Zinc | 20 | 3 | 4.6 | U | 4.4 | U | 3 | U | 3 | U | 3.5 | U | 5.1 | U |
| DILUTION FACTOR | | | | | | | 1 | | 1 | | | | 1 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 0.5 | U | 0.5 | U | 29.3 | | 29.8 | | 0.81 | | 23.8 | |
| Total Dissolved Solids | | 1 | 392 | | 384 | | 29100 | | 29600 | | 912 | | 23200 | |
| Chloride | | 5 | 97.6 | | 97.9 | | 16800 | | 16800 | | 355 | | 13400 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-19S | | MW07-19D | | MW07-20S | | MW07-20D | | MW07-21S | | MW07-20D/Dup | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/19/95 | | 12/19/95 | | 12/14/95 | | 12/14/95 | | 12/18/95 | | 12/14/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18 | U | 71.6 | UJ | 39.9 | U | 18 | U | 22.2 | U | 18 | U |
| Antimony | 60 | 42 | 42 | UJ | 42 | U | 42 | UJ | 42 | UJ | 42 | UJ | 42 | UJ |
| Arsenic | 10 | 2 | 3.8 | J | 2 | U | 2 | U | 2.4 | J | 2 | U | 4.4 | J |
| Barium | 200 | 1 | 10.5 | U | 42.5 | J | 20.8 | J | 26.1 | J | 6.3 | U | 28 | J |
| Beryllium | 5 | 1 | 1 | U | 1 | UJ | 1 | U | 1 | U | 1 | U | 1 | U |
| Cadmium | 5 | 3 | 3 | U | 3 | UJ | 3 | U | 3 | U | 3 | U | 3 | U |
| Calcium | 5000 | 11 | 99400 | | 113000 | | 216000 | | 377000 | | 166000 | | 388000 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ |
| Cobalt | 50 | 3 | 3 | U | 3 | UJ | 3 | U | 3.6 | J | 3 | U | 3.5 | J |
| Copper | 25 | 4 | 4 | U | 4.6 | U | 12.1 | J | 4 | U | 4.4 | J | 5.7 | J |
| Iron | 100 | 3 | 1650 | | 6810 | J | 2470 | | 11200 | | 1310 | | 11500 | |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 40600 | | 255000 | | 627000 | | 742000 | | 71000 | | 765000 | |
| Manganese | 15 | 1 | 3410 | J | 377 | J | 342 | J | 2280 | J | 3830 | J | 2340 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.14 | U | 0.14 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ |
| Potassium | 5000 | 96 | 23400 | | 110000 | | 208000 | | 201000 | | 33500 | | 208000 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 5.3 | J | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | UJ | 4 | U | 4 | U | 4 | U | 4 | U |
| Sodium | 5000 | 39 | 238000 | | 3220000 | | 6030000 | | 7210000 | | 390000 | J | 7850000 | |
| Thallium | 10 | 3 | 3.5 | J | 13 | | 25.1 | | 27.7 | | 3 | U | 31.6 | |
| Vanadium | 50 | 2 | 2 | U | 2 | UJ | 2 | U | 2 | U | 2 | U | 2 | U |
| Zinc | 20 | 3 | 10.1 | U | 3.7 | U | 5.6 | U | 9.4 | U | 3 | U | 9.6 | U |
| DILUTION FACTOR | | | 1 | | 50 | | 1 | | 1 | | 1 | | 1 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 1.09 | | 11.6 | | 23.7 | | 29 | | 1.62 | | 27.9 | |
| Total Dissolved Solids | | 1 | 1430 | | 11600 | | 23300 | | 28200 | | 1940 | J | 28000 | |
| Chloride | | 5 | 269 | | 6590 | | 13500 | | 15700 | | 562 | | 16000 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-21D | | MW07-21R | | MW07-22S | | MW07-22D | | MW07-23S | | MW07-23D | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/15/95 | | 12/18/95 | | 12/07/95 | | 12/08/95 | | 12/20/95 | | 12/20/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 34.7 | U | 18 | U | 42 | U | 45.2 | U | 65.1 | UJ | 18 | UJ |
| Antimony | 60 | 42 | 42 | UJ | 42 | UJ | 42 | U | 42 | U | 42 | U | 42 | U |
| Arsenic | 10 | 2 | 2 | U | 2 | U | 2 | UJ | 2 | UJ | 7.7 | U | 4.1 | U |
| Barium | 200 | 1 | 24.8 | J | 20.2 | J | 8.6 | U | 9.4 | U | 19 | J | 88.5 | J |
| Beryllium | 5 | 1 | 1 | U | 1 | U | 1 | U | 1 | U | 1 | UJ | 1 | UJ |
| Cadmium | 5 | 3 | 3 | U | 3 | U | 3 | U | 3 | U | 3 | UJ | 3 | UJ |
| Calcium | 5000 | 11 | 133000 | | 120000 | | 4920 | | 9710 | | 108000 | | 51400 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 14.6 | U | 8 | UJ | 8 | UJ | 8 | UJ |
| Cobalt | 50 | 3 | 3 | U | 29.1 | J | 3 | U | 113 | | 3 | UJ | 3 | UJ |
| Copper | 25 | 4 | 4.7 | J | 4 | U | 4 | U | 5.6 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 6270 | | 1720 | | 49.6 | U | 36 | U | 3640 | J | 8640 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 200000 | | 119000 | | 776 | | 2170 | | 84900 | | 162000 | |
| Manganese | 15 | 1 | 458 | J | 2290 | J | 29.4 | J | 123 | J | 546 | J | 1240 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.13 | U | 0.13 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 19 | J | 12 | UJ | 12 | UJ | 12 | UJ |
| Potassium | 5000 | 96 | 97300 | | 55500 | | 1170 | | 2610 | | 27300 | | 87300 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4.1 | U | 4 | U | 4 | U | 4 | UJ | 4 | UJ |
| Sodium | 5000 | 39 | 3030000 | | 2180000 | | 8100 | | 8880 | | 852000 | | 2300000 | |
| Thallium | 10 | 3 | 8 | J | 9.1 | J | 5 | U | 3 | UJ | 5.4 | J | 7.2 | J |
| Vanadium | 50 | 2 | 2 | U | 2 | U | 2 | U | 2 | U | 3.1 | UJ | 2 | UJ |
| Zinc | 20 | 3 | 4.5 | U | 12.8 | U | 3 | U | 10.9 | U | 3.7 | U | 3 | U |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 50 | | 50 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 9.72 | | 7.61 | | 0.5 | U | 0.5 | U | 3 | | 7.6 | |
| Total Dissolved Solids | | 1 | 9840 | | 7770 | J | 88.8 | | 109 | | 3190 | | 8120 | |
| Chloride | | 5 | 5120 | | 4140 | | 5.4 | | 12.1 | | 1370 | | 4170 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
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All values reported in micrograms per liter (ug/L)
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-24S | | MW07-24D | | MW07-24D/Dup | | MW07-25D | | MW07-25R | | MW07-26S | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/13/95 | | 12/12/95 | | 12/12/95 | | 12/26/95 | | 12/22/95 | | 12/22/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 18 | U | 44.3 | U | 77.4 | U | 18 | U | 33.3 | UJ | 18 | UJ |
| Antimony | 60 | 42 | 42 | UJ | 42 | UJ | 42 | UJ | 42 | UJ | 42 | U | 42 | U |
| Arsenic | 10 | 2 | 2.8 | J | 2 | U | 2 | U | 2 | UJ | 2 | U | 46.9 | |
| Barium | 200 | 1 | 51.8 | J | 67.2 | J | 68.2 | J | 20.6 | U | 57.4 | J | 51.1 | J |
| Beryllium | 5 | 1 | 1 | U | 1 | U | 1 | U | 1 | U | 1 | UJ | 1 | UJ |
| Cadmium | 5 | 3 | 3 | U | 3 | U | 3 | U | 3 | U | 3 | UJ | 3 | UJ |
| Calcium | 5000 | 11 | 270000 | | 290000 | | 270000 | | 15900 | | 70400 | | 72600 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 8 | UJ | 8 | U | 8 | UJ | 8 | UJ |
| Cobalt | 50 | 3 | 3 | U | 3 | U | 3 | U | 14.6 | U | 5 | J | 3 | UJ |
| Copper | 25 | 4 | 5 | J | 4 | U | 4 | U | 4 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 8050 | | 13200 | | 12300 | | 3350 | J | 265 | J | 53100 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 764000 | | 478000 | | 441000 | | 6040 | U | 11200 | | 142000 | |
| Manganese | 15 | 1 | 367 | J | 1190 | J | 1210 | J | 900 | | 829 | J | 2040 | J |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.13 | U | 0.14 | U | 0.13 | U | 0.13 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 12 | UJ | 12 | U | 12 | UJ | 12 | UJ |
| Potassium | 5000 | 96 | 239000 | | 158000 | | 146000 | | 3190 | | 4920 | J | 72600 | |
| Selenium | 5 | 3 | 3 | J | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | U | 4 | U | 4 | U | 4 | U | 4 | UJ | 4 | UJ |
| Sodium | 5000 | 39 | 7620000 | | 4740000 | | 4330000 | | 70100 | | 107000 | | 1380000 | |
| Thallium | 10 | 3 | 29.3 | | 19.4 | | 17 | | 3 | UJ | 3 | U | 5.7 | J |
| Vanadium | 50 | 2 | 2 | U | 2 | U | 2 | U | 2 | U | 2 | UJ | 2 | UJ |
| Zinc | 20 | 3 | 3.4 | U | 3.9 | U | 3.6 | U | 5.4 | U | 13.4 | U | 3 | U |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | | | 1 | | 50 | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 28.3 | | 16.3 | | 16.4 | | 0.5 | U | 0.5 | U | 4.5 | |
| Total Dissolved Solids | | 1 | 27600 | | 17400 | | 17100 | | 360 | U | 1110 | | 4650 | |
| Chloride | | 5 | 15400 | | 9370 | | 9970 | | 82 | | 138 | | 1990 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
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All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | MW07-27D | | MW07-28D | | MW07-29D | | MW07-29D/Dup | | MW07-30D | | MW07-311 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date Collected | | | 12/19/95 | | 12/19/95 | | 12/14/95 | | 12/14/95 | | 12/20/95 | | 12/27/95 | |
| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
| Aluminum | 200 | 18 | 66.8 | UJ | 73.4 | UJ | 18 | U | 18 | U | 202 | UJ | 18 | U |
| Antimony | 60 | 42 | 42 | U | 42 | U | 42 | UJ | 42 | UJ | 42 | U | 42 | U |
| Arsenic | 10 | 2 | 2.2 | U | 4.7 | U | 2 | U | 4 | J | 2 | U | 2 | UJ |
| Barium | 200 | 1 | 9.1 | UJ | 100 | J | 56.8 | J | 66.1 | J | 41 | J | 15.4 | U |
| Beryllium | 5 | 1 | 1 | UJ | 1 | UJ | 1 | U | 1 | U | 1 | UJ | 1 | U |
| Cadmium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | U | 3 | U | 3 | UJ | 3 | U |
| Calcium | 5000 | 11 | 12900 | | 98300 | | 293000 | | 333000 | | 277000 | | 43900 | |
| Chromium | 10 | 8 | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | UJ | 8 | U |
| Cobalt | 50 | 3 | 3 | UJ | 4.8 | J | 10.6 | J | 15.6 | J | 4.3 | J | 4.1 | U |
| Copper | 25 | 4 | 4 | U | 4 | U | 4 | U | 4 | U | 4 | U | 4 | U |
| Iron | 100 | 3 | 354 | J | 31300 | J | 25200 | | 30000 | | 12000 | J | 1110 | J |
| Lead | 3 | 1 | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ | 1 | UJ |
| Magnesium | 5000 | 33 | 9310 | | 155000 | | 504000 | | 577000 | | 709000 | | 3420 | U |
| Manganese | 15 | 1 | 81.5 | J | 1560 | J | 2310 | J | 2700 | J | 1280 | J | 851 | |
| Mercury | 0.2 | 0.1 | 0.13 | U | 0.13 | U | 0.1 | U | 0.13 | U | 0.14 | J | 0.13 | U |
| Nickel | 40 | 12 | 12 | UJ | 12 | UJ | 12 | UJ | 12 | UJ | 12.8 | UJ | 22.6 | U |
| Potassium | 5000 | 96 | 26100 | | 43800 | | 147000 | | 169000 | | 221000 | | 3670 | |
| Selenium | 5 | 3 | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ | 3 | UJ |
| Silver | 10 | 4 | 4 | UJ | 4 | UJ | 4 | U | 4 | U | 4 | UJ | 4 | U |
| Sodium | 5000 | 39 | 438000 | | 1410000 | | 5080000 | | 5880000 | | 6070000 | | 15400 | |
| Thallium | 10 | 3 | 3.8 | J | 6.4 | J | 17.4 | | 21.4 | | 26.6 | | 3 | UJ |
| Vanadium | 50 | 2 | 2 | UJ | 2 | UJ | 2 | U | 2 | U | 2 | UJ | 2 | U |
| Zinc | 20 | 3 | 3.8 | U | 4.4 | U | 4.2 | U | 3.3 | U | 12.3 | U | 3 | U |
| DILUTION FACTOR | | | 50 | | 50 | | 1 | | 1 | | 50 | | | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 1.2 | | 4.72 | | 21.8 | | 21 | | 23.5 | | 0.5 | U |
| Total Dissolved Solids | | 1 | 1340 | | 5090 | | 21100 | | 21400 | | 24300 | | 226 | |
| Chloride | | 5 | 471 | | 2630 | | 11400 | | 11900 | | 15000 | | 11.7 | |
| DILUTION FACTOR | | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | |

**All data is VALIDATED**

**NOTES:**
All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. / Date Collected / ANALYTE | CRQL | MDL/ID | Source water | MW07-32D 02/02/98 | MW07-32R 01/28/98 | GW09-16-7 5-9 5 11/13/97 | GW09-16-30-32 11/10/97 | GW09-16B-41-43 11/14/97 | GW09-17A-7-9 11/21/97 |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 200 | 18 | 54.7 | NA | NA | **43 B** | **74.6 B** | **75.6 B** | **303** |
| Antimony | 60 | 42 | 42 U | NA | NA | 1.6 U | 1.2 U | **1.2 B** | **4.7 B** |
| Arsenic | 10 | 2 | 2 UJ | NA | NA | 3.1 U | 3.1 U | **3.6 B** | **6 B** |
| Barium | 200 | 1 | 9.8 | NA | NA | **41.1 B** | **123 B** | **13.5 B** | **58.6 B** |
| Beryllium | 5 | 1 | 1 U | NA | NA | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| Cadmium | 5 | 3 | 3 U | NA | NA | 0.4 U | 0.4 U | 0.4 U | **2.6 B** |
| Calcium | 5000 | 11 | 9610 | NA | NA | NA | NA | NA | NA |
| Chromium | 10 | 8 | 8 U | NA | NA | 2.8 U | 2.8 U | 2.8 U | **4.4 J** |
| Cobalt | 50 | 3 | 3 U | NA | NA | 6.7 U | 6.7 U | 6.7 U | 6.7 U |
| Copper | 25 | 4 | 8.6 | NA | NA | 2.6 U | 2.6 U | 2.6 U | 14.8 U |
| Iron | 100 | 3 | 200 J | NA | NA | NA | NA | NA | NA |
| Lead | 3 | 1 | 1.7 J | NA | NA | 0.6 U | 0.6 UJ | 0.6 UJ | **4.1** |
| Magnesium | 5000 | 33 | 1900 | NA | NA | NA | NA | NA | NA |
| Manganese | 15 | 1 | 162 | NA | NA | **463** | **936** | **400** | **467** |
| Mercury | 0.2 | 0.1 | 0.13 U | NA | NA | 0.2 U | 0.2 U | 0.2 U | 0.2 U |
| Nickel | 40 | 12 | 12 U | NA | NA | 10.6 U | **23.3 B** | 10.6 U | **20.9 B** |
| Potassium | 5000 | 96 | 1880 | NA | NA | NA | NA | NA | NA |
| Selenium | 5 | 3 | 3 UJ | NA | NA | NA | NA | NA | NA |
| Silver | 10 | 4 | 4 U | NA | NA | 0.7 U | 0.7 U | **0.91 B** | 0.7 UJ |
| Sodium | 5000 | 39 | 19200 | NA | NA | NA | NA | NA | NA |
| Thallium | 10 | 3 | 3 UJ | NA | NA | 1 UJ | 1 UJ | 1 UJ | 10 UJ |
| Vanadium | 50 | 2 | 2 U | NA | NA | 3 U | 3 U | 3 U | 3 U |
| Zinc | 20 | 3 | 20 | NA | NA | 16.2 U | 26.8 U | 18.2 U | **76.6 B** |
| DILUTION FACTOR | | | | | | | | | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| ANALYTE | CRQL | MDL/ID | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Salinity | | 0.5 | 0.5 U | 28.4 | 28 | 4.2 | 1.9 | 1.3 | 14.8 |
| Total Dissolved Solids | | 1 | 145 | NA | NA | NA | NA | NA | NA |
| Chloride | | 5 | 37.4 | NA | NA | NA | NA | NA | NA |
| DILUTION FACTOR | | | 1 | | | | | | |

**All data is VALIDATED**

**NOTES:** All Data in this table has been Validated.
All values reported in micrograms per liter (ug/L).
CRQL = contract required quantitation limit
MDL/IDL = method detection limit / instrument detection limit
U = unqualified (below laboratory detection limit)
J = estimated value below sample qualification limit (SQL)
NA = Not included in site specific parameter list
Refer to IR Program Site 09 Offshore Investigation Report, April 1998

# Summary of Dissolved Metals and Wet Chemistry Detected in Ground-Water Samples (ug/L)

**TABLE 4-5**
**Site 07, NCBC Davisville, R.I.**
Calf Pasture Point
**METALS (UG/L)**

| Sample I.D. | | | GW09-17A-30-32 | GW09-17A-48-50 |
|---|---|---|---|---|
| Date Collected | | | 11/24/97 | 11/26/97 |
| **ANALYTE** | **CRQL** | **MDL/ID** | | |
| Aluminum | 200 | 18 | **439** | **120 B** |
| Antimony | 60 | 42 | **3.2 J** | 1.2 UJ |
| Arsenic | 10 | 2 | **9 B** | **4.1 B** |
| Barium | 200 | 1 | **74.5 B** | **57.5 B** |
| Beryllium | 5 | 1 | 0.2 U | 0.2 U |
| Cadmium | 5 | 3 | 0.4 U | 0.4 U |
| Calcium | 5000 | 11 | NA | NA |
| Chromium | 10 | 8 | 2.8 UJ | 11.6 U |
| Cobalt | 50 | 3 | **7.7 B** | 6.7 U |
| Copper | 25 | 4 | 8 U | 7 U |
| Iron | 100 | 3 | NA | NA |
| Lead | 3 | 1 | **0.73 B** | 0.6 U |
| Magnesium | 5000 | 33 | NA | NA |
| Manganese | 15 | 1 | **2140** | **1070** |
| Mercury | 0.2 | 0.1 | 0.2 U | 0.2 U |
| Nickel | 40 | 12 | **41.8** | **59.7** |
| Potassium | 5000 | 96 | NA | NA |
| Selenium | 5 | 3 | NA | NA |
| Silver | 10 | 4 | 0.7 UJ | 0.7 UJ |
| Sodium | 5000 | 39 | NA | NA |
| Thallium | 10 | 3 | 10 UJ | 1 UJ |
| Vanadium | 50 | 2 | 3 U | 3 U |
| Zinc | 20 | 3 | 37.6 U | 27.1 U |
| DILUTION FACTOR | | | | |

**AQUEOUS WET CHEMISTRY**
(ppm except salinity in ppt (parts per thousand))

| **ANALYTE** | **CRQL** | **MDL/ID** | | |
|---|---|---|---|---|
| Salinity | | 0.5 | 23.7 | 8 |
| Total Dissolved Solids | | 1 | NA | NA |
| Chloride | | 5 | NA | NA |
| DILUTION FACTOR | | | | |

**All data is VALIDATED**

# TABLE 5-1

## PHYSICAL AND CHEMICAL PROPERTIES OF VOC
IR PROGRAM SITE 07 - CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Compound | Molecular Weight | Specific Density @ 20°C | Octanol-Water Partition Coefficient (log $K_{ow}$) | Solubility in Water @ 25°C (mg/L) | Vapor Pressure @ 20°C (mmHg) | Henry's Law Constant (atm-m$^3$/mol) | Organic Carbon Adsorption Coefficient (log $K_{oc}$) |
|---|---|---|---|---|---|---|---|
| 1,2-DCA | 98.96 | 1 235 | 1.45-1 48 | 7986-8650 | 64 | $9.10 \times 10^{-4}$ - $1.31 \times 10^{-3}$ | 1.15-1.28 |
| 1,1,2-TCA | 133.40 | 1 434-1 441 | 2 18 | 4500 | 19 | $7 40 \times 10^{-4}$ - $9 09 \times 10^{-4}$ | 1.75 |
| 1,1,2,2-PCA | 167 85 | 1 5953 | 2 39-2.56 | 2900-2970 | 5.8 | $3 8 \times 10^{-4}$ - $4 56 \times 10^{-4}$ | 1.66-2.07 |
| 1,2-Dichloropropane | 112.99 | 1 158-1 560 | 2.28 | 2800 | 42 | $2.30 \times 10^{-3}$ - $2 94 \times 10^{-3}$ | 1 43-1.71 |
| 1,2-DCE (trans) | 96.94 | 1.2565 | 2.09 | 6300 | 265 | $5 32 \times 10^{-3}$ - $7.20 \times 10^{-3}$ | 1.77 |
| Acetone | 58.08 | 0.7899-0.7912 | -0 24 | miscible | 180 | $3.97 \times 10^{-5}$ | -0 43 |
| Benzene | 78 11 | 0.8765-0.8789 | 1.56-2.15 | 1696-1860 | 76 | $5.38 \times 10^{-3}$ - $5 48 \times 10^{-3}$ | 1 69-2 00 |
| Chlorobenzene | 112 56 | 1.1058 | 2.71-2.98 | 295-503 | 9 | $3 60 \times 10^{-3}$ - $4 45 \times 10^{-3}$ | 1.68-2 52 |
| TCE | 131.39 | 1 464 | 2 29-3 30 | 1100-1470 | 57 8 | $9 10 \times 10^{-3}$ - $1 17 \times 10^{-3}$ | 1 81-2.10 |
| Toluene | 92.14 | 0 8666-0.86697 | 2 11-2.80 | 490-627 | 22 | $6.70 \times 10^{-3}$ | 2 06-2 18 |
| Vinyl Chloride | 62.50 | 0.9106 | 0.60 | 1100-2700 | 2530 | $2.20 \times 10^{-2}$ - 2.78 | 0.39 |

NOTES· Modified from Ground Water Chemicals Desk Reference (Montgomery and Welkom, 1990)

# TABLE 5-2

## ENVIRONMENTAL FATE PARAMETERS OF VOC
IR PROGRAM SITE 07-CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Compound | Bioconcentration Potential | Mobility Potential in Soil | Biodegradability Soil | Biodegradability Ground Water | Environmental Fate |
|---|---|---|---|---|---|
| 1,2 -DCA | very low | high | slow | slow | V, P |
| 1,2 -DCE | very low | high | slow | slow | V, Ph, P |
| 1,1,2 -TCA | low | high | very slow | very slow | V, P |
| 1,1,2,2 -PCA | low | high | moderate | moderate | V, B, P |
| 1,2 -Dichloropropane | very low | very high | very slow | very slow | V, P |
| Acetone | very low | very high | rapid | rapid | V, B, P |
| Benzene | very low | high | moderate | moderate | V, B, Ph, P |
| Chlorobenzene | low | moderate | slow | slow | V, P |
| TCE | low | high | very slow | very slow | V, B, P |
| Toluene | low | moderate | moderate | moderate | V, B, Ph, P |
| Vinyl Chloride | very low | very high | slow | slow | V, P |

NOTES: V - Volatilization
B - Biodegredation
Ph - Photodegradation
P - Percolation to ground water

# TABLE 5-3
## COMPARISON OF CALCULATED FLUX RATES FOR VOC PRESENT IN THE VADOSE ZONE
IR PROGRAM SITE 07 - CALF PASTURE POINT, PHASE III RI, NCBC DAVISVILLE, RHODE ISLAND

| Chemical | Max. Soil Concentration[1] ($\mu$g/kg) | Freq | Steady State Flux Rate[1] (g/m$^2$-sec) |
|---|---|---|---|
| ***Ketone VOC*** | | | |
| Acetone | 5,500[2] | 2/7 | 5.47E-10 |

Notes:
(1) The ground-water table varies over the areal extent of Calf Pasture Point and fluctuates due to tidal influences. The values in this table are based upon a water table at 6 ft BGS which is representative of the typical water table elevation in the area of concern.
(2) The detected concentrations of acetone in the soil samples from the vadose zone at Site 07 were likely introduced by the decontamination procedures which were employed during sampling.

# TABLE 5-4

## ESTIMATED HALF-LIVES OF VOC IN VARIOUS MEDIA
IR PROGRAM SITE 07 - CALF PASTURE POINT, PHASE III RI
NCBC DAVISVILLE, RHODE ISLAND

| Compound | Soil | Air | Surface Water | Ground Water | Aerobic Aqueous Biodegradation | Anaerobic Aqueous Biodegradation |
|---|---|---|---|---|---|---|
| 1.2 -DCA | 2.400-4.320 | 292-2.917 | 2,400-4.320 | 2.400-8,640 | 2,400-4.320 | 9.600-17.280 |
| 1.2 -DCE (total) | 672-4.320 | 25.2-286 | 672-4.320 | 1.344-69,000 | 672-4,320 | 2.688-17,280 |
| 1.1.2 -TCA | 3.263-8.760 | 196-1.956 | 3.263-8,760 | 3.263-17.520 | 4,320-8,760 | 17,280-35,040 |
| 1.1.2.2 -PCA | 10 7-1056 | 213-2.131 | 10.7-1.056 | 10.7-1,056 | 672-4,320 | 168-672 |
| 1.2 -Dichloropropane | 4,008-30.936 | 65-646 | 4,008-30.936 | 8.016-61.872 | 4,008-30.936 | 16.032-123.744 |
| Acetone | 24-168 | 279-2.790 | 24-168 | 48-336 | 24-168 | 96-672 |
| Benzene | 120-384 | 50.1-501 | 120-384 | 240-17.280 | 120-384 | 2,688-17.280 |
| Chlorobenzene | 1.632-3.600 | 72.9-729 | 1.632-3,600 | 3.264-7,200 | 1.632-3.600 | 6,528-14.400 |
| TCE | 4.320-8.640 | 27-272 | 4,320-8,640 | 7,704-39,672 | 4.320-8,640 | 2.352-39672 |
| Toluene | 96-528 | 10-104 | 96-528 | 168-672 | 96-528 | 1.344-5.040 |
| Vinyl Chloride | 672-4.320 | 9.7-97 | 672-4.320 | 1.344-69.000 | 672-4.320 | 2.688-17.280 |

NOTES Modified from Handbook of Environmental Degradation Rates (Howard, et al , 1991)
All values given in hours

# TABLE 5-5 SUMMARY OF SITE DATA FOR NAPL EVALUATION

| Parameter | Maximum Detected Conc ($\mu$g/L)[1] | Calculated Effective Pore Water Conc ($\mu$g/L)[2] | Water Solubility ($\mu$g/L)[3] |
|---|---|---|---|
| *Petroleum VOC* | | | |
| Benzene | 5.50E+02 | 6.69E+00 | 1.70E+06 |
| Toluene | 9.60E+01 | 4.11E+00 | 4.90E+05 |
| Total Xylenes | 2.20E+02 | N/A | 3.00E+02 |
| *Chlorinated VOC* | | | |
| Chlorobenzene | 1.00E+02 | 5.53E-01 | 2.95E+05 |
| Vinyl Chloride | 3.10E+01 | 5.94E+00 | 1.10E+06 |
| 1,2-Dichloroethene | 5.70E+03 | 1.60E+03 | 6.30E+06 |
| 1,2-Dichloroethane | 1.20E+02 | N/A | 8.00E+06 |
| Trichloroethene | 1.20E+05 | 3.32E+04 | 1.10E+06 |
| 1,1,2-Trichloroethane | 1.20E+03 | 6.31E+02 | 4.50E+06 |
| 1,1,2,2-Tetrachloroethane | 7.70E+04 | 6.00E+04 | 2.90E+06 |
| 1,1-Dichloroethane | 7.40E+01 | N/A | 1.00E+06 |
| 1,1-Dichloroethene | 2.10E+01 | N/A | 6.30E+06 |
| Tetrachloroethene | 1.00E+03 | 2.90E+02 | 1.50E+05 |
| Chloroform | 2.40E+02 | 1.74E+01 | 8.20E+06 |
| *Other VOC* | | | |
| Carbon Disulfide | 4.00E+00 | 1.65E+01 | 2.94E+06 |
| Styrene | 7 20E+01 | N/A | 3.00E+05 |

**NOTES:**
(1) Data from Table 4-3.
(2) Calculated from maximum detected soil concentration (Table 4-2).
(3) Data from EPA (1986) and Table 5-1.
ND = non detect
N/A = not applicable (analyte non-detect in soil)

# TABLE 5-6 SCREENING CRITERIA AND PARTITIONING COEFFICIENTS FOR VOC AND METALS DETECTED AT SITE 07, CALF PASTURE POINT

| Parameter | Phase III RI Detection Frequency | Koc | AWQC (ug/L) | AWQC Source | Sediment Screening Criteria (ug/Kg) | Sediment Screening Criteria Source |
|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | 19/47 | 79 | 2400 | F-C (a) | 16000 | AL (b) |
| 1,1,2-Trichloroethane | 13/47 | 76 | 9400 | F-C (a) | 12000 | AL (b) |
| 1,1-Dichloroethane | 1/47 | 62 (d) | 20000 | F-C (a) | 12400 | 1%TOC |
| 1,1-Dichloroethene | 2/47 | 135 (d) | 580 | F-A/20 (a) | 10000 | AL (b) |
| 1,2-Dichloroethane | 4/47 | 32 | 20000 | F-C (a) | 6400 | 1%TOC |
| 1,2-Dichloroethene (total) | 19/47 | 35 | 580 | F-A/20 (a) | 203 | 1%TOC |
| 1,2-Dichloropropane | 1/47 | 27 | 3040 | M-C (a) | 5600 | AL (b) |
| cis-1,3-Dichloropropene | 1/47 | 93 (d) | 244 | F-C (a) | 227 | 1%TOC |
| 2-Butanone | 2/47 | 5.2 | 6000 | © | 312 | 1%TOC |
| Acetone | 5/47 | 18 | nd | | nd | |
| Benzene | 1/47 | 98 | 700 | M-C (a) | 61 0 | AL (b) |
| Bromodichloromethane | 1/47 | 126 (d) | 15215 | F-C (b) | 18 000 | AL (b) |
| Carbon Disulfide | 3/47 | 100 (d) | 210 | F-C (b) | 310 | AL (b) |
| Chlorobenzene | 1/47 | 275 | 50 | © | 138 | 1%TOC |
| Chloroform | 4/47 | 40 | 1240 | F-C © | 496 | 1%TOC |
| Chloromethane | 1/47 | 8.1 (d) | nd | | nd | |
| Styrene | 1/47 | 870 (d) | 201 | F-A/20 (b) | 1750 | 1%TOC |
| Tetrachloroethene | 7/47 | 363 | 450 | M-C (a) | 60 | AET (b) |
| Toluene | 1/47 | 95 | 5000 | M-C (a) | 4500 | AL (b) |
| Trichloroethene | 21/47 | 104 | 100 | M-A/20 (a) | 230 | AL (b) |
| Vinyl Chloride | 5/47 | 29.5 | nd | | nd | |
| Xylenes (total) | 1/47 | 193 | 1340 | F-C (b) | 40 | AET (b) |
| | | | | | | |
| Site 07 Metals | | Kd | | | | |
| Arsenic | 8/47 | 200 | 36 | M-C (a) | 8200 | ER-L (b) |
| Barium | 23/47 | 60 | 340 | © | 20000 | © |
| Beryllium | 1/47 | 650 | 5.3 | F-C (a) | 3445 | Eq Part |
| Cobalt | 12/47 | 45 | 250 | F-A/20 © | 11250 | Eq Part |
| Copper | 7/47 | 336 (f) | 2.9 | M-C (a) | 34000 | ER-L (b) |
| Iron | 38/47 | 25 | 1000 | F-C (a) | 25000 | Eq Part |
| Manganese | 44/47 | 65 | 2500 | F-A/20 © | 162500 | Eq Part |
| Mercury | 2/47 | 10 | 0.025 | M-C (a) | 150 | ER-L (b) |
| Nickel | 1/47 | 150 | 8.3 | M-C (a) | 20900 | ER-L (b) |
| Selenium | 3/47 | 300 | 71 | M-C (a) | 21300 | Eq Part |
| Thallium | 22/47 | 1500 | 107 | M-A/20 (a) | 160000 | Eq Part |
| Zinc | 3/47 | 420(e) | 86 | M-C (a) | 150000 | ER-L (b) |

| Parameter | Phase III RI Detection Frequency | Koc | AWQC (ug/L) | AWQC Source | Sediment Screening Criteria (ug/Kg) | Sediment Screening Criteria Source |
|---|---|---|---|---|---|---|

Notes: a) EPA 1991
b) Marine ERA, 1996
c) Freshwater/Terrestrial ERA, 1996
d) Karickhoff (personal communication)
e) EPA 1994
f) Battelle 1989
F-C - Freshwater Chronic
M-C - Marine Chronic
F-A/20 - Freshwater Acute divided by 20
M-A/20 - Marine Acute divided by 20
Eq Part - Equilibrium Partitioning
AL - Aquatic Life; Nd - Not determined

# TABLE 5-7 DETECTION FREQUENCY, SITE-WIDE GEOMETRIC MEAN AND SITE-WIDE MAXIMUM CONCENTRATIONS OF VOC, PHASE II RI AND PHASE III RI GROUND-WATER SAMPLES

| | Phase II RI | | | | | Phase III RI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Detection Frequency | | | Concentration (ug/L) | | Detection Frequency | | | Concentration (ug/L) | |
| Parameter | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max |
| 1,1,1-Trichloroethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| 1,1,2,2-Tetrachloroethane | 2/7 | 5/7 | 7/14 | 151 | 33000 | 3/18 | 16/29 | 19/47 | 2011 | 77000 |
| 1,1,2-Trichloroethane | 0/7 | 4/7 | 4/14 | 21 7 | 260 | 3/18 | 10/29 | 13/47 | 77.68 | 1200 |
| 1,1-Dichloroethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 74 | 74 |
| 1,1-Dichloroethene | 0/7 | 0/7 | 0/14 | | | 0/18 | 2/29 | 2/47 | 18.33 | 21 |
| 1,2-Dichloroethane | 0/7 | 0/7 | 0/14 | | | 1/18 | 3/29 | 4/47 | 10.95 | 120 |
| 1,2-Dichloroethene (total) | 2/7 | 6/7 | 8/14 | 61.4 | 2800 | 3/18 | 16/29 | 19/47 | 308 | 5700 |
| 1,2-Dichloropropane | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 98 | 98 |
| cis-1,3-Dichloropropene | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 66 | 66 |
| trans-1,3-Dichloropropene | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| 2-Butanone | 0/7 | 0/7 | 0/14 | | | 1/18 | 1/29 | 2/47 | 13.04 | 34 |
| 2-Hexanone | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| 4-Methyl-2-Pentanone | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Acetone | 0/7 | 2/7 | 2/14 | 41.4 | 57 | 4/18 | 1/29 | 5/47 | 207 | 1800 |
| Benzene | 0/7 | 1/7 | 1/14 | 40 | 40 | 0/18 | 1/29 | 1/47 | 550 | 550 |
| Bromodichloromethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 78 | 78 |
| Bromoform | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Bromomethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Carbon Disulfide | 0/7 | 0/7 | 0/14 | | | 0/18 | 3/29 | 3/47 | 2.88 | 4 |
| Carbon Tetrachloride | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Chlorobenzene | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 100 | 100 |
| Chloroethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Chloroform | 0/7 | 0/7 | 0/14 | | | 0/18 | 4/29 | 4/47 | 68.13 | 240 |
| Chloromethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 98 | 98 |
| Dibromochloromethane | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Ethylbenzene | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Methylene Chloride | 0/7 | 0/7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |

| | Phase II RI | | | | | Phase III RI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Detection Frequency | | | Concentration (ug/L) | | Detection Frequency | | | Concentration (ug/L) | |
| Parameter | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max |
| Styrene | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 72 | 72 |
| Tetrachloroethene | 0/7 | 0/7 | 0/14 | | | 2/18 | 5/29 | 7/47 | 135.78 | 1000 |
| Toluene | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 96 | 96 |
| Trichloroethene | 2/7 | 5/7 | 7/14 | 116 | 22000 | 4/18 | 17/29 | 21/47 | 1714 | 120000 |
| Vinyl Chloride | 0/7 | 0/7 | 0/14 | | | 1/18 | 4/29 | 5/47 | 10.95 | 31 |
| Xylenes (total) | 0/7 | 0/7 | 0/14 | | | 0/18 | 1/29 | 1/47 | 220 | 220 |

* - calculated from only well samples where parameter was detected

# TABLE 5-8 DETECTION FREQUENCY, SITE-WIDE GEOMETRIC MEAN, AND SITE-WIDE MAXIMUM METAL CONCENTRATIONS, PHASE II RI AND PHASE III RI GROUND-WATER SAMPLES

| | | Phase II RI | | | | | Phase III RI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Detection Frequency | | | Concentration (ug/L) | | Detection Frequency | | | Concentration (ug/L) | |
| Parameter | COC | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max |
| Aluminum | | 5/ 7 | 7/ 7 | 12/14 | 258 | 129000 | 0/18 | 0/29 | 0/47 | | |
| Antimony | F | 0/ 7 | 0/ 7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Arsenic | M | 6/ 7 | 4/ 7 | 10/14 | 2.86 | 63.5 | 5/18 | 3/29 | 8/47 | 5.3 | 46.9 |
| Barium | F | 7/ 7 | 7/ 7 | 14/14 | 14.3 | 253 | 5/18 | 18/29 | 23/47 | 37.8 | 123 |
| Beryllium | F | 0/ 7 | 3/ 7 | 3/14 | 1.67 | 6.4 | 1/18 | 0/29 | 1/47 | 3.5 | 3.5 |
| Cadmium | F,M | 0/ 7 | 0/ 7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Calcium | | 7/ 7 | 7/ 7 | 14/14 | 56866 | 142000 | 18/18 | 29/29 | 47/47 | 69999 | 388000 |
| Chromium | F,M | 1/ 7 | 3/ 7 | 4/14 | 30.25 | 292 | 0/18 | 0/29 | 0/47 | | |
| Cobalt | F | 0/ 7 | 6/ 7 | 6/14 | 22.81 | 117 | 0/18 | 12/29 | 12/47 | 12.64 | 151 |
| Copper | F,M | 2/ 7 | 3/ 7 | 5/14 | 14.75 | 268 | 4/18 | 3/29 | 7/47 | 5.84 | 12.1 |
| Iron | | 7/ 7 | 7/ 7 | 14/14 | 3128 | 295000 | 13/18 | 25/29 | 38/47 | 4205 | 53100 |
| Lead | F,M | 5/ 5 | 7/ 7 | 12/12 | 8 | 125 | 0/18 | 0/29 | 0/47 | | |
| Magnesium | | 7/ 7 | 7/ 7 | 14/14 | 10142 | 389000 | 13/18 | 24/29 | 37/47 | 59487 | 765000 |
| Manganese | F | 7/ 7 | 7/ 7 | 14/14 | 359 | 4100 | 15/18 | 29/29 | 44/47 | 576 | 15500 |
| Mercury | F,M | 0/ 7 | 0/ 7 | 0/14 | | | 0/18 | 2/29 | 2/47 | 0.14 | 0.15 |
| Nickel | F,M | 1/ 7 | 5/ 7 | 6/14 | 39.4 | 320 | 1/18 | 0/29 | 1/47 | 19 | 19 |
| Potassium | | 7/ 7 | 7/ 7 | 14/14 | 10501 | 145000 | 17/18 | 29/29 | 46/47 | 20328 | 262000 |
| Selenium | F | 2/ 7 | 1/ 7 | 3/14 | 1.49 | 1.7 | 2/18 | 1/29 | 3/47 | 4.36 | 5.3 |
| Silver | F,M | 0/ 7 | 0/ 7 | 0/14 | | | 0/18 | 0/29 | 0/47 | | |
| Sodium | | 6/ 6 | 7/ 7 | 13/13 | 76944 | 3610000 | 18/18 | 29/29 | 47/47 | 273048 | 8240000 |
| Thallium | F | 1/ 4 | 0/ 5 | 1/ 9 | 1.2 | 1.2 | 6/18 | 16/29 | 22/47 | 12.05 | 31.6 |
| Vanadium | F | 0/ 7 | 3/ 7 | 3/14 | 56.44 | 224 | 0/18 | 0/29 | 0/47 | | |
| Zinc | F,M | 0/ 7 | 4/ 7 | 4/14 | 171.57 | 626 | 1/18 | 2/29 | 3/47 | 68.64 | 79.5 |

| | | Phase II RI | | | | | Phase III RI | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Detection Frequency | | | Concentration (ug/L) | | Detection Frequency | | | Concentration (ug/L) | |
| Parameter | COC | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max | Shallow | Deep/Rock | Site Total | Site GeoMean* | Site Max |

NOTES: * - calculated from only well samples where parameter was detected
F = Freshwater/Terrestial ERA Report (EA 1996)
M = Marine ERA Report (SAIC 1996)

# TABLE 5-9. FIRST-STEP SCREENING OF VOC DETECTED IN GROUND-WATER SAMPLES FROM SITE 07 SHALLOW WELLS

| Parameter | Phase III RI Detect Frequency | Concentrations in Water (ug/L) | | | | |
|---|---|---|---|---|---|---|
| | | Site GeoMean* | Site Max | Detected in MW07-19S | Detected in MW07-21S | AWQC |
| 1,1,2,2-Tetrachloroethane | 3/18 | 1774 | 12000 | 1500 | 310 | 2400 |
| 1,1,2-Trichloroethane | 3/18 | 54.28 | 130 | 130 | 41 | 9400 |
| 1,2-Dichloroethane | 1/18 | 30 | 30 | nd | nd | 20000 |
| 1,2-Dichloroethene (total) | 3/18 | 886 | 1400 | 920 | 540 | 580 |
| 2-Butanone | 1/18 | 5 | 5 | nd | nd | 6000 |
| Acetone | 4/18 | 212 | 1800 | nd | nd | not deter |
| Tetrachloroethene | 2/18 | 19.75 | 390 | nd | nd | 450 |
| Trichloroethene | 4/18 | 600 | 3400 | 3400 | 590 | 100 |
| Vinyl Chloride | 1/18 | 23 | 23 | nd | nd | not deter |

| Parameter | Sediment Screening Critieria (ug/Kg) | Koc | Estimated Sediment Conc (ug/Kg) for 5% TOC | | | Below Sediment Screening Criteria | | |
|---|---|---|---|---|---|---|---|---|
| | | | Based on Site Mean | Based on MW07-19S | Based on MW07-21S | Based on Site Mean | Based on MW07-19S | Based on MW07-21S |
| 1,1,2,2-Tetrachloroethane | 16000 | 79 | 7007 | 5925 | 1225 | Y | Y | Y |
| 1,1,2-Trichloroethane | 12000 | 76 | 206 | 494 | 156 | Y | Y | Y |
| 1,2-Dichloroethane | 6400 | 32 | 48 | na | na | Y | na | na |
| 1,2-Dichloroethene (total) | 203 | 35 | 1551 | 1610 | 945 | N | N | N |
| 2-Butanone | 312 | 5.2 | 1.3 | na | na | Y | na | na |
| Acetone | not deter | 18 | 191 | na | na | not deter | na | na |
| Tetrachloroethene | 60 | 363 | 358 | na | na | N | na | na |
| Trichloroethene | 230 | 104 | 3120 | 17680 | 3068 | N | N | N |
| Vinyl Chloride | not deter | 29.5 | 34 | na | na | not deter | na | na |

* - calculated from only well samples where parameter was detected
nd - not detected  not deter - not determined  na - not applicable

# TABLE 5-10 DETECTED METAL CONCENTRATIONS AT SIX SELECTED SHALLOW WELLS NEAR THE ALLEN HARBOR ENTRANCE CHANNEL

| Parameter | Metal Concentrations (ug/L) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 23S | 19S | 21S | 13S | 24S | 20S | Max[a] |
| Arsenic | - | 3.8 | - | 8 | 2.8 | - | 8 |
| Barium | 19 | - | - | - | 51.8 | 20.8 | 51.8 |
| Beryllium | - | - | - | - | - | - | - |
| Copper | - | - | 4.4 | - | 5 | 12.1 | 12.1 |
| Iron | 3,640 | 1,650 | 1,310 | - | 8,050 | 2,470 | 8,050 |
| Manganese | 546 | 3,410 | 3,830 | 1,270 | 367 | 342 | 3,830 |
| Nickel | - | - | - | - | - | - | - |
| Selenium | - | - | - | - | 3 | 5.3 | 5.3 |
| Thallium | 5.4 | 3.5 | - | - | 29.3 | 25.1 | 29.3 |
| Zinc | - | - | - | - | - | - | - |

(-) Not detected
(a) The maximum value at the six shallow wells was used in the first-step screening analysis.

# TABLE 5-11 FIRST-STEP SCREENING OF METALS DETECTED IN GROUND-WATER SAMPLES FROM SITE 07 SHALLOW WELLS

| Parameter | Phase III RI Detect Freq | Ground-Water Concentration (ug/L) | | | | Sediment Screening Criteria (ug/Kg) | Kd | Estimated Sediment Conc (ug/Kg) | | Below Sediment Screening Criteria | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site GeoMean* | Site Max | Near Shoreline Max[(a)] | AWQC | | | Based on Site GeoMean | Based on Near Shoreline Max [(a)] | Site Geo. Mean | Near Shore Max |
| Arsenic | 5/18 | 6.09 | 46.9 | 8 | 36 | 8200 | 200 | 1218 | 1600 | Y | Y |
| Barium | 5/18 | 27.98 | 51.8 | 51.8 | 340 | 20000 | 60 | 1678.8 | 3108 | Y | Y |
| Beryllium | 1/18 | 3.5 | 3.5 | na | 5.3 | 3445 | 650 | 2275 | na | Y | na |
| Calcium | 18/18 | 79316 | 270000 | Macro-Nutrient | | | | | | | |
| Copper | 4/18 | 5.88 | 12.1 | 12.1 | 2.9 | 34000 | 336 | 1975.68 | 4065.6 | Y | Y |
| Iron | 13/18 | 2527 | 53100 | 8050 | 1000 | 25000 | 25 | 63175 | 201250 | N | N |
| Magnesium | 13/18 | 21432 | 765000 | Macro-Nutrient | | | | | | | |
| Manganese | 15/18 | 218 | 3830 | 3830 | 2500 | 162500 | 65 | 14170 | 248950 | Y | N |
| Nickel | 1/18 | 19 | 19 | na | 8.3 | 20900 | 150 | 2850 | na | Y | na |
| Potassium | 17/18 | 9988 | 239000 | Macro-Nutrient | | | | | | | |
| Selenium | 2/18 | 3.99 | 5.3 | 5.3 | 71 | 21300 | 300 | 1197 | 1590 | Y | Y |
| Sodium | 18/18 | 49805 | 7620000 | Macro-Nutrient | | | | | | | |
| Thallium | 6/18 | 8.22 | 29.3 | 29.3 | 107 | 60000 | 1500 | 12330 | 43950 | Y | Y |
| Zinc | 1/18 | 71.5 | 71.5 | na | 86 | 150000 | 420 | 30030 | na | Y | na |

* - calculated from only well samples where parameter was detected
na - not applicable because not detected in a sample from one of the 6 selected near shore (channel) monitoring wells located in the southern end of the Site.
(a) - the maximum concentration detected at one of six selected shallow wells near the entrance channel.

# TABLE 5-12 FIRST-STEP SCREENING OF VOC DETECTED IN GROUND-WATER SAMPLES FROM SITE 07 DEEP/ROCK WELLS

| Parameter | Phase III RI Detection Frequency | Concentration in Water (ug/L) | | | Sediment Screening Criteria (ug/Kg) | Koc | Estimated Sediment Conc (ug/kg) @ 5% TOC | | Below Sediment Screening Criteria | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Site GeoMean* | Site Max | AWQC | | | Based on GeoMean | Based on Site Max | Geo Mean | Site Max |
| 1,1,2,2-Tetrachloroethane | 16/29 | 2059 | 77000 | 2400 | 16000 | 79 | 8,133 | 304,150 | Y | N |
| 1,1,2-Trichloroethane | 10/29 | 86.49 | 1200 | 9400 | 12000 | 76 | 329 | 4,560 | Y | Y |
| 1,1-Dichloroethane | 1/29 | 74 | 74 | 20000 | 12400 | 62 | 229 | 229 | Y | Y |
| 1,1-Dichloroethene | 2/29 | 18.33 | 21 | 580 | 10000 | 135 | 124 | 142 | Y | Y |
| 1,2-Dichloroethane | 3/29 | 7.83 | 120 | 20000 | 6400 | 32 | 13 | 192 | Y | Y |
| 1,2-Dichloroethene (total) | 16/29 | 253 | 5700 | 580 | 203 | 35 | 443 | 9,975 | N | N |
| 1,2-Dichloropropane | 1/29 | 98 | 98 | 3040 | 5600 | 27 | 132 | 132 | Y | Y |
| cis-1,3-Dichloropropene | 1/29 | 66 | 66 | 244 | 227 | 93 | 307 | 307 | N | N |
| 2-Butanone | 1/29 | 34 | 34 | 6000 | 312 | 5.2 | 9 | 9 | Y | Y |
| Acetone | 1/29 | 190 | 190 | not deter | not deter | 19 | 180 | 180 | not deter | not deter |
| Benzene | 1/29 | 550 | 550 | 700 | 610 | 98 | 2,695 | 2,695 | N | N |
| Bromodichloromethane | 1/29 | 78 | 78 | 15215 | 18000 | 126 | 491 | 491 | Y | Y |
| Carbon Disulfide | 3/29 | 2.88 | 4 | 210 | 310 | 100 | 14 | 20 | Y | Y |
| Chlorobenzene | 1/29 | 100 | 100 | 50 | 138 | 275 | 1,375 | 1,375 | N | N |
| Chloroform | 4/29 | 68.13 | 240 | 1240 | 496 | 40 | 136 | 480 | Y | Y |
| Chloromethane | 1/29 | 98 | 98 | not deter | not deter | 8.1 | 40 | 40 | not deter | not deter |
| Styrene | 1/29 | 72 | 72 | not deter | 1750 | 870 | 3,132 | 3,132 | N | N |
| Tetrachloroethene | 5/29 | 293.59 | 1000 | 450 | 60 | 363 | 5,329 | 18,150 | N | N |
| Toluene | 1/29 | 96 | 96 | 5000 | 4500 | 95 | 456 | 456 | Y | Y |
| Trichloroethene | 17/29 | 2195 | 120000 | 100 | 230 | 104 | 11,414 | 624,000 | N | N |
| Vinyl Chloride | 4/29 | 9.1 | 31 | not deter | not deter | 29.5 | 13 | 46 | not deter | not deter |
| Xylenes (total) | 1/29 | 220 | 220 | 1340 | 40 | 193 | 2,123 | 2,123 | N | N |

* - calculated from only well samples where parameter was detected
not deter - not determined

| |
|---|
| **(ug/L)** |

# TABLE 5-14 ESTIMATED SHORELINE CONCENTRATIONS OF VOC USING THE AT123D MODEL BASED ON GROUND-WATER SAMPLE DATA FOR MW07-19S AND MW07-21S

| Parameter | Half-Life (yrs) | Detected at MW07-19S (ug/L) | Estimated Conc (ug/L) | | Below AWQC | Estimated Sediment Conc (ug/Kg) | Sediment Screening Criteria (ug/Kg) | Below Sediment Screening Criteria |
|---|---|---|---|---|---|---|---|---|
| | | | MW07-21S | Shoreline | | | | |
| 1,1,2,2-PCA | 1 | 1500 | 1095 | 825 | Y | 3259 | 16000 | Y |
| | 0.5 | 1500 | 885 | 580 | Y | 2252 | 16000 | Y |
| 1,1,2-TCA | 2 | 130 | 105 | 87 | Y | 331 | 12000 | Y |
| | 1 | 130 | 95 | 72 | Y | 274 | 12000 | Y |
| 1,2-DCE | 6 | 920 | 837 | 745 | N | 1304 | 203 | N |
| | 4 | 920 | 828 | 727 | N | 1272 | 203 | N |
| TCE | 4 | 3400 | 2890 | 2448 | N | 12730 | 230 | N |
| | 2 | 3400 | 2686 | 2176 | N | 11315 | 230 | N |
| | | **Detected at MW07-21S** | | **Shoreline** | | | | |
| 1,1,2,2-PCA | 1 | 310 | | 234 | Y | 924 | 16000 | Y |
| | 0.5 | 310 | | 200 | Y | 790 | 16000 | Y |
| 1,1,2-TCA | 2 | 41 | | 34 | Y | 129 | 12000 | Y |
| | 1 | 41 | | 31 | Y | 118 | 12000 | Y |
| 1,2-DCE | 6 | 540 | | 481 | N | 842 | 203 | N |
| | 4 | 540 | | 474 | N | 829 | 203 | N |
| TCE | 4 | 590 | | 500 | N | 2600 | 230 | N |
| | 2 | 590 | | 478 | N | 2486 | 230 | N |

# TABLE 5-15 ESTIMATED ALLEN HARBOR SURFACE WATER CONCENTRATIONS RESULTING FROM NEAR SHORE SHALLOW SITE GROUND WATER

| Parameter | Near Shoreline GW Concentration (ug/L) | | Estimated Mass Flux to Channel (gm/day) | | Estimated Surface Water Conc (ug/L) | | |
|---|---|---|---|---|---|---|---|
| | Estimated from MW07-19S [a] | Detected at MW07-21S[b] | Based on MW07-19S [a] | Based on MW07-21S[b] | MW07-19S | MW07-21S | AWQC |
| 1,1,2,2-PCA | 825 | 310 | 116 | 43.4 | 1.3 | 0.5 | 2400 |
| 1,1,2-TCA | 87 | 41 | 12.2 | 5.7 | 0.1 | 0.1 | 9400 |
| 1,2-DCE | 745 | 540 | 104 | 76 | 1.2 | 0.9 | 580 |
| TCE | 2448 | 590 | 343 | 83 | 4.0 | 1.0 | 100 |
| | Max Detected in Near Shore GW (ug/L)[c] | | | | Est. SW Conc (ug/L) | | |
| Iron | 8050 | | | | 13.1 | | 1000 |
| Manganese | 3830 | | | | 6.2 | | 2500 |

(a) Shoreline concentration was estimated with the AT123D model from the detected value at MW07-19S.
(b) The detected concentration at MW07-21S was used directly in the calculation.
(c) The maximum concentration at the six selected shallow wells near the entrance channel.

# TABLE 5-16 SECOND-STEP SCREENING OF VOC DETECTED IN SITE 07 DEEP/ROCK WELLS BASED ON AT123D MODEL PREDICTION FROM MW07-04D/05D TO NEAR ENTRANCE CHANNEL SHORELINE

| Parameter | Phase III RI Detect Freq | Site Detected Maximum (ug/L) | Half-Life (yrs) | Estimated Conc in Ground Water (ug/L) at Selected Distance from Source | | | Sediment Conc (ug/kg) | | Below Sediment Criteria | AWQC (ug/L) | Below AWQC[b] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 300 ft (10D/25D) | 550 ft (12D) | 780 ft (23D) | 5% TOC[a] | Sediment Criteria | | | |
| 1,1,2,2-PCA | 16/29 | 77000 | 1 | 29370 | 169 | 13.8 | 55 | 16000 | Y | 2400 | Y |
| 1,2-DCE | 16/29 | 5700 | 6 | 2550 | 1358 | 854 | 1,495 | 203 | N | 580 | N |
| | | 5700 | 4 | 2198 | 1018 | 561 | 982 | 203 | N | 580 | N |
| Benzene | 1/29 | 550 | 2 | 58 | 8.5 | 1.6 | 8 | 610 | Y | 700 | Y |
| Chlorobenzene | 1/29 | 100 | 1 | 0.1 | — | — | — | 138 | Y | 50 | Y |
| PCE | 5/29 | 1000 | 6 | 99 | 13.7 | 2.5 | 45 | 60 | Y | 450 | Y |
| TCE | 12/29 | 120000 | 4 | 27500 | 8170 | 2980 | 10,296 | 230 | N | 100 | N |
| | | 120000 | 2 | 11855 | 1615 | 289 | 1,503 | 230 | N | 100 | N |

(a) Estimated sediment concentration calculated from predicted ground-water concentration at 780 ft.
(b) Comparison of predicted ground-water concentration at 780 ft to AWQC.

**TABLE 5-17 PREDICTED TCE GROUND-WATER CONCENTRATIONS BEYOND THE SHORELINE OF THE ALLEN HARBOR ENTRANCE CHANNEL USING THE AT123D MODEL**

| Retard-ation | Half-Life (yrs) | Source Conc (ug/l) | TCE Ground-water Concentration (ug/L) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 ft | 250 ft | 500 ft | 750 ft | 1000 ft |
| Till Unit | | | | | | | |
| 4.91 | 2 | 3000[a] | 995 | 48.4 | 2.3 | 0.11 | 0.004 |
| 4.91 | 4 | 3000 | 1653 | 307 | 55.2 | 9.9 | 1.8 |
| 4.91 | 2 | 5800 | 1925 | 93.7 | 4.4 | 0.21 | 0.01 |
| 4.91 | 4 | 5800 | 3195 | 594 | 107 | 19.2 | 3.5 |
| Bedrock Unit | | | | | | | |
| 1.0 | 2 | 5800[b] | 4768 | 2469 | 1242 | 626 | 317 |
| 2.0 | 2 | 5800 | 3964 | 1192 | 347 | 101 | 29.6 |
| 1.0 | 4 | 5800 | 5298 | 3655 | 2525 | 1656 | 1127 |
| 2.0 | 4 | 5800 | 4827 | 2500 | 1257 | 634 | 321 |

(a) The maximum near shore TCE concentrations at a deep well (till unit) was 3000 ug/L at MW07-25D.

(b) The maximum near shore TCE concentrations at a rock well (bedrock unit) was 5800 ug/L at MW07-21R.

## TABLE 6-1. Selection of Chemicals of Concern from List of Detected Analytes in Total Soils (Surface to depth of 10 feet)

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Statistically Elevated above Background? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | |
| Aluminum | 7,720 | 100,000 | No | No | 26 / 26 | Yes | No | | No |
| Antimony | 3.9 | 82 | No | ND | 1 / 26 | No | No | | No |
| Arsenic | 2.2 | 3.3 | No | No | 26 / 26 | Yes | No | COC in sediment | YES |
| Barium | 18.6 | 14,000 | No | No | 26 / 26 | Yes | No | | No |
| Beryllium | 0.49 | 1.3 | No | No | 22 / 26 | Yes | No | | No |
| Cadmium | 4.7 | 100 | No | No | 2 / 26 | Yes | No | | No |
| Calcium | 8,390 | ND | - - | Yes | 26 / 26 | Yes | Yes | | No |
| Chromium [1] | 13.1 | 1,000 | No | No | 25 / 26 | Yes | No | | No |
| Cobalt | 6.1 | 12,000 | No | No | 26 / 26 | Yes | No | | No |
| Copper | 14.6 | 7,600 | No | No | 22 / 26 | Yes | No | | No |
| Cyanide | 0.16 | 4,100 | No | ND | 1 / 26 | No | No | | No |
| Iron | 15,600 | ND | - - | No | 26 / 26 | Yes | Yes | | No |
| Lead | 8.6 | ND | - - | No | 26 / 26 | Yes | No | | YES |
| Magnesium | 1,190 | ND | - - | No | 26 / 26 | Yes | Yes | | No |
| Manganese [2] | 137 | 10,000 | No | No | 26 / 26 | Yes | No | | No |
| Nickel | 243 | 4,100 | No | No | 17 / 26 | Yes | No | | No |
| Potassium | 1,230 | ND | - - | No | 23 / 26 | Yes | Yes | | No |
| Selenium | 0.32 | 1,000 | No | No | 12 / 26 | Yes | No | | No |
| Sodium | 411 | ND | - - | No | 7 / 26 | Yes | Yes | | No |
| Thallium [3] | 0.87 | 16 | No | No | 3 / 26 | Yes | No | | No |
| Vanadium | 14.3 | 1,400 | No | No | 26 / 26 | Yes | No | | No |
| Zinc | 33.6 | 61,000 | No | No | 24 / 26 | Yes | No | | No |
| **SEMIVOLATILES** | | | | | | | | | |

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Statistically Elevated above Background? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| Bis(2-ethylhexyl)phthalate | 0.38 | 410 | No | NA | 2 / 8 | Yes | NA | | No |
| **VOLATILES** | | | | | | | | | |
| Acetone | 6.1 | 20,000 | No | NA | 8 / 37 | Yes | NA | | No |
| Chloroform | 0.001 | 940 | No | NA | 1 / 37 | No | NA | | No |
| 1,1,2,2-Tetrachloroethane | 0.015 | 29 | No | NA | 1 / 37 | No | NA | | No |
| Toluene | 0.003 | 41,000 | No | NA | 2 / 37 | Yes | NA | | No |
| 1,1,1-Trichloroethane | 0.006 | 18,000 | No | NA | 4 / 37 | Yes | NA | | No |
| Trichloroethene | 0.018 | 520 | No | NA | 1 / 37 | No | NA | | No |
| **PESTICIDES / PCBs** | | | | | | | | | |
| 4,4'-DDE | 0.019 | 17 | No | NA | 1 / 14 | Yes | NA | | No |
| 4,4'-DDT | 0.022 | 17 | No | NA | 1 / 14 | Yes | NA | | No |

NOTES:

NA Not applicable
ND No data
(1) RBC for hexavalent chromium, the most toxic form of chromium.
(2) RBC for manganese recalculated using the updated RfD for nondietary exposures from IRIS (1996).
(3) RBC for thallium carbonate, the lowest available RBC for a thallium compound.

## TABLE 6-2. Selection of Chemicals of Concern from List of Detected Analytes in Surface Soil

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | 1,010 | 100,000 | No | 16 / 16 | Yes | No | | No |
| Arsenic | 1.5 | 3.3 | No | 16 / 16 | Yes | No | COC in sediment | YES |
| Barium | 9.4 | 14,000 | No | 16 / 16 | Yes | No | | No |
| Beryllium | 0 36 | 1.3 | No | 14 / 16 | Yes | No | | No |
| Cadmium | 4.7 | 100 | No | 2 / 16 | Yes | No | | No |
| Calcium | 5,790 | ND | - - | 16 / 16 | Yes | Yes | | No |
| Chromium [1] | 5.7 | 1,000 | No | 15 / 16 | Yes | No | | No |
| Cobalt | 4.10 | 12,000 | No | 16 / 16 | Yes | No | | No |
| Copper | 9.10 | 7,600 | No | 14 / 16 | Yes | No | | No |
| Cyanide | 0.16 | 4,100 | No | 1 / 16 | Yes | No | | No |
| Iron | 8,840 | ND | - - | 16 / 16 | Yes | Yes | | No |
| Lead | 8.6 | ND | - - | 16 / 16 | Yes | No | | YES |
| Magnesium | 1,190 | ND | - - | 16 / 16 | Yes | Yes | | No |
| Manganese [2] | 116 | 10,000 | No | 16 / 16 | Yes | No | | No |
| Nickel | 243 | 4,100 | No | 13 / 16 | Yes | No | | No |
| Potassium | 448 | ND | - - | 15 / 16 | Yes | Yes | | No |
| Selenium | 0.32 | 1,000 | No | 9 / 16 | Yes | No | | No |
| Sodium | 411 | ND | - - | 4 / 16 | Yes | Yes | | No |
| Thallium [3] | 0.87 | 16 | No | 3 / 16 | Yes | No | | No |
| Vanadium | 7.6 | 1,400 | No | 16 / 16 | Yes | No | | No |
| Zinc | 32.1 | 61,000 | No | 15 / 16 | Yes | No | | No |
| **SEMIVOLATILES** | | | | | | | | |
| Bis(2-ethylhexyl)phthalate | 0.38 | 410 | No | 1 / 4 | Yes | NA | | No |

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| **VOLATILES** | | | | | | | | |
| Acetone | 0.037 | 20,000 | No | 2 / 19 | Yes | NA | | No |
| Chloroform | 0.001 | 940 | No | 1 / 19 | Yes | NA | | No |
| Toluene | 0.003 | 110 | No | 1 / 19 | Yes | NA | | No |
| 1,1,1-Trichloroethane | 0.006 | 18,000 | No | 2 / 19 | Yes | NA | | No |
| **PESTICIDES / PCBs** | | | | | | | | |
| 4,4'-DDE | 0.019 | 17 | No | 1 / 12 | Yes | NA | | No |
| 4,4'-DDT | 0.022 | 17 | No | 1 / 12 | Yes | NA | | No |

NOTES: .

ND No data
(1) RBC for hexavalent chromium, the most toxic form of chromium.
(2) RBC for manganese recalculated using the updated RfD for nondietary exposures of 0.05 mg/kg-day from IRIS (1996).
(3) RBC for thallium carbonate, the lowest available RBC for a thallium compound.

# TABLE 6-3. Selection of Chemicals of Concern from List of Detected Analytes in Sediments

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | 14,400 | 100,000 | No | 3 / 3 | Yes | No | | No |
| Arsenic | 22.1 | 3.3 | Yes | 8 / 8 | Yes | No | | YES |
| Barium | 125 | 1,000 | No | 3 / 3 | Yes | No | See Note (8) | No |
| Beryllium | 0.4 | 1.3 | No | 1 / 3 | Yes | No | | No |
| Cadmium | 3.9 | 100 | No | 3 / 8 | Yes | No | | No |
| Calcium | 4,640 | ND | - - | 3 / 3 | Yes | Yes | | No |
| Chromium [1] | 40.2 | 1,000 | No | 8 / 8 | Yes | No | | No |
| Cobalt | 83.3 | 12,000 | No | 3 / 3 | Yes | No | | No |
| Copper | 50.4 | 1,000 | No | 7 / 8 | Yes | No | See Note (8) | No |
| Iron | 70,200 | ND | - - | 3 / 3 | Yes | Yes | | No |
| Lead | 91.3 | ND | - - | 8 / 8 | Yes | No | | YES |
| Magnesium | 4,690 | ND | - - | 3 / 3 | Yes | Yes | | No |
| Manganese [2] | 730 | 1,000 | No | 3 / 3 | Yes | No | See Note (8) | No |
| Nickel | 121 | 1,000 | No | 8 / 8 | Yes | No | See Note (8) | No |
| Potassium | 707 | ND | - - | 1 / 3 | Yes | Yes | | No |
| Silver | 1.10 | 1,000 | No | 4 / 8 | Yes | No | | No |
| Sodium | 270 | ND | - - | 3 / 3 | Yes | Yes | | No |
| Thallium [3] | 5.50 | 14 | No | 1 / 3 | Yes | No | See Note (8) | No |
| Vanadium | 27 4 | 1,000 | No | 3 / 3 | Yes | No | See Note (8) | No |
| Zinc | 591 | 1,000 | No | 8 / 8 | Yes | No | See Note (8) | No |
| **SEMIVOLATILES** | | | | | | | | |
| Acenaphthene | 0.00088 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Acenaphthylene [4] | 0.00323 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Anthracene | 0.00876 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| Benzo(a)anthracene | 0.0342 | 7.8 | No | 5 / 8 | Yes | NA | | No |
| Benzo(a)pyrene | 0.0342 | 0 78 | No | 5 / 8 | Yes | NA | | No |
| Benzo(b)fluoranthene | 0.0556 | 7.8 | No | 6 / 8 | Yes | NA | | No |
| Benzo(e)pyrene (4) | 0.0282 | 1,000 | No | 5 / 5 | Yes | NA | See Note (8) | No |
| Benzo(g,h,i)perylene (4) | 0.0208 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Benzo(k)fluoranthene | 0.054 | 78 | No | 6 / 8 | Yes | NA | | No |
| Bis(2-ethylhexyl)phthalate | 0.3 | 410 | No | 2 / 3 | Yes | NA | | No |
| Chrysene | 0.0386 | 780 | No | 5 / 8 | Yes | NA | | No |
| Dibenzo(a,h)anthracene | 0.00559 | 0.78 | No | 5 / 8 | Yes | NA | | No |
| Fluoranthene | 0.0775 | 1,000 | No | 6 / 8 | Yes | NA | See Note (8) | No |
| Fluorene | 0.00243 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Indeno(1,2,3-cd)pyrene | 0.0219 | 7.8 | No | 5 / 8 | Yes | NA | | No |
| 4-Methylphenol | 1.3 | 1,000 | No | 1 / 3 | Yes | NA | | No |
| Naphthalene | 0.00395 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Phenanthrene (4) | 0.0289 | 1,000 | No | 5 / 8 | Yes | NA | See Note (8) | No |
| Pyrene | 0.0721 | 1,000 | No | 6 / 8 | Yes | NA | See Note (8) | No |
| **VOLATILES** | | | | | | | | |
| 2-Butanone | 0.16 | 1,000 | No | 1 / 3 | Yes | NA | See Note (8) | No |
| **PESTICIDES / PCBs** | | | | | | | | |
| beta-BHC | 0.0017 | 3.2 | No | 1 / 3 | Yes | NA | | No |
| delta-BHC (5) | 0.00022 | 0.91 | No | 1 / 3 | Yes | NA | | No |
| alpha Chlordane (6) | 0.0001 | 4.4 | No | 1 / 3 | Yes | NA | | No |
| gamma Chlordane (6) | 0.00053 | 4.4 | No | 1 / 3 | Yes | NA | | No |
| 4,4'-DDD | 0.003 | 24 | No | 2 / 3 | Yes | NA | | No |
| 4,4'-DDE | 0.011 | 17 | No | 1 / 3 | Yes | NA | | No |
| Endrin aldehyde (7) | 0 00078 | 61 | No | 1 / 3 | Yes | NA | | No |
| Aroclor-1260 (8) | 0.06 | 0.74 | No | 1 / 3 | Yes | NA | | No |

NOTES:

NA Not Applicable
ND No data
(1) RBC for hexavalent chromium, the most toxic form of chromium.
(2) RBC for manganese recalculated using the updated RfD for nondietary exposures from IRIS (1996) of 0.05 mg/kg-day.
(2) RBC for thallium carbonate, the lowest available RBC for a thallium compound.
(3) RBC for pyrene, a structurally similar noncarcinogenic PAH, used for this chemical.
(4) The lowest available RBC for a BHC isomer, that for alpha-BHC, was applied to delta-BHC.
(5) RBC for chlordane applied to both alpha and gamma isomers.
(6) RBC for endrin applied to all forms of endrin.
(7) RBC for "PCBs" applied to all Aroclor mixtures.
(8) RBC is RIDEM's Method 1 Direct Exposure Criteria value for industrial/commercial exposure scenario (Rules and regulations for the Investigation and Remediation of Hazardous Material Releases, State of Rhode Island and Providence Plantations, Department of Environmental Management, Division of Site Remediation, Table 1, pg 35-38, Dated 31 March 1993, Amended August 1996).

## TABLE 6-4. Selection of Chemicals of Concern from List of Detected Analytes in Shallow Ground Water

| Chemical | Max. Conc. (μg/L) | Risk-Based Conc. (μg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | |
| Aluminum | 110 | 3,700 | No | ND | 5/20 | Yes | No | COC in deep gw | Yes |
| Arsenic | 46.9 | 0.045 | Yes | ND | 11/20 | Yes | No | | Yes |
| Barium | 51.8 | 260 | No | ND | 12/22 | Yes | No | | No |
| Beryllium | 3.5 | 0.016 | Yes | ND | 1/20 | No | No | COC in deep gw | Yes |
| Calcium | 270,000 | ND | -- | ND | 25/25 | Yes | Yes | | No |
| Chromium (2) | 4.2 | 18 | No | ND | 1/14 | Yes | No | COC in deep gw | Yes |
| Copper | 12.1 | 150 | No | ND | 6/25 | Yes | No | COC in deep gw | Yes |
| Iron | 53,100 | ND | -- | ND | 20/24 | Yes | Yes | | No |
| Lead(3) | 21.4 | 15 | Yes | ND | 5/5 | Yes | No | | Yes |
| Magnesium | 764,000 | ND | -- | ND | 19/25 | Yes | Yes | | No |
| Manganese (4) | 3,830 | 18 | Yes | ND | 22/25 | Yes | No | | Yes |
| Nickel | 19 | 73 | No | ND | 2/14 | Yes | No | COC in deep gw | Yes |
| Potassium | 239,000 | ND | -- | ND | 24/25 | Yes | Yes | | No |
| Selenium | 5.3 | 18 | No | ND | 4/9 | Yes | No | | No |
| Sodium | 7,620 | ND | -- | ND | 25/25 | Yes | Yes | | No |
| Thallium (5) | 29.3 | 0.29 | Yes | ND | 7/14 | Yes | No | | Yes |
| Zinc | 75 | 1,100 | No | ND | 1/25 | No | No | | No |

| Chemical | Max. Conc. (µg/L) | Risk-Based Conc. (µg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILES** | | | | | | | | | |
| Acetone | 1,800 | 370 | Yes | NA | 4/21 | Yes | NA | | Yes |
| 2-Butanone | 5 | 190 | No | NA | 1/23 | No | NA | | No |
| 1,2-Dichloroethane | 30 | 0.12 | Yes | NA | 1/25 | No | NA | COC in deep gw | Yes |
| 1,2-Dichloroethene (total) | 1,400 | 5.5 | Yes | NA | 5/25 | Yes | NA | | Yes |
| 1,1,2,2 Tetrachloroethane | 12,000 | 0.052 | Yes | NA | 5/24 | Yes | NA | | Yes |
| Tetrachloroethene | 390 | 1.1 | Yes | NA | 2/25 | Yes | NA | | Yes |
| 1,1,2-Trichloroethane | 130 | 0.19 | Yes | NA | 3/25 | Yes | NA | | Yes |
| Trichlorethene | 3,400 | 1.6 | Yes | NA | 6/25 | Yes | NA | | Yes |
| Vinyl chloride | 23 | 0.019 | Yes | NA | 1/25 | No | NA | COC in deep gw | Yes |

NOTES:

NA Not applicable
ND No data
(1) Statistical comparisons of reported inorganic concentrations to background could not be made because no upgradient wells near Site 07 were sampled.
(2) RBC for hexavalent chromium, the most toxic form of chromium.
(3) Action level for lead in drinking water used for screen
(4) RBC for manganese recalculated using the updated RfD for dietary exposures of 0.14 mg/kg-day from IRIS (1996).
(5) RBC for thallium carbonate, the lowest available RBC for a thallium compound.

## TABLE 6-5a. Selection of Chemicals of Concern from List of Detected Analytes in Deep Ground Water

| Chemical | Max. Conc. (µg/L) | Risk-Based Conc. (µg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | |
| Aluminum | 129,000 | 3,700 | Yes | ND | 7/22 | Yes | No | | Yes |
| Arsenic | 63.5 | 0.045 | Yes | ND | 6/25 | Yes | No | | Yes |
| Barium | 253 | 260 | No | ND | 22/30 | Yes | No | | No |
| Beryllium | 6.4 | 0.016 | Yes | ND | 3/20 | Yes | No | | Yes |
| Calcium | 270,000 | ND | -- | ND | 31/31 | Yes | Yes | | No |
| Chromium (2) | 292 | 18 | Yes | ND | 3/12 | Yes | No | | Yes |
| Cobalt | 117 | 220 | No | ND | 14/27 | Yes | No | | No |
| Copper | 268 | 150 | No | ND | 6/29 | Yes | No | | Yes |
| Iron | 295,000 | ND | -- | ND | 27/31 | Yes | Yes | | No |
| Lead | 125 | 15 | Yes | ND | 7/7 | Yes | No | | Yes |
| Magnesium | 765,000 | ND | -- | ND | 25/30 | Yes | Yes | | No |
| Manganese (3) | 4,100 | 18 | Yes | ND | 31/31 | Yes | No | | Yes |
| Mercury | 0.15 | 1.1 | No | ND | 2/26 | Yes | No | | No |
| Nickel | 320 | 73 | Yes | ND | 5/13 | Yes | No | | Yes |
| Potassium | 262,000 | ND | -- | ND | 31/31 | Yes | Yes | | No |
| Selenium | 5.2 | 18 | No | ND | 2/4 | Yes | No | | No |
| Sodium | 8,240,000 | ND | -- | ND | 31/31 | Yes | Yes | | No |
| Thallium (4) | 31.6 | 0.29 | Yes | ND | 13/16 | Yes | No | | Yes |
| Vanadium | 224 | 26 | Yes | ND | 3/20 | Yes | No | | Yes |
| Zinc | 626 | 1,100 | No | ND | 5/30 | Yes | No | | No |
| **SEMIVOLATILES** | | | | | | | | | |
| Styrene | 72 | 160 | No | NA | 1/26 | No | NA | | No |

| Chemical | Max. Conc. (µg/L) | Risk-Based Conc. (µg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILES** | | | | | | | | | |
| Acetone | 190 | 370 | No | NA | 3/21 | Yes | NA | COC in shallow gw | Yes |
| Benzene | 550 | 0.36 | Yes | NA | 2/27 | Yes | NA | | Yes |
| Bromodichloromethane | 78 | 0.17 | Yes | NA | 1/26 | No | NA | | No |
| 2-Butanone | 34 | 190 | No | NA | 1/22 | No | NA | | No |
| Carbon Disulfide | 4 | 100 | No | NA | 2/26 | Yes | NA | | No |
| Chlorobenzene | 100 | 3.9 | Yes | NA | 1/26 | No | NA | | No |
| Chloroform | 24 | 0.15 | Yes | NA | 3/26 | Yes | NA | | Yes |
| Chloromethane | 98 | 1.4 | Yes | NA | 1/26 | No | NA | | No |
| 1,1-Dichloroethane | 74 | 81 | No | NA | 1/26 | No | NA | | No |
| 1,2-Dichloroethane | 120 | 0.12 | Yes | NA | 2/26 | Yes | NA | | Yes |
| 1,1-Dichloroethene | 16 | 0.044 | Yes | NA | 1/25 | No | NA | COC in bedrock gw | Yes |
| 1,2-Dichloroethene (total) | 5,700 | 5.5 | Yes | NA | 19/30 | Yes | NA | | Yes |
| 1,2-Dichloropropane | 98 | 0.16 | Yes | NA | 1/25 | No | NA | | No |
| 1,3-Dichloropropene | 66 | 0.077 | Yes | NA | 1/25 | No | NA | | No |
| 1,1,2,2 Tetrachloroethane | 77,000 | 0.052 | Yes | NA | 18/30 | Yes | NA | | Yes |
| Tetrachloroethene | 1,000 | 1.1 | Yes | NA | 4/26 | Yes | NA | | Yes |
| Toluene | 96 | 75 | Yes | NA | 1/26 | No | NA | | No |
| 1,1,2-Trichloroethane | 1,200 | 0.19 | Yes | NA | 13/30 | Yes | NA | | Yes |
| Trichlorethene | 120,000 | 1.6 | Yes | NA | 19/29 | Yes | NA | | Yes |
| Vinyl chloride | 31 | 0.019 | Yes | NA | 3/26 | Yes | NA | | Yes |
| Xylenes (total) | 220 | 1,200 | Yes | NA | 1/26 | No | NA | | No |

NOTES:

NA Not applicable
ND No data
(1) Statistical comparisons of reported inorganic concentrations to background could not be made because no upgradient wells near Site 07 were sampled.
(2) RBC for hexavalent chromium, the most toxic form of chromium.
(3) RBC for manganese recalculated using the updated RfD for dietary exposures of 0.14 mg/kg-day from IRIS (1996).
(4) RBC for thallium carbonate, the lowest available RBC for a thallium compound.

## TABLE 6-5b. Selection of Chemicals of Concern from List of Detected Analytes in Bedrock Ground Water

| Chemical | Max. Conc. (μg/L) | Risk-Based Conc. (μg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | |
| Arsenic | 42 | 0.045 | Yes | ND | 1/5 | Yes | No | COC in deep gw | Yes |
| Barium | 123 | 260 | No | ND | 4/5 | Yes | No | | No |
| Calcium | 275,000 | ND | -- | ND | 5/5 | Yes | Yes | | No |
| Cobalt | 151 | 220 | No | ND | 4/5 | Yes | No | | No |
| Iron | 15,500 | ND | -- | ND | 5/5 | Yes | Yes | | No |
| Magnesium | 753,000 | ND | -- | ND | 5/5 | Yes | Yes | | No |
| Manganese (2) | 15,500 | 18 | Yes | ND | 5/5 | Yes | No | | Yes |
| Potassium | 203,000 | ND | -- | ND | 5/5 | Yes | Yes | | No |
| Sodium | 7,730,000 | ND | -- | ND | 5/5 | Yes | Yes | | No |
| Thallium (3) | 29 | 0.29 | Yes | ND | 3/4 | Yes | No | | Yes |
| Zinc | 56.9 | 1,100 | No | ND | 1/5 | Yes | No | | No |

| Chemical | Max. Conc. (µg/L) | Risk-Based Conc. (µg/L) | Max. > RBC? | Statistically Elevated above Background? (1) | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|---|
| **VOLATILES** | | | | | | | | | |
| Carbon Disulfide | 2 | 2.1 | No | NA | 1/5 | Yes | NA | | No |
| Chloroform | 48 | 0 15 | Yes | NA | 1/5 | Yes | NA | | Yes |
| 1,2-Dichloroethane | 1 | 0.12 | Yes | NA | 1/5 | Yes | NA | | Yes |
| 1,1-Dichloroethene | 21 | 0.044 | Yes | NA | 1/5 | Yes | NA | | Yes |
| 1,2-Dichloroethene (total) | 2,200 | 5.5 | Yes | NA | 3/5 | Yes | NA | | Yes |
| 1,1,2,2 Tetrachloroethane | 12,000 | 0.052 | Yes | NA | 3/5 | Yes | NA | | Yes |
| Tetrachloroethene | 51 | 1.1 | Yes | NA | 1/5 | Yes | NA | | Yes |
| 1,1,2-Trichloroethane | 390 | 0.19 | Yes | NA | 1/5 | Yes | NA | | Yes |
| Trichlorethene | 27,000 | 1.6 | Yes | NA | 3/5 | Yes | NA | | Yes |
| Vinyl chloride | 17 | 0.019 | Yes | NA | 1/5 | No | NA | COC in deep gw | Yes |

NOTES:

NA Not applicable
ND No data
(1) Statistical comparisons of reported inorganic concentrations to background could not be made because no upgradient wells near Site 07 were sampled.
(2) RBC for manganese recalculated using the updated RfD for dietary exposures of 0.14 mg/kg-day from IRIS (1996).
(3) RBC for thallium carbonate, the lowest available RBC for a thallium compound.

# TABLE 6-6. Selection of Chemicals of Concern from List of Detected Analytes in Shellfish

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | 0.0314 | 140 | No | 1 / 2 | Yes | No | | No |
| Arsenic | 2.50 | 0.018 | Yes | 6 / 6 | Yes | No | | YES |
| Cadmium | 2.39 | 0.068 | Yes | 6 / 6 | Yes | No | | YES |
| Chromium [1] | 0.704 | 0.68 | Yes | 5 / 6 | Yes | No | | YES |
| Copper | 126 | 5 | Yes | 6 / 6 | Yes | No | | YES |
| Iron | 800 | ND | - - | 6 / 6 | Yes | Yes | | No |
| Lead | 0.36 | ND | - - | 4 / 6 | Yes | No | | YES |
| Manganese [2] | 21.6 | 19 | Yes | 6 / 6 | Yes | No | Endpoint HI < 1 | No |
| Mercury | 49.1 | 0.041 | Yes | 4 / 4 | Yes | No | | YES |
| Nickel | 5.0 | 2.7 | Yes | 6 / 6 | Yes | No | Endpoint HI < 1 | No |
| Silver | 6.20 | 0.68 | Yes | 6 / 6 | Yes | No | Endpoint HI < 1 | No |
| Zinc | 4,730 | 41 | Yes | 6 / 6 | Yes | No | | YES |
| **SEMIVOLATILES** | | | | | | | | |
| Acenaphthene | 0.00846 | 8.1 | No | 2 / 2 | Yes | NA | | No |
| Acenaphthylene [3] | 0.00316 | 4.1 | No | 2 / 2 | Yes | NA | | No |
| Anthracene | 0.00625 | 41 | No | 6 / 6 | Yes | NA | | No |
| Benzo(a)anthracene | 0.003 | 0.0043 | No | 6 / 6 | Yes | NA | | No |
| Benzo(a)pyrene | 0.00606 | $4.3 \times 10^{-4}$ | Yes | 5 / 6 | Yes | NA | | YES |
| Benzo(b)fluoranthene [4] | 0.0358 | 0.0043 | Yes | 6 / 6 | Yes | NA | | YES |
| Benzo(e)pyrene [3] | 0.0374 | 4.1 | No | 6 / 6 | Yes | NA | | No |
| Benzo(g,h,i)perylene [3] | 0.0113 | 4.1 | No | 5 / 6 | Yes | NA | | No |
| Benzo(k)fluoranthene | 0.00596 | 0.043 | No | 2 / 2 | Yes | NA | | No |
| Benzotriazole | 0.0254 | ND | - - | 4 / 4 | Yes | NA | | YES |
| Chlorinated benzotriazole | 0.00362 | ND | - - | 4 / 4 | Yes | NA | | YES |

| Chemical | Max. Conc. (mg/kg) | Risk-Based Conc. (mg/kg) | Max. > RBC? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| Chrysene | 0.0893 | 0.43 | No | 6 / 6 | Yes | NA | | No |
| Coronene [3] | 0.00052 | 4.1 | No | 4 / 4 | Yes | NA | | No |
| Dibenzo(a,h)anthracene | 0.00128 | $4.3 \times 10^{-4}$ | Yes | 5 / 6 | Yes | NA | | YES |
| Fluoranthene | 0.216 | 5.4 | No | 6 / 6 | Yes | NA | | No |
| Fluorene | 0.0107 | 5.4 | No | 6 / 6 | Yes | NA | | No |
| Hexachlorobenzene | 0.00101 | 0.002 | No | 3 / 5 | Yes | NA | | No |
| Indeno(1,2,3-cd)pyrene | 0.00416 | 0.0043 | No | 5 / 6 | Yes | NA | | No |
| Perylene [3] | 0.00609 | 4.1 | No | 5 / 6 | Yes | NA | | No |
| Phenanthrene [3] | 0.062 | 4.1 | No | 6 / 6 | Yes | NA | | No |
| Pyrene | 0.0979 | 4.1 | No | 6 / 6 | Yes | NA | | No |
| **PESTICIDES / PCBs** | | | | | | | | |
| Aldrin | 0 000244 | $1.9 \times 10^{-4}$ | Yes | 1 / 2 | Yes | NA | | YES |
| alpha-BHC | 0.00007 | 0.0005 | No | 1 / 3 | Yes | NA | | No |
| gamma-BHC (Lindane) | 0.00004 | 0.0024 | No | 1 / 3 | Yes | NA | | No |
| alpha Chlordane [5] | 0.00042 | 0.0024 | No | 2 / 3 | Yes | NA | | No |
| gamma Chlordane [5] | 0.00054 | 0.0024 | No | 3 / 3 | Yes | NA | | No |
| 4,4'-DDD | 0.00697 | 0.013 | No | 2 / 3 | Yes | NA | | No |
| 4,4'-DDE | 0.0228 | 0.0093 | Yes | 4 / 5 | Yes | NA | | YES |
| 4,4'-DDT | 0.00025 | 0.0093 | No | 2 / 3 | Yes | NA | | No |
| Mirex | 0.0000928 | 0.0018 | No | 1 / 2 | Yes | NA | | No |
| Aroclor-1242 [6] | 0.022 | $4.1 \times 10^{-5}$ | Yes | 2 / 6 | Yes | NA | | YES |
| Aroclor-1254 [6] | 0.1335 | $4.1 \times 10^{-5}$ | Yes | 6 / 6 | Yes | NA | | YES |
| Aroclor-1260 [6] | 0.0849 | $4.1 \times 10^{-5}$ | Yes | 2 / 2 | Yes | NA | | YES |

NOTES:

NA Not applicable
ND No data
(1) RBC for hexavalent chromium, the most toxic form of chromium.
(2) RBC for manganese recalculated using the updated RfD for dietary exposures from IRIS (1996) of 0.14 mg/kg-day.
(3) RBC for pyrene, a structurally similar noncarcinogenic PAH, used for this chemical.
(4) For shellfish, some data were reported as "benzofluoranthene" without distinction between benzo(b)fluoranthene and benzo(k)fluoranthene. These data were treated as benzo(b)fluoranthene, the more toxic of the two compounds.
(5) RBC for chlordane applied to both alpha and gamma isomers.
(6) RBC for "PCBs" applied to all Aroclor mixtures.

# TABLE 6-7. Selection of Chemicals of Concern in Soil for Air Exposures Based on Transfers to Air from List of Detected Analytes in Soil

| Chemicals | Max. Conc. (mg/kg) | Soil Screening Level (mg/kg) | Max. > SSL? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | 7,720 | ND | - - | 26 / 26 | Yes | No | Not COC in soil | No |
| Antimony | 3.9 | ND | - - | 1 / 26 | No | No | Not COC in soil | No |
| Arsenic | 2.2 | 380 | No | 26 / 26 | Yes | No | | No |
| Barium | 18.6 | 350,000 | No | 26 / 26 | Yes | No | | No |
| Beryllium | 0.49 | 690 | No | 22 / 26 | Yes | No | | No |
| Cadmium | 4.7 | 920 | No | 2 / 26 | Yes | No | | No |
| Calcium | 8,390 | ND | - - | 26 / 26 | Yes | Yes | | No |
| Chromium [1] | 13.1 | 140 | No | 25 / 26 | Yes | No | | No |
| Cobalt | 6.1 | ND | - - | 26 / 26 | Yes | No | Not COC in soil | No |
| Copper | 14.6 | ND | - - | 22 / 26 | Yes | No | Not COC in soil | No |
| Cyanide | 0 16 | ND | - - | 1 / 26 | No | No | Not COC in soil | No |
| Iron | 15,600 | ND | - - | 26 / 26 | Yes | Yes | | No |
| Lead | 8.6 | ND | - - | 26 / 26 | Yes | No | | YES |
| Magnesium | 1,190 | ND | - - | 26 / 26 | Yes | Yes | | No |
| Manganese | 137 | ND | - - | 26 / 26 | Yes | No | Not COC in soil | No |
| Nickel | 243 | 6,900 | No | 17 / 26 | Yes | No | | No |
| Potassium | 1,230 | ND | - - | 23 / 26 | Yes | Yes | | No |
| Selenium | 0.32 | ND | - - | 12 / 26 | Yes | No | Not COC in soil | No |
| Sodium | 411 | ND | - - | 7 / 26 | Yes | Yes | | No |
| Thallium | 0 87 | ND | - - | 3 / 26 | Yes | No | Not COC in soil | No |
| Vanadium | 14 3 | ND | - - | 26 / 26 | Yes | No | Not COC in soil | No |

| Chemicals | Max. Conc. (mg/kg) | Soil Screening Level (mg/kg) | Max. > SSL? | Frequency of Detection | Frequency of Detection > 5%? | Essential nutrient? | Additional Considerations | COC? |
|---|---|---|---|---|---|---|---|---|
| Zinc | 33.6 | ND | - - | 24 / 26 | Yes | No | Not COC in soil | No |
| **SEMIVOLATILES** | | | | | | | | |
| Bis(2-ethylhexyl)phthalate | 0.38 | 210 | No | 2 / 8 | Yes | NA | | No |
| **VOLATILES** | | | | | | | | |
| Acetone | 6.1 | 62,000 | No | 8 / 37 | Yes | NA | | No |
| Chloroform | 0.001 | 0.2 | No | 1 / 37 | No | NA | | No |
| 1,1,2,2-Tetrachloroethane | 0.015 | 0.4 | No | 1 / 37 | No | NA | | No |
| Toluene | 0.003 | 520 | No | 2 / 37 | Yes | NA | | No |
| 1,1,1-Trichloroethane | 0.006 | 980 | No | 4 / 37 | Yes | NA | | No |
| Trichloroethene | 0.018 | 3 | No | 1 / 37 | No | NA | | No |
| **PESTICIDES / PCBs** | | | | | | | | |
| 4,4'-DDE | 0.019 | 10 | No | 1 / 14 | Yes | NA | | No |
| 4,4'-DDT | 0 022 | 80 | No | 1 / 14 | Yes | NA | | No |

NOTES:

NA Not applicable
ND No data
(1) SSL for hexavalent chromium, the most toxic form of chromium.

## TABLE 6-8. Summary of Background Data for Inorganics in Surface Soil

| Inorganic Chemical | Range of Concentrations at NCBC Davisville Background Locations (a) (mg/kg) | Range of Concentrations at Eastern U.S. Background Locations (b) (mg/kg) |
|---|---|---|
| Aluminum | 1,170 - 8,560 | 7 - 100,000 |
| Antimony | ND | ND - 8.8 |
| Arsenic | 0.59 - 8.1 | ND - 73 |
| Barium | 5.6 - 15.5 | 10 - 1,500 |
| Beryllium | ND - 0.66 | ND - 7 |
| Cadmium | ND - 0.46 | NA |
| Calcium | 62.7 - 627 | 100 - 280,000 |
| Chromium | 3.5 - 9.6 | 1 - 1,000 |
| Cobalt | ND - 4.6 | ND - 70 |
| Copper | 3.9 - 15 | ND - 700 |
| Cyanide | ND | NA |
| Iron | 3,810 - 12,000 | 100 - 100,000 |
| Lead | 3.4 - 53.8 | ND - 300 |
| Magnesium | 325 - 1,220 | 50 - 50,00 |
| Manganese | 21.8 - 150 | ND - 7,000 |
| Mercury | ND - 0.03 | ND - 3.4 |
| Nickel | ND - 5 | ND - 700 |
| Potassium | 145 - 728 | 50 - 37.000 |
| Selenium | ND - 0.77 | ND - 3.9 |
| Silver | ND - 0.06 | NA |
| Sodium | ND - 119 | ND - 50,000 |
| Thallium | ND | NA |
| Vanadium | 3.3 - 24.6 | ND - 300 |
| Zinc | 10.3 - 172 | ND - 2,900 |

NA Not available
ND Not detected
(a) Collected from unimpacted areas at or near Sites 02, 03, 05, 06, and 07 (data provided in TRC 1994).
(b) USGS (1984)

## TABLE 6-9. Summary of Chemicals of Concern in All Environmental Media

| Chemical of Concern | Total Soil | Surface Soil | Sediment | Shallow Ground Water | Deep Ground Water | Bedrock Ground Water | Surface Water | Shellfish | Air |
|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | |
| Aluminum | | | | ✔ | ✔ | | | | |
| Arsenic | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔ | |
| Beryllium | | | | ✔ | ✔ | | | | |
| Cadmium | | | | | | | | ✔ | |
| Chromium | | | | ✔ | ✔ | | | ✔ | |
| Copper | | | | ✔ | ✔ | | | ✔ | |
| Lead [1] | ✔ | ✔ | ✔ | ✔ | ✔ | | | ✔ | ✔ |
| Manganese | | | | ✔ | ✔ | ✔ | | | |
| Mercury | | | | | | | | ✔ | |
| Nickel | | | | ✔ | ✔ | | | | |
| Thallium | | | | ✔ | ✔ | ✔ | | | |
| Vanadium | | | | | ✔ | | | | |
| Zinc | | | | | | | | ✔ | |
| **SEMIVOLATILES** | | | | | | | | | |
| Benzo(a)pyrene | | | | | | | | ✔ | |
| Benzo(b)fluoranthene | | | | | | | | ✔ | |
| Benzotriazole [1] | | | | | | | | ✔ | |
| Chlorinated benzotriazole [1] | | | | | | | | ✔ | |
| Dibenzo(a,h)anthracene | | | | | | | | ✔ | |
| **VOLATILES** | | | | | | | | | |
| Acetone | | | | ✔ | ✔ | | | | |
| Benzene | | | | | ✔ | | | | |
| 2-Butanone | | | | | | | | | |
| Chlorobenzene | | | | | | | | | |
| Chloroform | | | | | ✔ | ✔ | | | |
| 1,4-Dichlorobenzene | | | | | | | | | |
| 1,2-Dichloroethane | | | | ✔ | ✔ | ✔ | | | |
| 1,1-Dichloroethene | | | | | ✔ | ✔ | | | |
| 1,2-Dichloroethene (total) | | | | ✔ | ✔ | ✔ | ✔ | | |
| 1,2-Dichloropropane | | | | | | | | | |
| Ethylbenzene | | | | | | | | | |
| Methylene chloride | | | | | | | | | |
| 1,1,2,2-Tetrachloroethane | | | | ✔ | ✔ | ✔ | ✔ | | |
| Tetrachloroethene | | | | ✔ | ✔ | ✔ | | | |
| Toluene | | | | | | | | | |
| 1,1,2-Trichloroethane | | | | ✔ | ✔ | ✔ | ✔ | | |

| Chemical of Concern | Total Soil | Surface Soil | Sediment | Shallow Ground Water | Deep Ground Water | Bedrock Ground Water | Surface Water | Shellfish | Air |
|---|---|---|---|---|---|---|---|---|---|
| Trichloroethene | | | | ✔ | ✔ | ✔ | ✔ | | |
| Vinyl chloride | | | | ✔ | ✔ | ✔ | | | |
| **PESTICIDES / PCBs** | | | | | | | | | |
| Aldrin | | | | | | | | ✔ | |
| 4,4′-DDE | | | | | | | | ✔ | |
| Aroclor-1242 | | | | | | | | ✔ | |
| Aroclor-1254 | | | | | | | | ✔ | |
| Aroclor-1260 | | | | | | | | ✔ | |

NOTES:

(1) Risks and hazards are discussed qualitatively because toxicity values (e.g., RfDs or SFs) were not available.

## TABLE 6-10. Summary Statistics for Chemicals of Concern in Total Soils

| Chemical of Concern | Frequency Detected | Range of Detection (mg/kg) | Arithmetic Mean (mg/kg) | 95 UCLM (mg/kg) |
|---|---|---|---|---|
| **INORGANICS** | | | | |
| Arsenic | 26 / 26 | 0.44 - 2.2 | 1.0 | 1.2 |
| Lead | 26 / 26 | 1.5 - 8.6 | 3.7 | 4.5 |

## TABLE 6-11. Summary Statistics for Chemicals of Concern in Surface Soil

| Chemical of Concern | Frequency Detected | Range of Detection (mg/kg) | Arithmetic Mean (mg/kg) | 95 UCLM (mg/kg) |
|---|---|---|---|---|
| **INORGANICS** | | | | |
| Arsenic | 16 / 16 | 0.44 - 1.5 | 1.0 | 1.2 |
| Lead | 16 / 16 | 2 - 8.6 | 4.3 | 5.3 |

## TABLE 6-12. Summary Statistics for Chemicals of Concern in Sediment

| Chemical of Concern | Frequency Detected | Range of Detection (mg/kg) | Arithmetic Mean (mg/kg) | 95 UCLM (mg/kg) |
|---|---|---|---|---|
| **INORGANICS** | | | | |
| Arsenic | 8 / 8 | 3 - 22.1 | 10 | 19 |
| Lead | 8 / 8 | 3 - 91.3 | 23 | 120 * |

NOTES:

"*" 95 UCLM exceeds highest measured value.

## TABLE 6-13. Summary Statistics for Chemicals of Concern in Shallow Ground Water

| Chemical of Concern | Frequency Detected | Range of Detection (mg/L) | Arithmetic Mean (mg/L) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | 5/20 | $1.46 \times 10^{-2}$ - $1.1 \times 10^{-1}$ | 0.0368 |
| Arsenic | 11/20 | $8.9 \times 10^{-4}$ - $4.69 \times 10^{-2}$ | 0.0067 |
| Beryllium | 1/20 | $3.5 \times 10^{-3}$ - $3.5 \times 10^{-3}$ | 0.0035 |
| Chromium | 1/14 | $4.2 \times 10^{-3}$ - $4.2 \times 10^{-3}$ | 0.0042 |
| Copper | 6/25 | $2.1 \times 10^{-3}$ - $1.21 \times 10^{-2}$ | 0.0051 |
| Lead | 5/5 | $1.0 \times 10^{-3}$ - $2.14 \times 10^{-2}$ | 0.0092 |
| Manganese | 22/25 | $7.1 \times 10^{-3}$ - $3.83 \times 10^{+0}$ | 0.624 |
| Nickel | 2/14 | $1.12 \times 10^{-2}$ - $1.9 \times 10^{-2}$ | 0.0151 |
| Thallium | 7/14 | $1.2 \times 10^{-3}$ - $2.93 \times 10^{-2}$ | 0.0106 |
| **VOLATILES** | | | |
| Acetone | 4/20 | $2.8 \times 10^{-2}$ - $1.8 \times 10^{+0}$ | 0.557 |
| 1,2-Dichloroethane | 1/24 | $3.0 \times 10^{-2}$ - $3.0 \times 10^{-2}$ | 0.03 |
| 1,2-Dichloroethene (total) | 5/24 | $1.0 \times 10^{-2}$ - $1.4 \times 10^{+0}$ | 0.576 |
| 1,1,2,2-Tetrachloroethane | 4/23 | $9.0 \times 10^{-3}$ - $1.5 \times 10^{+0}$ | 0.459 |
| Tetrachloroethene | 1/24 | $1.0 \times 10^{-3}$ - $1.0 \times 10^{-3}$ | 0.001 |
| 1,1,2-Trichloroethane | 3/24 | $3.0 \times 10^{-2}$ - $1.3 \times 10^{-1}$ | 0.067 |
| Trichloroethene | 5/24 | $7.0 \times 10^{-3}$ - $3.4 \times 10^{+0}$ | 0.805 |
| Vinyl chloride | 1/24 | $2.3 \times 10^{-2}$ - $2.3 \times 10^{-2}$ | 0.023 |

## TABLE 6-14a. Summary Statistics for Chemicals of Concern in Deep Ground Water

| Chemical of Concern | Frequency Detected | Range of Detection (mg/L) | Arithmetic Mean (mg/L) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | 7/22 | $4.01 \times 10^{-2}$ - $1.29 \times 10^{+2}$ | 25 |
| Arsenic | 6/25 | $1.5 \times 10^{-3}$ - $6.35 \times 10^{-2}$ | 0.015 |
| Beryllium | 3/20 | $3.8 \times 10^{-4}$ - $6.4 \times 10^{-3}$ | 0.0029 |
| Chromium | 3/12 | $1.14 \times 10^{-2}$ - $2.92 \times 10^{-1}$ | 0.121 |
| Copper | 6/29 | $4.7 \times 10^{-3}$ - $2.68 \times 10^{-1}$ | 0.0608 |
| Lead | 7/7 | $2.2 \times 10^{-3}$ - $1.25 \times 10^{-1}$ | 0.029 |
| Manganese | 31/31 | $8.15 \times 10^{-2}$ - $4.1 \times 10^{+0}$ | 1.35 |
| Nickel | 5/13 | $1.3 \times 10^{-2}$ - $3.2 \times 10^{-1}$ | 0.0983 |
| Thallium | 13/16 | $3.8 \times 10^{-3}$ - $3.16 \times 10^{-2}$ | 0.0162 |
| Vanadium | 3/20 | $1.22 \times 10^{-2}$ - $2.24 \times 10^{-1}$ | 0.101 |
| **VOLATILES** | | | |
| Acetone | 3/22 | $3.0 \times 10^{-2}$ - $1.9 \times 10^{-1}$ | 0.0923 |
| Benzene | 2/28 | $4.0 \times 10^{-2}$ - $5.5 \times 10^{-1}$ | 0.295 |
| Chloroform | 3/27 | $1.7 \times 10^{-2}$ - $2.4 \times 10^{-1}$ | 0.122 |
| 1,2-Dichloroethane | 2/27 | $4.0 \times 10^{-3}$ - $1.2 \times 10^{-1}$ | 0.062 |
| 1,1-Dichloroethene | 1/27 | $1.6 \times 10^{-2}$ - $1.6 \times 10^{-2}$ | 0.016 |
| 1,2-Dichloroethene (total) | 19/31 | $3.0 \times 10^{-3}$ - $5.7 \times 10^{+0}$ | 1.0 |
| 1,1,2,2-Tetrachloroethane | 19/31 | $6.0 \times 10^{-3}$ - $7.7 \times 10^{+1}$ | 15.9 |
| Tetrachloroethene | 5/27 | $8.4 \times 10^{-2}$ - $1.0 \times 10^{+0}$ | 0.581 |
| 1,1,2-Trichloroethane | 13/31 | $2.0 \times 10^{-3}$ - $1.2 \times 10^{+0}$ | 0.211 |
| Trichloroethene | 20/30 | $2.0 \times 10^{-3}$ - $1.2 \times 10^{+2}$ | 15.6 |
| Vinyl chloride | 3/27 | $1.0 \times 10^{-3}$ - $3.1 \times 10^{-2}$ | 0.015 |

## TABLE 6-14b. Summary Statistics for Chemicals of Concern in Bedrock Ground Water

| Chemical of Concern | Frequency Detected | Range of Detection (mg/L) | Arithmetic Mean (mg/L) |
|---|---|---|---|
| **INORGANICS** | | | |
| Arsenic | 1/5 | $4.2 \times 10^{-3}$ - $4.2 \times 10^{-3}$ | 0.0042 |
| Manganese | 5/5 | $7.67 \times 10^{-1}$ - $1.55 \times 10^{+1}$ | 4.04 |
| Thallium | 3/4 | $9.1 \times 10^{-3}$ - $2.9 \times 10^{-2}$ | 0.018 |
| **VOLATILES** | | | |
| Chloroform | 1/5 | $4.8 \times 10^{-2}$ - $4.8 \times 10^{-2}$ | 0.048 |
| 1,2-Dichloroethane | 1/5 | $1.0 \times 10^{-3}$ - $1.0 \times 10^{-3}$ | 0.001 |
| 1,1-Dichloroethene | 1/5 | $2.1 \times 10^{-2}$ - $2.1 \times 10^{-2}$ | 0.021 |
| 1,2-Dichloroethene (total) | 3/5 | $8.9 \times 10^{-1}$ - $2.2 \times 10^{+0}$ | 1.36 |
| 1,1,2,2-Tetrachloroethane | 3/5 | $5.1 \times 10^{-1}$ - $1.2 \times 10^{+1}$ | 4.74 |
| Tetrachloroethene | 1/5 | $5.1 \times 10^{-2}$ - $5.1 \times 10^{-2}$ | 0.051 |
| 1,1,2-Trichloroethane | 1/5 | $3.9 \times 10^{-1}$ - $3.9 \times 10^{-1}$ | 0.39 |
| Trichloroethene | 3/5 | $2.9 \times 10^{+0}$ - $2.7 \times 10^{+1}$ | 11.9 |
| Vinyl chloride | 1/24 | $1.7 \times 10^{-2}$ - $1.7 \times 10^{-2}$ | 0.017 |

## TABLE 6-15. Summary Statistics for Chemicals of Concern in Shellfish

| Chemical of Concern | Frequency Detected | Range of Detection (mg/kg) | Arithmetic Mean (mg/kg) | 95 UCLM (mg/kg) |
|---|---|---|---|---|
| **INORGANICS** | | | | |
| Arsenic | 6 / 6 | 0.27 - 2.5 | 1.1 | 6.1 * |
| Cadmium | 6 / 6 | 0.05 - 2.39 | 0.49 | 19 * |
| Chromium | 5 / 6 | 0.02 - 0.704 | 0.22 | 7.6 * |
| Copper | 6 / 6 | 1.69 - 126 | 26 | 3,700 * |
| Lead | 4 / 6 | 0.07 - 0.875 | 0.38 | 1.7 * |
| Mercury | 4 / 4 | 0.01 - 49.1 | 20 | NA |
| Zinc | 6 / 6 | 9.26 - 4,730 | 820 | NA |
| **SEMIVOLATILES** | | | | |
| Benzo(a)pyrene | 5 / 6 | $3\times10^{-4}$ - 0.00606 | 0.0017 | 0.011 * |
| Benzo(b)fluoranthene | 6 / 6 | 0.00371 - 0.0359 | 0.011 | 0.038 * |
| Benzotriazole | 4 / 4 | 0.00971 - 0.0254 | 0.021 | 0.053 * |
| Chlorinated benzotriazole | 4 / 4 | 0.00223 - 0.00362 | 0.0027 | 0.0037 * |
| Dibenzo(a,h)anthracene | 5 / 6 | $1.3\times10^{-4}$ - 0.00128 | 0.00064 | 0.0028 * |
| **PESTICIDES / PCBs** | | | | |
| Aldrin | 1 / 2 | $2.44\times10^{-4}$ - $<2.74\times10^{-4}$ | 0.00019 | NA |
| 4,4'-DDE | 4 / 5 | $<4\times10^{-5}$ - 0.0228 | 0.0064 | NA |
| Aroclor-1242 | 2 / 6 | <0.00082 - 0.022007 | 0.0074 | 5.9 * |
| Aroclor-1254 | 6 / 6 | 0.027 - 0.133501 | 0.058 | 0.13 |
| Aroclor-1260 | 2 / 2 | 0.0322 - 0.0849 | 0.059 | NA |

NOTES:

"*" 95 UCLM exceeds highest measured value.
"<" Indicates a nondetect at the given detection limit.
NA 95 UCLM could not be calculated because less than 3 data points were available or the estimated 95 UCLM exceeded $1\times10^{6}$ mg/kg.

## TABLE 6-16. Chemical and Environmental Fate Parameters for Chemicals of Concern

| Chemical | Molecular Formula | Molecular Weight (g/mol) | $K_{OC}$ (L/kg) | Henry's Law Constant (atm-m$^3$/mol) | Diffusivity in Air [1] (cm$^2$/s) | Relative Absorption Factors from Soil [2] | | Aqueous Dermal Permeability Constant [3] (cm/hr) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Oral | Dermal | |
| **INORGANICS** | | | | | | | | |
| Aluminum | Al | 26.98 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Antimony | Sb | 121.75 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Arsenic | As | 74.92 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Beryllium | Be | 9.012 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Cadmium | Cd | 112.4 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Chromium | Cr | 51.996 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Copper | Cu | 63.546 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Lead | Pb | 207.2 | NA | NA | NA | 0.3 / 0.5 | - - | $4\times10^{-6}$ |
| Manganese | Mn | 54.94 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Mercury | Hg | 200.59 | NA | $1.1\times10^{-2}$ | NA | 1 | - - | $1\times10^{-3}$ |
| Thallium | Th | 204.38 | NA | NA | NA | 1 | - - | $1\times10^{-3}$ |
| Zinc | Zn | 65.38 | NA | NA | NA | 1 | - - | $6\times10^{-4}$ |
| **SEMIVOLATILES** | | | | | | | | |
| Acenaphthene | $C_{12}H_{10}$ | 154.21 | $4.6\times10^{3}$ | $1.55\times10^{-4}$ [11] | $6\times10^{-2}$ | 1 | 0.05 | $1.5\times10^{-1}$ |
| Anthracene | $C_{14}H_{10}$ | 178.2 | $1.4\times10^{4}$ | $8.6\times10^{-5}$ | $5.8\times10^{-2}$ | 1 | 0.05 | $2.2\times10^{-1}$ |
| Benzo(a)anthracene | $C_{18}H_{12}$ | 228.29 | $2\times10^{5}$ | $1\times10^{-6}$ | NA | 1 | 0.05 | $8.1\times10^{-1}$ |
| Benzo(a)pyrene | $C_{20}H_{12}$ | 252.3 | $5.5\times10^{6}$ | $4.9\times10^{-7}$ | NA | 1 | 0.05 | 1.2 |
| Benzo(b)fluoranthene | $C_{20}H_{12}$ | 252.3 | $5.5\times10^{5}$ | $1.22\times10^{-5}$ | NA | 1 | 0.05 | 1.2 |
| Benzo(e)pyrene [11] | $C_{20}H_{12}$ | 252.3 | $1.6\times10^{7}$ | $1.07\times10^{-6}$ | NA | 1 | 0.05 | ND |
| Benzo(g,h,i)perylene | $C_{22}H_{12}$ | 276.34 | $1.6\times10^{6}$ | $1.44\times10^{-7}$ | NA | 1 | 0.05 | 1.6 |
| Benzo(k)fluoranthene | $C_{20}H_{12}$ | 252.3 | $5.5\times10^{5}$ | $3.87\times10^{-5}$ | NA | 1 | 0.05 | 1.1 |

| Chemical | Molecular Formula | Molecular Weight (g/mol) | $K_{oc}$ (L/kg) | Henry's Law Constant (atm-m$^3$/mol) | Diffusivity in Air [1] (cm$^2$/s) | Relative Absorption Factors from Soil [2] | | Aqueous Dermal Permeability Constant [3] (cm/hr) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Oral | Dermal | |
| Benzotriazole [11] | $C_6H_5N_3$ | 119.12 | ND | ND | ND | 1 | 0.05 | ND |
| Bis(2-chloroethyl)ether [11] | $C_4H_8Cl_2O$ | 143.01 | $2.4\times10^1$ | ND | $7.1\times10^{-2}$ | 1 | 0.05 | $2.1\times10^{-3}$ |
| Bis(2-chloroisopropyl)ether [11] | $C_6H_{12}Cl_2O$ | 171.07 | ND | ND | $6.2\times10^{-2}$ | 1 | 0.05 | ND |
| Carbazole [11] | $C_{12}H_9N$ | 167.2 | $6.37\times10^2$ | $8.65\times10^{-8}$ | NA | 1 | 0.05 | ND |
| Chlorinated benzotriazole [11] | NA | NA | ND | ND | NA | 1 | 0.05 | ND |
| Chrysene | $C_{18}H_{12}$ | 228.3 | $2\times10^5$ | $1.05\times10^{-6}$ | NA | 1 | 0.05 | $8.1\times10^{-1}$ |
| Coronene [11] | $C_{24}H_{12}$ | 300.36 | ND | ND | NA | 1 | 0.05 | ND |
| Dibenzo(a,h)anthracene | $C_{22}H_{14}$ | 278.35 | $3.3\times10^6$ | $7.3\times10^{-8}$ | NA | 1 | 0.05 | 2.7 |
| Dibenzofuran [11] | $C_{12}H_8O$ | 168.19 | $4.6\times10^3$ | $9.73\times10^{-5}$ | NA | 1 | 0.05 | $1.5\times10^{-1}$ |
| Fluoranthene | $C_{16}H_{10}$ | 202.26 | $3.8\times10^4$ | $6.5\times10^{-6}$ | NA | 1 | 0.05 | $3.6\times10^{-1}$ |
| Fluorene | $C_{13}H_{10}$ | 166.2 | $7.2\times10^3$ | $6.4\times10^{-5}$ | $5.8\times10^{-2}$ | 1 | 0.05 | $1.7\times10^{-1}$ |
| Indeno(1,2,3-cd)pyrene | $C_{22}H_{12}$ | 276.3 | $1.6\times10^6$ | $6.95\times10^{-8}$ | NA | 1 | 0.05 | 1.9 |
| 2-Methylphenol | $C_8H_{10}O$ | 108.14 | 10.7 | $1.2\times10^{-6}$ | NA | 1 | 0.05 | $1.57\times10^{-2}$ |
| 4-Methylphenol [11] | $C_8H_{10}O$ | 108.14 | $6.5\times10^2$ | $9.6\times10^{-7}$ | NA | 1 | 0.05 | $1.8\times10^{-2}$ |
| Naphthalene | $C_{10}H_8$ | 128.17 | $9.3\times10^2$ | $4.6\times10^{-4}$ | $6.8\times10^{-2}$ | 1 | 0.05 | $6.9\times10^{-2}$ |
| Perylene [11] | $C_{20}H_{12}$ | 252.3 | ND | ND | NA | 1 | 0.05 | ND |
| Phenanthrene | $C_{14}H_{10}$ | 178.2 | $1.4\times10^4$ | $2.26\times10^{-4}$ | $5.8\times10^{-2}$ | 1 | 0.05 | $2.3\times10^{-1}$ |
| Pyrene | $C_{16}H_{10}$ | 202.3 | $3.8\times10^4$ | $5.1\times10^{-6}$ | NA | 1 | 0.05 | $3.2\times10^{-1}$ |
| 2,3,7,8-TCDD | $C_{12}H_4Cl_4O_2$ | 321.98 | $2.5\times10^7$ [11] | $1.6\times10^{-5}$ [11] | NA | 0.3 | 0.05 | 1.4 |
| **VOLATILES** | | | | | | | | |
| Benzene | $C_6H_6$ | 78.11 | $7.9\times10^1$ | $5.5\times10^{-3}$ | $8.7\times10^{-2}$ | 1 | 0.5 | $2.1\times10^{-2}$ |
| 2-Butanone [11] | $C_4H_8O$ | 72.11 | "low" | "high" | $8.9\times10^{-2}$ | 1 | 0.5 | $5\times10^{-3}$ |
| Chlorobenzene [11] | $C_6H_5Cl$ | 112.56 | ND | $3.56\times10^{-3}$ | $7.7\times10^{-2}$ | 1 | 0.5 | $4.1\times10^{-2}$ |
| Chloroform | $CHCl_3$ | 119.38 | $4.47\times10^1$ | $3.67\times10^{-3}$ | $9.0\times10^{-2}$ | 1 | 0.05 | $8.9\times10^{-3}$ |

| Chemical | Molecular Formula | Molecular Weight (g/mol) | $K_{OC}$ (L/kg) | Henry's Law Constant (atm-m$^3$/mol) | Diffusivity in Air [1] (cm$^2$/s) | Relative Absorption Factors from Soil [2] | | Aqueous Dermal Permeability Constant [3] (cm/hr) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Oral | Dermal | |
| 1,4-Dichlorobenzene [H] | $C_6H_4Cl_2$ | 147.01 | $1.82\times10^3$ | $1.5\times10^{-3}$ | $7.1\times10^{-2}$ | 1 | 0.05 | $6.2\times10^{-2}$ |
| 1,2-Dichloroethane | $C_2H_4Cl_2$ | 98.96 | $1.91\times10^1$ | $4.5\times10^{-2}$ | $8.9\times10^{-2}$ | 1 | 0.5 | $5.3\times10^{-3}$ |
| 1,2-Dichloroethene(total) | $C_2H_2Cl_2$ | 96.94 | $4.9\times10^1$ | $9.38\times10^{-3}$ | $9.1\times10^{-2}$ | 1 | 0.5 | $1\times10^{-2}$ |
| 1,2-Dichloropropane | $C_3H_6Cl_2$ | 112.99 | $4.68\times10^1$ | $2.07\times10^{-3}$ | $8\times10^{-2}$ | 1 | 0.5 | $1\times10^{-2}$ |
| Ethylbenzene [H] | $C_8H_{10}$ | 106.16 | $1.64\times10^2$ | $8.44\times10^{-3}$ | $7.1\times10^{-2}$ | 1 | 0.5 | $7.4\times10^{-2}$ |
| Methylene chloride | $CH_2Cl_2$ | 84.93 | $3.2\times10^2$ | $2.03\times10^{-3}$ | ND | 1 | 0.5 | $4.5\times10^{-3}$ |
| 1,1,2,2-Tetrachloroethane | $C_2H_2Cl_4$ | 167.85 | $4.6\times10^1$ | $3.8\times10^{-4}$ | $7.3\times10^{-2}$ | 1 | 0.5 | $9.0\times10^{-3}$ |
| Toluene | $C_6H_5CH_3$ | 92.15 | $2.95\times10_2$ | $6.66\times10^{-3}$ | $7.8\times10^{-2}$ | 1 | 0.5 | $4.5\times10^{-2}$ |
| 1,1,2-Trichloroethane [H] | $C_2H_3Cl_3$ | 133.42 | $7\times10^1$ | $8.2\times10^{-4}$ | $8.2\times10^{-2}$ | 1 | 0.5 | $8.4\times10^{-3}$ |
| Trichloroethene | $C_2HCl_3$ | 131.4 | $1\times10^2$ [H] | $1.1\times10^{-2}$ | $8.1\times10^{-2}$ | 1 | 0.5 | $1.6\times10^{-2}$ |
| Vinyl chloride | $C_2H_3Cl$ | 62.5 | $9.8\times10^1$ | 1.2 | $1.1\times10^{-1}$ | 1 | 0.5 | $7.3\times10^{-3}$ |
| **PESTICIDES / PCBs** | | | | | | | | |
| Aldrin | $C_{12}H_8Cl_6$ | 364.3 | $4.9\times10^4$ | $3.2\times10^{-4}$ | $5.1\times10^{-2}$ | 0.3 | 0.05 | $1.6\times10^{-3}$ |
| 4,4'-DDE | $C_{14}H_8Cl_4$ | 318.03 | $4.4\times10^6$ | $6.8\times10^{-5}$ | $4.8\times10^{-2}$ | 0.3 | 0.05 | $2.6\times10^{-1}$ |
| Aroclor-1242 [H] | NA | 261 | $1.5\times10^5$ | $3.43\times10^{-4}$ | ND | 0.3 | 0.05 | ND |
| Aroclor-1254 [H] | NA | 327 | $1.3\times10^6$ | $2.83\times10^{-4}$ | ND | 0.3 | 0.05 | ND |
| Aroclor-1260 [H] | NA | 375.7 | $1\times10^6$ | $3.4\times10^{-4}$ | ND | 0.3 | 0.05 | ND |

NOTES:

NA Not applicable
ND No data
(A) Values obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for each chemical unless otherwise noted.
(H) Values obtained from the Hazardous Substances Database (HSDB 1995) profile for that chemical.
(1) Calculated according to methodology given in EPA (1988); values listed only for identified volatile COCs in air.
(2) EPA (1994a)
(3) EPA (1992c)

## TABLE 6-17. Summary of Toxicity Values for Chemicals of Concern

| Chemical | Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$ | | | Toxicity Values for Health Effects Other Than Cancer (mg/kg-day) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Subchronic | | | Chronic | | |
| | Ingestion | Inhalation | Dermal [I] | Ingestion | Inhalation | Dermal [I] | Ingestion | Inhalation | Dermal [I] |
| **INORGANICS** | | | | | | | | | |
| Aluminum | NA | | | 1 [X] | 1 [X] | NA | 1 [S] | 1 [X] | NA |
| Antimony | NA | | | $4\times10^{-4}$ [X] | $4\times10^{-4}$ [X] | NA | $4\times10^{-4}$ [I] | $4\times10^{-4}$ [X] | NA |
| Arsenic | 1.8 [I] | 15 [I] | NA | $3\times10^{-4}$ [X] | $3\times10^{-4}$ [X] | NA | $3\times10^{-4}$ [I] | $3\times10^{-4}$ [X] | NA |
| Beryllium | 4.3 [I] | 8.4 [I] | NA | $5\times10^{-3}$ [X] | $5\times10^{-3}$ [X] | NA | $5\times10^{-3}$ [I] | $5\times10^{-3}$ [X] | NA |
| Cadmium | NA | 6.3 [I] | NA | $1\times10^{-3}$ [f,X]<br>$5\times10^{-4}$ [w,X] | $5\times10^{-4}$ [X] | NA | $1\times10^{-3}$ [f,I]<br>$5\times10^{-4}$ [w,I] | $5\times10^{-4}$ [X] | NA |
| Chromium VI | NA | 42 [I] | NA | $2\times10^{-2}$ [H] | $2\times10^{-2}$ [X] | NA | $5\times10^{-3}$ [I] | $5\times10^{-3}$ [X] | NA |
| Copper | NA | | | $3.7\times10^{-2}$ [I] | NA | NA | $3.7\times10^{-2}$ [I] | NA | NA |
| Lead | NA | | | NA | | | NA | | |
| Manganese | NA | | | $5\times10^{-3}$ [w,H]<br>$1.4\times10^{-1}$ [f,H] | $5\times10^{-3}$ [X] | NA | $5\times10^{-3}$ [w,I]<br>$1.4\times10^{-1}$ [f,I] | $5\times10^{-3}$ [x] | NA |
| Mercury | NA | | | $3\times10^{-4}$ [H] | $8.6\times10^{-5}$ [H] | NA | $3\times10^{-4}$ [I] | $8.6\times10^{-5}$ [I] | NA |
| Thallium | NA | | | $8\times10^{-4}$ [H] | $8\times10^{-4}$ [X] | NA | $8\times10^{-5}$ [I] | $8\times10^{-5}$ [X] | NA |
| Zinc | NA | | | NA | NA | NA | 0.3 [I] | 0.3 [X] | NA |
| **SEMIVOLATILES** | | | | | | | | | |
| Acenaphthene | NA | | | $6\times10^{-1}$ [H] | $6\times10^{-1}$ [X] | $9\times10^{-2}$ | $6\times10^{-2}$ [I] | $6\times10^{-2}$ [X] | $9\times10^{-3}$ |
| Anthracene | NA | | | 3 [H] | 3 [X] | $4.5\times10^{-1}$ | $3\times10^{-1}$ [I] | $3\times10^{-1}$ [X] | $4.5\times10^{-2}$ |
| Benzo(a)anthracene | 7.3 [R] | NA | NA | NA | | | NA | | |
| Benzo(a)pyrene | 7.3 [R] | NA | NA | NA | | | NA | | |
| Benzo(b)fluoranthene | 7.3 [R] | NA | NA | NA | | | NA | | |
| Benzo(g,h,i)perylene | NA | | | Toxicity values for pyrene, a structurally similar analogue, were used. | | | | | |
| Benzo(k)fluoranthene | 7.3 [R] | NA | NA | NA | | | NA | | |

| Chemical | Cancer Slope Factor (mg/kg-day)$^{-1}$ | | | Toxicity Values for Health Effects Other Than Cancer (mg/kg-day) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Subchronic | | | Chronic | | |
| | Ingestion | Inhalation | Dermal [1] | Ingestion | Inhalation | Dermal [1] | Ingestion | Inhalation | Dermal [1] |
| Benzotriazole | NA | | | NA | | | NA | | |
| Bis(2-chloroethyl)ether | 1.1 [H] | 1.1 [H] | 2.2 | NA | | | NA | | |
| Bis(2-chloroisopropyl)ether | $7\times10^{-2}$ [H] | $3.5\times10^{-2}$ [H] | $2.8\times10^{-1}$ | $4\times10^{-2}$ [H] | $4\times10^{-2}$ [X] | $2\times10^{-2}$ | $4\times10^{-2}$ [X] | $4\times10^{-2}$ [X] | $2\times10^{-2}$ |
| Carbazole | $2\times10^{-2}$ [H] | NA | NA | NA | | | NA | | |
| Chlorinated benzotriazole | NA | | | NA | | | NA | | |
| Chrysene | 7.3 [R] | NA | NA | NA | | | NA | | |
| Dibenzo(a,h)anthracene | 7.3 [R] | NA | NA | NA | | | NA | | |
| Dibenzofuran | NA | | | $4\times10^{-3}$ [X] | $4\times10^{-3}$ [X] | $2\times10^{-3}$ | $4\times10^{-3}$ [E] | $4\times10^{-3}$ [X] | $2\times10^{-3}$ |
| Fluoranthene | NA | | | $4\times10^{-1}$ [H] | $4\times10^{-1}$ [X] | $6\times10^{-2}$ | $4\times10^{-2}$ [I] | $4\times10^{-2}$ [X] | $6\times10^{-3}$ |
| Fluorene | NA | | | $4\times10^{-1}$ [H] | $4\times10^{-1}$ [X] | $6\times10^{-2}$ | $4\times10^{-2}$ [I] | $4\times10^{-2}$ [X] | $6\times10^{-3}$ |
| Indeno(1,2,3-cd)pyrene | 7.3 [R] | NA | NA | NA | | | NA | | |
| 2-Methylphenol | NA | | | $5\times10^{-1}$ [H] | $5\times10^{-1}$ [X] | $4\times10^{-1}$ | $5\times10^{-2}$ [I] | $5\times10^{-2}$ [X] | $4\times10^{-2}$ |
| 4-Methylphenol | NA | | | $5\times10^{-2}$ [H] | $5\times10^{-2}$ [X] | $4\times10^{-2}$ | $5\times10^{-3}$ [H] | $5\times10^{-3}$ [X] | $4\times10^{-3}$ |
| Naphthalene | NA | | | $4\times10^{-2}$ [S] | $4\times10^{-2}$ [X] | $3.2\times10^{-2}$ | $4\times10^{-2}$ [S] | $4\times10^{-2}$ [X] | $3.2\times10^{-2}$ |
| Phenanthrene | NA | | | Toxicity values for pyrene, a structurally similar analogue, were used. | | | | | |
| Pyrene | NA | | | $3\times10^{-1}$ [H] | $3\times10^{-1}$ [X] | $4.5\times10^{-2}$ | $3\times10^{-2}$ [I] | $3\times10^{-2}$ [X] | $4.5\times10^{-3}$ |
| 2,3,7,8-TCDD | $1.5\times10^{5}$ [H] | $1.5\times10^{5}$ [H] | $2\times10^{5}$ | NA | | | NA | | |
| **VOLATILES** | | | | | | | | | |
| Acetone | NA | | | 1 [H] | 1 [X] | $8\times10^{-1}$ | $1\times10^{-1}$ [I] | $1\times10^{-1}$ [X] | $8\times10^{-2}$ |
| Benzene | $2.9\times10^{-2}$ [I] | $2.9\times10^{-2}$ [I] | $3.1\times10^{-2}$ | NA | | | NA | | |
| 2-Butanone | NA | | | $2\times10^{-1}$ [H] | $2.9\times10^{-1}$ [H] | $5.4\times10^{-1}$ | $6\times10^{-1}$ [I] | $2.9\times10^{-1}$ [I] | $5.4\times10^{-1}$ |
| Chlorobenzene | NA | | | $2\times10^{-2}$ [X] | $5.7\times10^{-3}$ [X] | $1.8\times10^{-2}$ | $2\times10^{-2}$ [I] | $5.7\times10^{-3}$ [I] | $1.8\times10^{-2}$ |
| Chloroform | $6.1\times10^{-3}$ | $8\times10^{-2}$ | $6.1\times10^{-3}$ | $1\times10^{-2}$ | $1\times10^{-2}$ | $1\times10^{-2}$ | $1\times10^{-2}$ | $1\times10^{-2}$ | $1\times10^{-2}$ |
| 1,4-Dichlorobenzene | $2.4\times10^{-2}$ [I] | NA | $4.8\times10^{-2}$ | NA | $7\times10^{-1}$ [H] | NA | NA | $2.3\times10^{-1}$ [I] | NA |

| Chemical | Cancer Slope Factor (mg/kg-day)$^{-1}$ | | | Toxicity Values for Health Effects Other Than Cancer (mg/kg-day) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Subchronic | | | Chronic | | |
| | Ingestion | Inhalation | Dermal [I] | Ingestion | Inhalation | Dermal [I] | Ingestion | Inhalation | Dermal [I] |
| 1,2-Dichloroethane | $9.1\times10^{-2}$ [I] | $9.1\times10^{-2}$ [I] | $1\times10^{-1}$ | NA | | | NA | | |
| 1,2-Dichloroethene (total) | NA | | | $9\times10^{-3}$ [H] | $9\times10^{-3}$ [X] | $8\times10^{-3}$ | $9\times10^{-3}$ [H] | $9\times10^{-3}$ [X] | $8\times10^{-3}$ |
| 1,2-Dichloropropane | $6.8\times10^{-2}$ [I] | $6.8\times10^{-2}$ [X] | $7.6\times10^{-2}$ | NA | $3.7\times10^{-3}$ [H] | NA | NA | $1.1\times10^{-3}$ [I] | NA |
| Ethylbenzene | NA | | | $1\times10^{-1}$ [X] | $2.9\times10^{-1}$ [X] | $9.2\times10^{-2}$ | $1\times10^{-1}$ [I] | $2.9\times10^{-1}$ [I] | $9.2\times10^{-2}$ |
| Methylene chloride | $7.5\times10^{-3}$ [I] | $1.6\times10^{-3}$ [I] | $7.8\times10^{-3}$ | $6\times10^{-2}$ [H] | $8.6\times10^{-1}$ [H] | $5.8\times10^{-2}$ | $6\times10^{-2}$ [I] | $8.6\times10^{-1}$ [I] | $5.8\times10^{-2}$ |
| 1,1,2,2-Tetrachloroethane | $2\times10^{-1}$ [I] | $2\times10^{-1}$ [I] | $2.2\times10^{-1}$ | NA | | | NA | | |
| Toluene | NA | | | 2 [H] | $3\times10^{-1}$ [S] | 1.8 | $2\times10^{-1}$ [I] | $1.1\times10^{-1}$ [I] | $1.8\times10^{-1}$ |
| 1,1,2-Trichloroethane | $5.7\times10^{-2}$ [I] | $5.7\times10^{-2}$ [I] | $6.3\times10^{-2}$ | $4\times10^{-2}$ [H] | $4\times10^{-2}$ [X] | $3.6\times10^{-2}$ | $4\times10^{-3}$ [I] | $4\times10^{-3}$ [X] | $3.6\times10^{-3}$ |
| Trichloroethene | $1.1\times10^{-2}$ [S] | $6\times10^{-3}$ [S] | $1.1\times10^{-2}$ | $6\times10^{-3}$ [E] | $6\times10^{-3}$ [X] | $5.4\times10^{-3}$ | $6\times10^{-3}$ [E] | $6\times10^{-3}$ [X] | $5.4\times10^{-3}$ |
| Vinyl chloride | 1.9 [H] | $3\times10^{-1}$ [H] | 2.1 | NA | | | NA | | |
| **PESTICIDES / PCBs** | | | | | | | | | |
| Aldrin | 17 [I] | 17 [I] | 21 | $3\times10^{-5}$ [X] | $3\times10^{-5}$ [X] | $2.4\times10^{-5}$ | $3\times10^{-5}$ [I] | $3\times10^{-5}$ [X] | $2.4\times10^{-5}$ |
| 4,4'-DDE | $3.4\times10^{-1}$ [I] | $3.4\times10^{-1}$ [X] | $4.3\times10^{-1}$ | NA | | | NA | | |
| Aroclor-1242 | 7.7 [E] | 7.7 [X] | 9.6 | $2\times10^{-5}$ [X] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ | $2\times10^{-5}$ [X] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ |
| Aroclor-1254 | 7.7 [E] | 7.7 [X] | 9.6 | $2\times10^{-5}$ [X] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ | $2\times10^{-5}$ [E] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ |
| Aroclor-1260 | 7.7 [E] | 7.7 [X] | 9.6 | $2\times10^{-5}$ [X] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ | $2\times10^{-5}$ [X] | $2\times10^{-5}$ [X] | $1.6\times10^{-5}$ |

NOTES:

NA Toxicity value not available.
(1) Dermal SFs were estimated by dividing oral SFs by the oral absorption fraction of the particular COC; dermal RfDs were estimated by multiplying the oral RfD by the oral absorption fraction of the particular COC (EPA 1989a).
(d) Value for use wtih exposures via dietary exposures (i.e., ingestion of food and water).
(f) Value for use with exposures via ingestion of food (and, by extrapolation, soil).
(s) Value for use with exposures via nondietary exposures (i.e., ingestion of soil and sediment).
(w) Value for use with exposures via ingestion of water.
(E) Value obtained from EPA Region III RBC tables (EPA 1995b).
(H) Value obtained from HEAST (EPA 1994b).
(I) Value obtained from IRIS (EPA 1995a).
(R) Value obtained from EPA Region I guidance (EPA 1994a).
(S) Value obtained from Superfund Technical Support Center, Cincinnati, Oholio (EPA 1995c).
(X) Assigned surrogate value (e.g., from oral to inhalation or from chronic to subchronic). Refer to Section 6.3.

## TABLE 6-18. Summary of Exposure Parameter Values Used in Estimating Exposures under all Exposure Scenarios

| Parameter | Value to Estimate: AE | Value to Estimate: RME | Rationale | Reference |
|---|---|---|---|---|
| **Global variables** | | | | |
| *Body Weight (kg)* | | | | |
| - Construction and Residential | 70 | 70 | Average of males and females between 18 and 65 years. | EPA 1989b |
| - Recreation (Youth) | 36 | 36 | Weighted average of males and females between 2 and 18 years. | EPA 1990a |
| - Shellfishing | 33 | 59 | Weighted averages of children and adults assuming 9 and 30 year exposures. | EPA 1994a |
| *Exposure Duration (yr)* | | | | |
| - Construction | 1 | 1 | Construction activity to be completed in one year; appropriate value for use in averaging subchronic exposures. | BPJ |
| - Recreation (yr) | 16 | 16 | Time period between ages 2 and 18. | BPJ |
| - Shellfishing and Residential (yr) | 9 | 30 | Median and upper-bound time at one residence, adults. | EPA 1994a |
| *Averaging Time (days)* | | | | |
| - Cancer risks | 25,550 | 25,550 | Based on 70 year life expectance. | EPA 1989b |
| - Noncancer risks | | | | |
| Construction | 365 | 365 | Based on exposure duration. | EPA 1989b |
| Recreation | 5,840 | 5,840 | Based on exposure duration. | EPA 1989b |
| Shellfishing and Residential | 3,285 | 10,950 | Based on exposure duration. | EPA 1989b |
| *Relative Absorption Factors* | | | | |
| - Ingestion of soil and shellfish | | | | EPA 1989b |
| VOCs | 1 | | | |
| PAHs | 1 | | | |
| PCBs | 0.3 | | | |
| Pesticides | 0.3 or 1 | | For chemicals with high and low sorption to soil, respectively. | |
| Inorganics | 1 | | | |
| Lead | 0.3 or 0.5 | | For adults and children, respectively. | |
| - Dermal contact with soil | | | | |
| VOCs | 0.5 | | | EPA 1989b |
| PAHs | 0.05 | | | |
| PCBs | 0.05 | | | |
| Pesticides | 0.05 or 0.5 | | For chemicals with high and low sorption to soils, respectively. | |
| Inorganics | negligible | | | |

| Parameter | Value to Estimate: AE | Value to Estimate: RME | Rationale | Reference |
|---|---|---|---|---|
| *Relative Absorption Factors (Continued)* | | | | |
| - Inhalation of dust and volatiles | 1 | | For all chemicals. | EPA 1989b |
| - Ingestion of ground water | 1 | | For all chemicals. | EPA 1989b |
| *Adherence Factor for Soil (mg/cm²)* | 0.5 | | Based on Region I review of soil adherence to hands. | EPA 1989b |
| *Fraction of Exposed Skin that Contacts Soil* | 0.5 | | | EPA 1989b |
| **Future Construction Scenario** | | | | |
| *Exposure Time (hr/day)* | 8 | 8 | Assumes an 8-hour work day | BPJ |
| *Exposure Frequency (day/yr)* | 65 | 85 | Assumes exposures during weekdays during the 3 and 4 months required to complete construction project. | BPJ |
| *Ingestion of Soil* | | | | |
| - Ingestion rate (mg/day) | 100 | 480 | AE is twice the EPA default value for "noncontact" worker; RME is default for contact intensive worker. | EPA 1994a |
| *Dermal Contact with Soil* | | | | |
| - Available skin surface area (cm²) | 1,980 | 3,780 | AE assumes contact with hands and forearms; RME assumes contact with face, hands and arms. | EPA 1992c |
| *Incidental Ingestion of Ground Water* | | | | |
| - Ingestion rate (L/d) | 0.025 | 0.05 | RME value is derived from assumptions about incidental ingestion of water while swimming and is thought to overstate likely exposures; AE value is one-half the RME value. | EPA 1989a |
| **Future Recreational Use Scenario** | | | | |
| *Exposure Time (hr/day)* | | | | |
| - Showering | 0.12 | 0.20 | Average and upper-bound showering times. | EPA 1989a |
| - Swimming | 0.5 | 1 | Recommended values for recreational and competitive swimmers, respectively. | EPA 1992c |
| *Exposure Frequency (day/yr)* | | | | |
| - Showering and Swimming | 13 | 39 | Assumes 1 or 3 swimming events per week during the three summer months. | BPJ |
| - Non-swimming Related Pathways | 36 | 144 | Assumes 1 or 4 events per week during the nine warmer months. | BPJ |

| Parameter | Value to Estimate: AE | Value to Estimate: RME | Rationale | Reference |
|---|---|---|---|---|
| *Incidental Ingestion of Soil*<br>- Ingestion rate (mg/day) | 62 | 126 | AE is the weighted average of central tendency soil ingestion rates of 100 mg/day from age 2 to 6 and 50 mg/day beyond that.. RME is the weighted average of reasonable maximum soil ingestion rates of 200 mg/day from age 2 to 6 and 100 mg/day beyond that. | EPA 1994a |
| *Dermal Contact with Soil*<br>- Available skin surface area ($cm^2$) | 760 | 925 | AE assumes contact with hands and forearms; RME assumes contact with face, hands and arms. | EPA 1992c |
| *Incidental Ingestion of Sediments*<br>- Ingestion rate (mg/day) | 31 | 63 | Values are one-half those for soil ingestion, assuming that sediments are more likely to be washed off. AE is one-half the weighted average of central tendency soil ingestion rates of 100 mg/d from age 2 to 6 and 50 mg/d beyond that. RME is one-half the weighted average of reasonable maximum soil ingestion rates of 200 mg/d from age 2 to 6 and 100 mg/d beyond that. | BPJ/<br>EPA 1994a |
| *Dermal Contact with Sediments*<br>- Available skin surface area ($cm^2$) | 380 | 463 | AE is a weighted average of median values assuming exposure to feet and hands; RME is a weighted average of 95th percentile values assuming exposure to feet and hands. Both based on data for male children aged 2 to 18. | EPA 1990a/<br>EPA 1992c |
| *Dermal Contact with Ground Water (Showering)*<br>- Available skin surface area ($cm^2$) | 11,800 | 14,600 | Weighted average of 50th and 95th percentile total body surface areas for male children aged 2 to 18, respectively. | EPA 1992c |
| *Inhalation of VOCs (Using Region I "Dose-Equivalent" Approach)*<br>- Contact rate (L/d) | 2 | 2 | Default Region I value for use in this "dose-equivalent" approach. | EPA 1994d |
| *Incidental Ingestion of Surface Water*<br>- Ingestion rate (L/d) | 0.025 | 0.050 | RME is defaut value, AE is one-half the RME | EPA 1989a |
| *Dermal Contact with Surface Water (Swimming)*<br>- Available skin surface area ($cm^2$) | 20,000<br>8,660 | 23,000<br>10,600 | Mean and maximum total body surface areas for adult males<br>Median and 95th percentile values for body surface areas of 6-year old male children. | EPA 1992c<br>EPA 1990 |

| Parameter | Value to Estimate: | | Rationale | Reference |
|---|---|---|---|---|
| | AE | RME | | |
| **Consumption of Locally-Caught Shellfish Scenario** | | | | |
| *Exposure Frequency (day/yr)* | 350 | 350 | Default value to use with daily average consumption rates. | EPA 1994a |
| *Ingestion Rate (g/day)* | 3 | 55 | Values for New England shellfish consumption. | EPA 1994a |
| *Fraction of Ingested Shellfish Caught Locally* | 1 | 1 | Conservative assumption in absence of site-specific data. | BPJ |
| **Hypothetical Residential Consumption of Ground Water Scenario** | | | | |
| *Exposure Frequency (day/yr)* | 350 | 350 | Default value for residential scenarios. | EPA 1994a |
| *Consumption Rate (L/day)* | 1.4 | 2 | Standard values for AE and RME. | EPA 1989a |

NOTES:

BPJ Best professional judgment

## TABLE 6-19. Exposure Point Concentrations for Chemicals of Concern in Total Soils

| Chemical of Concern | Exposure Point Concentration (mg/kg) (1) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Arsenic | 1.2 | 1.2 |
| Lead | 4.5 | 4.5 |

NOTES:

(1) Following EPA guidance (EPA 1994a), the 95 UCLM was used to estimate both average and reasonable maximum exposures.

## TABLE 6-20. Exposure Point Concentrations for Chemicals of Concern in Surface Soils

| Chemical of Concern | Exposure Point Concentration (mg/kg) [1] | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Arsenic | 1.2 | 1.2 |
| Lead | 5.3 | 5.3 |

NOTES:

(1) Following EPA guidance (EPA 1994a), the 95 UCLM was used to estimate both average and reasonable maximum exposures.

## TABLE 6-21. Exposure Point Concentrations for Chemicals of Concern in Sediment

| Chemical of Concern | Exposure Point Concentration (mg/kg) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Arsenic | 22 | 10 |
| Lead | 91 | 23 |

## TABLE 6-22. Exposure Point Concentrations for Chemicals of Concern in Shallow Ground Water

| Chemical of Concern | Exposure Point Concentration (mg/L) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Aluminum | 0.11 | 0.0368 |
| Arsenic | 0.0469 | 0.00672 |
| Beryllium | 0.001825 | 0.0035 |
| Chromium | 0.0073 | 0.0042 |
| Copper | 0.0121 | 0.00512 |
| Lead | 0.0214 | 0.0092 |
| Manganese | 3.83 | 0.624 |
| Nickel | 0.019 | 0.0151 |
| Thallium | 0.0293 | 0.0106 |
| **VOLATILES** | | |
| Acetone | 1.8 | 0.557 |
| 1,2-Dichloroethane | 0.25 | 0.03 |
| 1,2-Dichloroethene (total) | 1.4 | 0.576 |
| 1,1,2,2-Tetrachloroethane | 1.5 | 0.459 |
| Tetrachloroethene | 0.25 | 0.001 |
| 1,1,2-Trichloroethane | 0.13 | 0.067 |
| Trichloroethene | 3.4 | 0.805 |
| Vinyl chloride | 0.25 | 0.023 |

## TABLE 6-23a. Exposure Point Concentrations for Chemicals of Concern in Deep Ground Water

| Chemical of Concern | Exposure Point Concentration (mg/L) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Aluminum | 129 | 25 |
| Arsenic | 0.03238 | 0.015 |
| Beryllium | 0.0064 | 0.00289 |
| Chromium | 0.292 | 0.121 |
| Copper | 0.135 | 0.0608 |
| Lead | 0.125 | 0.029 |
| Manganese | 3.51 | 1.35 |
| Nickel | 0.32 | 0.0983 |
| Thallium | 0.0316 | 0.0162 |
| Vanadium | 0.224 | 0.101 |
| **VOLATILES** | | |
| Acetone | 2.5 | 0.0923 |
| Benzene | 2.5 | 0.295 |
| Chloroform | 2.5 | 0.122 |
| 1,2-Dichloroethane | 2.5 | 0.062 |
| 1,1-Dichloroethene | 2.5 | 0.016 |
| 1,2-Dichloroethene (total) | 5.7 | 1 |
| 1,1,2,2-Tetrachloroethane | 77 | 15.9 |
| Tetrachloroethene | 2.5 | 0.581 |
| 1,1,2-Trichloroethane | 2.5 | 0.211 |
| Trichloroethene | 120 | 15.6 |
| Vinyl chloride | 2.5 | 0 015 |

## TABLE 6-23b. Exposure Point Concentrations for Chemicals of Concern in Bedrock Ground Water

| Chemical of Concern | Exposure Point Concentration (mg/L) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Arsenic | 0.0042 | 0.0042 |
| Manganese | 15.5 | 4.04 |
| Thallium | 0 029 | 0.018 |
| **VOLATILES** | | |
| Chloroform | 0.25 | 0.048 |
| 1,2-Dichloroethane | 0.25 | 0.001 |
| 1,1-Dichloroethene | 0.25 | 0.021 |
| 1,2-Dichloroethene (total) | 2.2 | 1.36 |
| 1,1,2,2-Tetrachloroethane | 12 | 4.74 |
| Tetrachloroethene | 0.25 | 0.051 |
| 1,1,2-Trichloroethane | 0.39 | 0.39 |
| Trichloroethene | 27 | 11.9 |
| Vinyl chloride | 0.25 | 0.017 |

## TABLE 6-24. Exposure Point Concentrations for Chemicals of Concern in Shellfish

| Chemical of Concern | Exposure Point Concentration (mg/kg) | |
|---|---|---|
| | Reasonable Maximum | Average |
| **INORGANICS** | | |
| Arsenic | 2.5 | 1.1 |
| Cadmium | 2.4 | 0.49 |
| Chromium | 0.70 | 0.22 |
| Copper | 130 | 26 |
| Lead | 0.88 | 0.38 |
| Mercury | 49 | 20 |
| Zinc | 4,700 | 820 |
| **SEMIVOLATILES** | | |
| Benzo(a)pyrene | 0.0061 | 0.0017 |
| Benzo(b)fluoranthene | 0.036 | 0.011 |
| Benzotriazole | 0.025 | 0.021 |
| Chlorinated benzotriazole | 0.0036 | 0.0027 |
| Dibenzo(a,h)anthracene | 0.0013 | 0.00064 |
| **PESTICIDES / PCBs** | | |
| Aldrin | 0.00024 | 0.00019 |
| 4,4'-DDE | 0.023 | 0.0064 |
| Aroclor-1242 | 0.022 | 0.0074 |
| Aroclor-1254 | 0.13 | 0.058 |
| Aroclor-1260 | 0.085 | 0.059 |

## TABLE 6-25. Input Parameters Used to Calculate Exposures in Each Environmental Medium

| Media | Number of Analyzed Samples for COCs | Exposure Concentration | | Exposure Parameter Values | |
|---|---|---|---|---|---|
| | | Average | RME | Average | RME |
| Soil | 16 or 26 | 95 UCLM | 95 UCLM | Average | Maximum |
| Sediment | 3 or 8 | Mean | Maximum | Average | Maximum |
| Shallow Ground Water | 5, 6, 9, 14, 16, 18, 20, 21, 22, 23, 24 or 25 | Mean | Maximum | Average | Maximum |
| Deep Ground Water | 2, 4, 7, 12,13,16, 14,17, 18, 20, 22,23, 25, 26, 27, 28, 29, 30 or 31 | Mean | Maximum | Average | Maximum |
| Bedrock Ground Water | 1, 2, 3, 4 or 5 | Mean | Maximum | Average | Maximum |
| Surface Water | 1 | Maximum | Maximum | Average | Maximum |
| Shellfish | 2, 4, 5, or 6 | Mean | Maximum | Average | Maximum |

**TABLE 6-26. Summary of Subchronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils (1) (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | $7.2\times10^{-7}$ |
| Arsenic | $3.1\times10^{-7}$ | - - | $1.3\times10^{-7}$ |
| Beryllium | - - | - - | $6.8\times10^{-8}$ |
| Chromium | - - | - - | $8.2\times10^{-8}$ |
| Copper | - - | - - | $1.0\times10^{-7}$ |
| Manganese | - - | - - | $1.2\times10^{-5}$ |
| Nickel | - - | - - | $3.0\times10^{-7}$ |
| Thallium | - - | - - | $2.1\times10^{-7}$ |
| **VOLATILES** | | | |
| Acetone | - - | - - | $1.1\times10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - |
| 1,2-Dichloroethene (total) | - - | - - | $1.1\times10^{-5}$ |
| 1,1,2,2-Tetrachloroethane | - - | - - | $9.0\times10^{-6}$ |
| Tetrachloroethene | - - | - - | $2.0\times10^{-8}$ |
| 1,1,2-Trichloroethane | - - | - - | $1.3\times10^{-6}$ |
| Trichloroethene | - - | - - | $1.6\times10^{-5}$ |
| Vinyl chloride | - - | - - | - - |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-27. Summary of Subchronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils (1) (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | $4.3 \times 10^{-6}$ |
| Arsenic | $1.9 \times 10^{-6}$ | - - | $1.8 \times 10^{-6}$ |
| Beryllium | - - | - - | $7.1 \times 10^{-8}$ |
| Chromium | - - | - - | $2.9 \times 10^{-7}$ |
| Copper | - - | - - | $4.7 \times 10^{-7}$ |
| Manganese | - - | - - | $1.5 \times 10^{-4}$ |
| Nickel | - - | - - | $7.4 \times 10^{-7}$ |
| Thallium | - - | - - | $1.1 \times 10^{-6}$ |
| **VOLATILES** | | | |
| Acetone | - - | - - | $7.0 \times 10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - |
| 1,2-Dichloroethene (total) | - - | - - | $5.5 \times 10^{-5}$ |
| 1,1,2,2-Tetrachloroethane | - - | - - | $5.9 \times 10^{-5}$ |
| Tetrachloroethene | - - | - - | $9.8 \times 10^{-6}$ |
| 1,1,2-Trichloroethane | - - | - - | $5.1 \times 10^{-6}$ |
| Trichloroethene | - - | - - | $1.3 \times 10^{-4}$ |
| Vinyl chloride | - - | - - | - - |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-28. Summary of Intakes of Carcinogens via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils (1) (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | - - |
| Arsenic | $4.4 \times 10^{-9}$ | - - | $1.9 \times 10^{-9}$ |
| Beryllium | - - | - - | $9.8 \times 10^{-10}$ |
| Chromium | - - | - - | - - |
| Copper | - - | - - | - - |
| Manganese | - - | - - | - - |
| Nickel | - - | - - | - - |
| Thallium | - - | - - | - - |
| **VOLATILES** | | | |
| Acetone | - - | - - | - - |
| 1,2-Dichloroethane | - - | - - | $8.4 \times 10^{-9}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | - - | - - | $1.3 \times 10^{-7}$ |
| Tetrachloroethene | - - | - - | $2.8 \times 10^{-10}$ |
| 1,1,2-Trichloroethane | - - | - - | $1.9 \times 10^{-8}$ |
| Trichloroethene | - - | - - | $2.3 \times 10^{-7}$ |
| Vinyl chloride | - - | - - | $6.4 \times 10^{-9}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-29. Summary of Intakes of Carcinogens via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils [1] (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | - - |
| Arsenic | $2.7\times10^{-8}$ | - - | $2.6\times10^{-8}$ |
| Beryllium | - - | - - | $1.0\times10^{-9}$ |
| Chromium | - - | - - | - - |
| Copper | - - | - - | - - |
| Manganese | - - | - - | - - |
| Nickel | - - | - - | - - |
| Thallium | - - | - - | - - |
| **VOLATILES** | | | |
| Acetone | - - | - - | - - |
| 1,2-Dichloroethane | - - | - - | $1.4\times10^{-7}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | - - | - - | $8.4\times10^{-7}$ |
| Tetrachloroethene | - - | - - | $1.4\times10^{-7}$ |
| 1,1,2-Trichloroethane | - - | - - | $7.3\times10^{-8}$ |
| Trichloroethene | - - | - - | $1.9\times10^{-6}$ |
| Vinyl chloride | - - | - - | $1.4\times10^{-7}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-30. Summary of Chronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Average Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $2.0\times10^{-7}$ | - - | $2.8\times10^{-7}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | $9.1\times10^{-6}$ | $1.7\times10^{-4}$ | - - | - - |
| Benzene | - - | - - | - - | - - | - - | - - | - - | - - |
| Chloroform | - - | - - | - - | - - | $7.7\times10^{-6}$ | $2.2\times10^{-4}$ | $3.0\times10^{-6}$ | $8.8\times10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| 1,1-Dichloroethene | - - | - - | - - | - - | $1.5\times10^{-6}$ | $2.9\times10^{-5}$ | $2.0\times10^{-6}$ | $3.8\times10^{-5}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | $6.0\times10^{-5}$ | $1.8\times10^{-3}$ | $8.2\times10^{-5}$ | $2.5\times10^{-3}$ |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| Tetrachloroethene | - - | - - | - - | - - | $2.7\times10^{-4}$ | $1.1\times10^{-3}$ | $2.4\times10^{-5}$ | $9.3\times10^{-5}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $1.4\times10^{-5}$ | $3.9\times10^{-4}$ | $2.6\times10^{-5}$ | $7.1\times10^{-4}$ |
| Trichloroethene | - - | - - | - - | - - | $1.9\times10^{-3}$ | $2.8\times10^{-2}$ | $1.4\times10^{-3}$ | $2.2\times10^{-2}$ |
| Vinyl chloride | - - | - - | - - | - - | - - | - - | - - | - - |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-31. Summary of Chronic Intakes of COCs with Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | $1.7\times10^{-6}$ | -- | $5.1\times10^{-6}$ | -- | -- | -- | -- | -- |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- |
| Chromium | -- | -- | -- | -- | -- | -- | -- | -- |
| Copper | -- | -- | -- | -- | -- | -- | -- | -- |
| Lead | -- | -- | -- | -- | -- | -- | -- | -- |
| Manganese | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | -- | -- | -- | -- | -- | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | -- | -- | -- | -- | -- | -- | -- | -- |
| **VOLATILES** | | | | | | | | |
| Acetone | -- | -- | -- | -- | $1.2\times10^{-3}$ | $1.8\times10^{-2}$ | -- | -- |
| Benzene | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloroform | -- | -- | -- | -- | $7.8\times10^{-4}$ | $1.8\times10^{-2}$ | $7.8\times10^{-5}$ | $1.8\times10^{-3}$ |
| 1,2-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethene | -- | -- | -- | -- | $1.2\times10^{-3}$ | $1.8\times10^{-2}$ | $1.2\times10^{-4}$ | $1.8\times10^{-3}$ |
| 1,2-Dichloroethene (total) | -- | -- | -- | -- | $1.7\times10^{-3}$ | $4.2\times10^{-2}$ | $6.6\times10^{-4}$ | $1.6\times10^{-2}$ |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| Tetrachloroethene | - - | - - | - - | - - | $5.8\times10^{-3}$ | $1.8\times10^{-2}$ | $5.8\times10^{-4}$ | $1.8\times10^{-3}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $8.1\times10^{-4}$ | $1.8\times10^{-2}$ | $1.3\times10^{-4}$ | $2.8\times10^{-3}$ |
| Trichloroethene | - - | - - | - - | - - | $7.2\times10^{-2}$ | $8.8\times10^{-1}$ | $1.6\times10^{-2}$ | $2.0\times10^{-1}$ |
| Vinyl chloride | - - | - - | - - | - - | - - | - - | - - | - - |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-32. Summary of Chronic Intakes of Carcinogens via All Exposure Pathways for Recreational Users — Average Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $4.7\times10^{8}$ | - - | $6.5\times10^{-8}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | - - | - - | - - | - - |
| Benzene | - - | - - | - - | - - | $7.5\times10^{-6}$ | $1.2\times10^{-4}$ | - - | - - |
| Chloroform | - - | - - | - - | - - | $1.8\times10^{-6}$ | $5.1\times10^{-5}$ | $6.9\times10^{-7}$ | $2.0\times10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - | $4.6\times10^{-7}$ | $2.6\times10^{-5}$ | $7.4\times10^{-9}$ | $4.2\times10^{-7}$ |
| 1,1-Dichloroethene | - - | - - | - - | - - | $3.5\times10^{-7}$ | $6.7\times10^{-6}$ | $4.6\times10^{-7}$ | $8.8\times10^{-6}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | - - | - - | - - | - - |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | $3.2\times10^{-4}$ | $6.6\times10^{-3}$ | $9.7\times10^{-5}$ | $2.0\times10^{-3}$ |
| Tetrachloroethene | - - | - - | - - | - - | $6.2\times10^{-5}$ | $2.4\times10^{-4}$ | $5.5\times10^{-6}$ | $2.1\times10^{-5}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $3.2\times10^{-6}$ | $8.8\times10^{-5}$ | $5.8\times10^{-6}$ | $1.6\times10^{-4}$ |
| Trichloroethene | - - | - - | - - | - - | $4.4\times10^{-4}$ | $6.5\times10^{-3}$ | $3.3\times10^{-4}$ | $5.0\times10^{-3}$ |
| Vinyl chloride | - - | - - | - - | - - | $1.2\times10^{-7}$ | $6.3\times10^{-6}$ | $1.3\times10^{-7}$ | $7.1\times10^{-6}$ |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-33. Summary of Chronic Intakes of Carcinogens via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $3.8\times10^{-7}$ | - - | $1.2\times10^{-6}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | - - | - - | - - | - - |
| Benzene | - - | - - | - - | - - | $3.1\times10^{-4}$ | $4.2\times10^{-3}$ | - - | - - |
| Chloroform | - - | - - | - - | - - | $1.8\times10^{-4}$ | $4.2\times10^{-3}$ | $1.8\times10^{-5}$ | $4.2\times10^{-4}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - | $9.2\times10^{-5}$ | $4.2\times10^{-3}$ | $9.2\times10^{-6}$ | $4.2\times10^{-4}$ |
| 1,1-Dichloroethene | - - | - - | - - | - - | $2.7\times10^{-4}$ | $4.2\times10^{-3}$ | $2.7\times10^{-5}$ | $4.2\times10^{-4}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | - - | - - | - - | - - |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | $7.8\times10^{-3}$ | $1.3\times10^{-1}$ | $1.2\times10^{-3}$ | $2.0\times10^{-2}$ |
| Tetrachloroethene | - - | - - | - - | - - | $1.3\times10^{-3}$ | $4.2\times10^{-3}$ | $1.3\times10^{-4}$ | $4.2\times10^{-4}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $1.9\times10^{-4}$ | $4.2\times10^{-3}$ | $2.9\times10^{-5}$ | $6.5\times10^{-4}$ |
| Trichloroethene | - - | - - | - - | - - | $1.7\times10^{-2}$ | $2.0\times10^{-1}$ | $3.7\times10^{-3}$ | $4.5\times10^{-2}$ |
| Vinyl chloride | - - | - - | - - | - - | $9.8\times10^{-5}$ | $4.2\times10^{-3}$ | $9.8\times10^{-6}$ | $4.2\times10^{-4}$ |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-34. Summary of Intakes of COCs with Health Effects Other than Cancer for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios**

| Chemical of Concern | Consumption of Shellfish (mg/kg-day) | |
|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | |
| Arsenic | $9.6 \times 10^{-5}$ | $2.2 \times 10^{-3}$ |
| Cadmium | $4.3 \times 10^{-5}$ | $2.1 \times 10^{-3}$ |
| Chromium | $1.9 \times 10^{-5}$ | $6.3 \times 10^{-4}$ |
| Copper | $2.3 \times 10^{-3}$ | $1.2 \times 10^{-1}$ |
| Mercury | $1.7 \times 10^{-3}$ | $4.4 \times 10^{-2}$ |
| Zinc | $7.1 \times 10^{-2}$ | $4.2 \times 10^{0}$ |
| **PESTICIDES / PCBs** | | |
| Aldrin | $5.0 \times 10^{-9}$ | $6.4 \times 10^{-8}$ |
| Aroclor-1242 | $1.9 \times 10^{-7}$ | $5.9 \times 10^{-6}$ |
| Aroclor-1254 | $1.5 \times 10^{-6}$ | $3.5 \times 10^{-5}$ |
| Aroclor-1260 | $1.5 \times 10^{-6}$ | $2.3 \times 10^{-5}$ |

**TABLE 6-35. Summary of Intakes of Carcinogens for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios**

| Chemical of Concern | Consumption of Shellfish (mg/kg-day) | |
|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | |
| Arsenic | $1.2\times10^{-5}$ | $9.6\times10^{-4}$ |
| **SEMIVOLATILES** | | |
| Benzo(a)pyrene | $1.9\times10^{-8}$ | $2.3\times10^{-6}$ |
| Benzofluoranthene | $1.2\times10^{-8}$ | $1.4\times10^{-6}$ |
| Dibenzo(a,h)anthracene | $7.2\times10^{-9}$ | $5.0\times10^{-7}$ |
| **PESTICIDES / PCBs** | | |
| Aldrin | $6.4\times10^{-10}$ | $2.8\times10^{-8}$ |
| Aroclor-1242 | $2.5\times10^{-8}$ | $2.5\times10^{-6}$ |
| Aroclor-1254 | $2.0\times10^{-7}$ | $1.5\times10^{-5}$ |
| Aroclor-1260 | $2.0\times10^{-7}$ | $9.8\times10^{-6}$ |
| 4,4′-DDE | $2.2\times10^{-8}$ | $2.6\times10^{-6}$ |

**TABLE 6-36. Summary of Chronic Intakes of COCs with Health Effects Other than Cancer for Hypothetical Adult Residents Consuming Ground Water — Average and Reasonable Maximum Exposure Scenarios**

| Chemical of Concern | Ingestion of Deep Ground Water (mg/kg-day) | | Ingestion of Bedrock Ground Water (mg/kg-day) | |
|---|---|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | | | |
| Aluminum | $4.8 \times 10^{-1}$ | $3.5 \times 10^{0}$ | - - | - - |
| Arsenic | $2.9 \times 10^{-4}$ | $8.9 \times 10^{-4}$ | $8.1 \times 10^{-5}$ | $1.2 \times 10^{-4}$ |
| Beryllium | $5.5 \times 10^{-5}$ | $1.7 \times 10^{-4}$ | - - | - - |
| Chromium | $2.3 \times 10^{-3}$ | $8.0 \times 10^{-3}$ | - - | - - |
| Copper | $1.1 \times 10^{-3}$ | $3.7 \times 10^{-3}$ | - - | - - |
| Manganese | $2.6 \times 10^{-2}$ | $9.6 \times 10^{-2}$ | $7.7 \times 10^{-2}$ | $4.2 \times 10^{-1}$ |
| Nickel | $1.9 \times 10^{-3}$ | $8.8 \times 10^{-3}$ | - - | - - |
| Thallium | $3.1 \times 10^{-4}$ | $8.7 \times 10^{-4}$ | $3.4 \times 10^{-4}$ | $7.9 \times 10^{-4}$ |
| Vanadium | $1.9 \times 10^{-3}$ | $6.1 \times 10^{-3}$ | - - | - - |
| **VOLATILES** | | | | |
| Acetone | $1.8 \times 10^{-3}$ | $6.8 \times 10^{-2}$ | - - | - - |
| Benzene | - - | - - | - - | - - |
| Chloroform | $2.3 \times 10^{-3}$ | $6.8 \times 10^{-2}$ | $9.2 \times 10^{-4}$ | $6.8 \times 10^{-3}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - |
| 1,1-Dichloroethene | $3.1 \times 10^{-4}$ | $6.8 \times 10^{-2}$ | $4.0 \times 10^{-4}$ | $6.8 \times 10^{-3}$ |
| 1,2-Dichloroethene (total) | $1.9 \times 10^{-2}$ | $1.6 \times 10^{-1}$ | $2.6 \times 10^{-2}$ | $6.0 \times 10^{-2}$ |
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - |
| Tetrachloroethene | $1.1 \times 10^{-2}$ | $6.8 \times 10^{-2}$ | $9.8 \times 10^{-4}$ | $6.8 \times 10^{-3}$ |
| 1,1,2-Trichloroethane | $4.0 \times 10^{-3}$ | $6.8 \times 10^{-2}$ | $7.5 \times 10^{-3}$ | $1.1 \times 10^{-2}$ |
| Trichloroethene | $3.0 \times 10^{-1}$ | 3.3 | $2.3 \times 10^{-1}$ | $7.4 \times 10^{-1}$ |
| Vinyl Chloride | - - | - - | - - | - - |

**TABLE 6-37. Summary of Chronic Intakes of Carcinogens for Hypothetical Adult Residents Consuming Ground Water — Average and Reasonable Maximum Exposure Scenarios**

| Chemical of Concern | Ingestion of Deep Ground Water (mg/kg-day) | | Ingestion of Bedrock Ground Water (mg/kg-day) | |
|---|---|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | | | |
| Aluminum | - - | - - | - - | - - |
| Arsenic | $3.7 \times 10^{-5}$ | $3.8 \times 10^{-4}$ | $1.0 \times 10^{-5}$ | $4.9 \times 10^{-5}$ |
| Beryllium | $7.1 \times 10^{-6}$ | $7.5 \times 10^{-5}$ | - - | - - |
| Chromium | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - |
| **VOLATILES** | | | | |
| Acetone | - - | - - | - - | - - |
| Benzene | $7.3 \times 10^{-4}$ | $2.9 \times 10^{-2}$ | - - | - - |
| Chloroform | $3.0 \times 10^{-4}$ | $2.9 \times 10^{-2}$ | $1.2 \times 10^{-4}$ | $2.9 \times 10^{-3}$ |
| 1,2-Dichloroethane | $1.5 \times 10^{-4}$ | $2.9 \times 10^{-2}$ | $2.5 \times 10^{-6}$ | $2.9 \times 10^{-3}$ |
| 1,1-Dichloroethene | $3.9 \times 10^{-5}$ | $2.9 \times 10^{-2}$ | $5.2 \times 10^{-5}$ | $2.9 \times 10^{-3}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | $3.9 \times 10^{-2}$ | $9.0 \times 10^{-1}$ | $1.2 \times 10^{-2}$ | $1.4 \times 10^{-1}$ |
| Tetrachloroethene | $1.4 \times 10^{-3}$ | $2.9 \times 10^{-2}$ | $1.3 \times 10^{-4}$ | $2.9 \times 10^{-3}$ |
| 1,1,2-Trichloroethane | $5.2 \times 10^{-4}$ | $2.9 \times 10^{-2}$ | $9.6 \times 10^{-4}$ | $4.6 \times 10^{-3}$ |
| Trichloroethene | $3.8 \times 10^{-2}$ | 1.4 | $2.9 \times 10^{-2}$ | $3.2 \times 10^{-1}$ |
| Vinyl Chloride | $3.7 \times 10^{-5}$ | $2.9 \times 10^{-2}$ | $4.2 \times 10^{-5}$ | $2.9 \times 10^{-3}$ |

**TABLE 6-38. Summary of Subchronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils (1) (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | $7.2\times10^{-7}$ |
| Arsenic | $1.0\times10^{-3}$ | - - | $4.4\times10^{-4}$ |
| Beryllium | - - | - - | $1.4\times10^{-5}$ |
| Chromium | - - | - - | $4.1\times10^{-6}$ |
| Copper | - - | - - | $2.5\times10^{-6}$ |
| Manganese | - - | - - | $5.3\times10^{-4}$ |
| Nickel | - - | - - | $1.5\times10^{-5}$ |
| Thallium | - - | - - | $2.6\times10^{-4}$ |
| **VOLATILES** | | | |
| Acetone | - - | - - | $1.1\times10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - |
| 1,2-Dichloroethene (total) | - - | - - | $1.3\times10^{-3}$ |
| 1,1,2,2-Tetrachloroethane | - - | - - | $3.0\times10^{-4}$ |
| Tetrachloroethene | - - | - - | $2.0\times10^{-7}$ |
| 1,1,2-Trichloroethane | - - | - - | $3.3\times10^{-5}$ |
| Trichloroethene | - - | - - | $2.6\times10^{-3}$ |
| Vinyl chloride | - - | - - | - - |
| **TOTAL** | $1.0\times10^{-3}$ | - - | $4.4\times10^{-3}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-39. Summary of Subchronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils (1) (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | $4.3 \times 10^{-6}$ |
| Arsenic | $6.0 \times 10^{-3}$ | - - | $6.1 \times 10^{-3}$ |
| Beryllium | - - | - - | $1.4 \times 10^{-5}$ |
| Chromium | - - | - - | $1.4 \times 10^{-5}$ |
| Copper | - - | - - | $1.2 \times 10^{-5}$ |
| Manganese | - - | - - | $6.5 \times 10^{-3}$ |
| Nickel | - - | - - | $3.7 \times 10^{-5}$ |
| Thallium | - - | - - | $1.4 \times 10^{-3}$ |
| **VOLATILES** | | | |
| Acetone | - - | - - | $7.0 \times 10^{-5}$ |
| 1,2-Dichloroethane | - - | - - | - - |
| 1,2-Dichloroethene (total) | - - | - - | $6.1 \times 10^{-3}$ |
| 1,1,2,2-Tetrachloroethane | - - | - - | $2.0 \times 10^{-3}$ |
| Tetrachloroethene | - - | - - | $9.8 \times 10^{-5}$ |
| 1,1,2-Trichloroethane | - - | - - | $1.3 \times 10^{-4}$ |
| Trichloroethene | - - | - - | $2.2 \times 10^{-2}$ |
| Vinyl chloride | - - | - - | - - |
| **TOTAL** | $6.0 \times 10^{-3}$ | - - | $3.4 \times 10^{-2}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-40. Summary of Cancer Risks via All Exposure Pathways for Remediation/Construction Workers — Average Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils [1] (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | - - |
| Arsenic | $8.0 \times 10^{-9}$ | - - | $2.8 \times 10^{-9}$ |
| Beryllium | - - | - - | $4.2 \times 10^{-9}$ |
| Chromium | - - | - - | - - |
| Copper | - - | - - | - - |
| Manganese | - - | - - | - - |
| Nickel | - - | - - | - - |
| Thallium | - - | - - | - - |
| **VOLATILES** | | | |
| Acetone | - - | - - | - - |
| 1,2-Dichloroethane | - - | - - | $7.6 \times 10^{-10}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | - - | - - | $2.6 \times 10^{-8}$ |
| Tetrachloroethene | - - | - - | $1.5 \times 10^{-11}$ |
| 1,1,2-Trichloroethane | - - | - - | $1.1 \times 10^{-9}$ |
| Trichloroethene | - - | - - | $2.5 \times 10^{-9}$ |
| Vinyl chloride | - - | - - | $1.2 \times 10^{-8}$ |
| **TOTAL** | $8.0 \times 10^{-9}$ | - - | $4.9 \times 10^{-8}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-41. Summary of Cancer Risks via All Exposure Pathways for Remediation/Construction Workers — Reasonable Maximum Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Total Soils (mg/kg-day) | Dermal Contact with Total Soils [1] (mg/kg-day) | Incidental Ingestion of Shallow Ground Water (mg/kg-day) |
|---|---|---|---|
| **INORGANICS** | | | |
| Aluminum | - - | - - | - - |
| Arsenic | $5.0 \times 10^{-8}$ | - - | $3.9 \times 10^{-8}$ |
| Beryllium | - - | - - | $4.4 \times 10^{-9}$ |
| Chromium | - - | - - | - - |
| Copper | - - | - - | - - |
| Manganese | - - | - - | - - |
| Nickel | - - | - - | - - |
| Thallium | - - | - - | - - |
| **VOLATILES** | | | |
| Acetone | - - | - - | - - |
| 1,2-Dichloroethane | - - | - - | $1.3 \times 10^{-8}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | - - | - - | $1.7 \times 10^{-7}$ |
| Tetrachloroethene | - - | - - | $7.3 \times 10^{-9}$ |
| 1,1,2-Trichloroethane | - - | - - | $4.1 \times 10^{-9}$ |
| Trichloroethene | - - | - - | $2.1 \times 10^{-8}$ |
| Vinyl chloride | - - | - - | $2.7 \times 10^{-7}$ |
| **TOTAL** | $5.0 \times 10^{-8}$ | - - | $6.4 \times 10^{-8}$ |

NOTES:

- - COC is not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-42. Summary of Chronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Average Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $7.0\times10^{-4}$ | - - | $9.0\times10^{-4}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | $1.1\times10^{-4}$ | $1.7\times10^{-3}$ | - - | - - |
| Benzene | - - | - - | - - | - - | - - | - - | - - | - - |
| Chloroform | - - | - - | - - | - - | $7.7\times10^{-4}$ | $2.2\times10^{-2}$ | $3.0\times10^{-4}$ | $8.8\times10^{-3}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| 1,1-Dichloroethene | - - | - - | - - | - - | $1.7\times10^{-4}$ | $3.2\times10^{-3}$ | $2.2\times10^{-4}$ | $4.3\times10^{-3}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | $7.5\times10^{-3}$ | $2.0\times10^{-1}$ | $1.0\times10^{-2}$ | $2.8\times10^{-1}$ |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| Tetrachloroethene | - - | - - | - - | - - | $2.7\times10^{-2}$ | $1.1\times10^{-1}$ | $2.4\times10^{-3}$ | $9.3\times10^{-3}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $3.8\times10^{-3}$ | $9.6\times10^{-2}$ | $7.1\times10^{-3}$ | $1.8\times10^{-1}$ |
| Trichloroethene | - - | - - | - - | - - | $3.5\times10^{-1}$ | **4.7** | $2.7\times10^{-1}$ | **3.6** |
| Vinyl chloride | - - | - - | - - | - - | - - | - - | - - | - - |
| **TOTAL** | $7.0\times10^{-4}$ | - - | $9.0\times10^{-4}$ | - - | $3.9\times10^{-1}$ | **5.2** | $2.9\times10^{-1}$ | **4.1** |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-43. Summary of Chronic Hazard Quotients for Health Effects Other than Cancer via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario**

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $6.0\times10^{-3}$ | - - | $2.0\times10^{-2}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | $1.5\times10^{-2}$ | $1.8\times10^{-1}$ | - - | - - |
| Benzene | - - | - - | - - | - - | - - | - - | - - | - - |
| Chloroform | - - | - - | - - | - - | $7.8\times10^{-2}$ | **1.8** | $7.8\times10^{-3}$ | $1.8\times10^{-1}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| 1,1-Dichloroethene | - - | - - | - - | - - | $1.3\times10^{-1}$ | **2** | $1.3\times10^{-2}$ | $2.0\times10^{-1}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | $2.1\times10^{-1}$ | **4.6** | $8.2\times10^{-2}$ | **1.8** |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | - - | - - | - - | - - |
| Tetrachloroethene | - - | - - | - - | - - | $5.8\times10^{-1}$ | **1.8** | $5.8\times10^{-2}$ | $1.8\times10^{-1}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $2.2\times10^{-1}$ | **4.6** | $3.5\times10^{-2}$ | $7.1\times10^{-1}$ |
| Trichloroethene | - - | - - | - - | - - | **14** | **146.1** | **3** | **32.9** |
| Vinyl chloride | - - | - - | - - | - - | - - | - - | - - | - - |
| **TOTAL** | $6.0\times10^{-3}$ | - - | $2.0\times10^{-2}$ | - - | **14.7** | **161.2** | **3.2** | **35.9** |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-44. Summary of Cancer Risks via All Exposure Pathways for Recreational Users — Average Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $8.0\times10^{-8}$ | - - | $1.0\times10^{-7}$ | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | - - | - - | - - | - - |
| Benzene | - - | - - | - - | - - | $2.3\times10^{-7}$ | **$3.6\times10^{-6}$** | - - | - - |
| Chloroform | - - | - - | - - | - - | $1.1\times10^{-8}$ | **$4.1\times10^{-6}$** | $4.2\times10^{-9}$ | **$1.6\times10^{-6}$** |
| 1,2-Dichloroethane | - - | - - | - - | - - | $4.6\times10^{-8}$ | **$2.4\times10^{-6}$** | $7.4\times10^{-10}$ | $3.8\times10^{-8}$ |
| 1,1-Dichloroethene | - - | - - | - - | - - | $2.1\times10^{-7}$ | **$1.2\times10^{-6}$** | $2.8\times10^{-7}$ | **$1.5\times10^{-6}$** |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | - - | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | **$7.1\times10^{-5}$** | **$1.3\times10^{-3}$** | **$2.1\times10^{-5}$** | **$4.0\times10^{-4}$** |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| Tetrachloroethene | - - | - - | - - | - - | **$3.2\times10^{-6}$** | $4.9\times10^{-7}$ | $2.8\times10^{-7}$ | $4.3\times10^{-8}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | $2.0\times10^{-7}$ | **$4.9\times10^{-6}$** | $3.7\times10^{-7}$ | **$9.1\times10^{-6}$** |
| Trichloroethene | - - | - - | - - | - - | **$4.8\times10^{-6}$** | **$3.9\times10^{-5}$** | **$3.7\times10^{-6}$** | **$3.0\times10^{-5}$** |
| Vinyl chloride | - - | - - | - - | - - | $2.5\times10^{-7}$ | **$1.9\times10^{-6}$** | $2.8\times10^{-7}$ | **$2.1\times10^{-6}$** |
| **TOTAL** | | | | | **$8.0\times10^{-5}$** | **$1.4\times10^{-3}$** | **$2.6\times10^{-5}$** | **$4.5\times10^{-4}$** |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

## TABLE 6-45. Summary of Cancer Risks via All Exposure Pathways for Recreational Users — Reasonable Maximum Exposure Scenario

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil [1] (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment [1] (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering [1] (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | |
| Aluminum | - - | - - | - - | - - | - - | - - | - - | - - |
| Arsenic | $7.0\times10^{-7}$ | - - | **$2.0\times10^{-6}$** | - - | - - | - - | - - | - - |
| Beryllium | - - | - - | - - | - - | - - | - - | - - | - - |
| Chromium | - - | - - | - - | - - | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - | - - | - - | - - | - - |
| Lead | - - | - - | - - | - - | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - | - - | - - | - - | - - |
| Nickel | - - | - - | - - | - - | - - | - - | - - | - - |
| Thallium | - - | - - | - - | - - | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - | - - | - - | - - | - - |
| **VOLATILES** | | | | | | | | |
| Acetone | - - | - - | - - | - - | - - | - - | - - | - - |
| Benzene | - - | - - | - - | - - | **$9.7\times10^{-6}$** | **$1.2\times10^{-4}$** | - - | - - |
| Chloroform | - - | - - | - - | - - | **$1.1\times10^{-6}$** | **$3.4\times10^{-4}$** | $1.1\times10^{-7}$ | **$3.4\times10^{-5}$** |
| 1,2-Dichloroethane | - - | - - | - - | - - | **$9.2\times10^{-6}$** | **$3.8\times10^{-4}$** | $9.2\times10^{-7}$ | **$3.8\times10^{-5}$** |
| 1,1-Dichloroethene | - - | - - | - - | - - | **$1.6\times10^{-4}$** | **$7.3\times10^{-4}$** | **$1.6\times10^{-5}$** | **$7.3\times10^{-5}$** |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - | - - | - - | - - | - - |

| Chemical of Concern | Incidental Ingestion of Surface Soil (mg/kg-day) | Dermal Contact with Surface Soil (1) (mg/kg-day) | Incidental Ingestion of Sediment (mg/kg-day) | Dermal Contact with Sediment (1) (mg/kg-day) | Dermal Contact with Deep Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Deep Ground Water while Showering (mg/kg-day) | Dermal Contact with Bedrock Ground Water while Showering (1) (mg/kg-day) | Inhalation of Volatiles from Bedrock Ground Water while Showering (mg/kg-day) |
|---|---|---|---|---|---|---|---|---|
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - | **$1.7\times10^{-3}$** | **$2.6\times10^{-2}$** | **$2.7\times10^{-4}$** | **$4.1\times10^{-3}$** |
| Tetrachloroethene | - - | - - | - - | - - | **$6.9\times10^{-5}$** | **$8.5\times10^{-6}$** | **$6.9\times10^{-6}$** | $8.5\times10^{-7}$ |
| 1,1,2-Trichloroethane | - - | - - | - - | - - | **$1.2\times10^{-5}$** | **$2.3\times10^{-4}$** | **$1.8\times10^{-6}$** | **$3.6\times10^{-5}$** |
| Trichloroethene | - - | - - | - - | - - | **$1.8\times10^{-4}$** | **$1.2\times10^{-3}$** | **$4.1\times10^{-5}$** | **$2.7\times10^{-4}$** |
| Vinyl chloride | - - | - - | - - | - - | **$2.1\times10^{-4}$** | **$1.3\times10^{-3}$** | **$2.1\times10^{-5}$** | **$1.3\times10^{-4}$** |
| **TOTAL** | $7.0\times10^{-7}$ | | **$2.0\times10^{-6}$** | | **$2.4\times10^{-3}$** | **$3.0\times10^{-2}$** | **$3.5\times10^{-4}$** | **$4.6\times10^{-3}$** |

NOTES:

- - COC is either not of concern or is not associated with health effects other than cancer for this pathway.
(1) Dermal intakes of metals assumed to be negligible (EPA 1989b).

**TABLE 6-46. Summary of Chronic Hazard Quotients for Health Effects Other than Cancer for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios**

| Chemical of Concern | Noncancer Hazard Quotient | |
|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | |
| Arsenic | 0.3 | **7** |
| Cadmium | 0.04 | **2** |
| Chromium | 0.004 | 0.1 |
| Copper | 0.06 | **3** |
| Mercury | **6** | **147** |
| Zinc | 0.2 | **14** |
| **PESTICIDES / PCBs** | | |
| Aldrin | 0.0002 | 0.002 |
| Aroclor-1242 | 0.01 | 0.3 |
| Aroclor-1254 | 0.08 | **2** |
| Aroclor-1260 | 0.08 | **1** |
| **TOTAL** | **7** | **176** |

## TABLE 6-47. Summary of Cancer Risks for Consumers of Locally Caught Shellfish — Average and Reasonable Maximum Exposure Scenarios

| Chemical of Concern | Cancer Risk [1] | | Cancer Risk [2] | |
|---|---|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | | | |
| Arsenic | **$2\times10^{-5}$** | **$2\times10^{-3}$** | **$2\times10^{-5}$** | **$2\times10^{-3}$** |
| **SEMIVOLATILES** | | | | |
| Benzo(a)pyrene | $1\times10^{-7}$ | **$2\times10^{-5}$** | $1\times10^{-7}$ | **$2\times10^{-5}$** |
| Benzofluoranthene | $9\times10^{-8}$ | **$1\times10^{-5}$** | $9\times10^{-8}$ | **$1\times10^{-5}$** |
| Dibenzo(a,h)anthracene | $5\times10^{-8}$ | **$4\times10^{-6}$** | $5\times10^{-8}$ | **$4\times10^{-6}$** |
| **PESTICIDES / PCBs** | | | | |
| Aldrin | $1\times10^{-8}$ | $5\times10^{-7}$ | $1\times10^{-8}$ | $5\times10^{-7}$ |
| 4,4'-DDE | $7\times10^{-9}$ | $9\times10^{-7}$ | $7\times10^{-9}$ | $9\times10^{-7}$ |
| Aroclor-1242 | $2\times10^{-7}$ | **$2\times10^{-5}$** | $5\times10^{-8}$ | **$5\times10^{-6}$** |
| Aroclor-1254 | **$2\times10^{-6}$** | **$1\times10^{-4}$** | $4\times10^{-7}$ | **$3\times10^{-5}$** |
| Aroclor-1260 | **$2\times10^{-6}$** | **$8\times10^{-5}$** | $4\times10^{-7}$ | **$2\times10^{-5}$** |
| TOTAL | **$2.4\times10^{-5}$** | **$2\times10^{-3}$** | **$2\times10^{-5}$** | **$2\times10^{-3}$** |

Notes:

[1] Cancer risks for average exposure and RME scenarios are estimated using the existing IRIS PCB cancer slope factor of 7.7 $(mg/kg\text{-}day)^{-1}$ for Aroclor 1242, 1254 and 1260.

[2] Cancer risks for average exposure and RME scenarios are estimated using the proposed high-end PCB slope factor of 2 $(mg/kg\text{-}day)^{-1}$ for Aroclor 1242, 1254 and 1260 (PCBs: Cancer Dose-response Assessment and Application to Environmental Mixtures, EPA/600/P-96/001A, January 1996, External Review Draft).

**TABLE 6-48. Summary of Chronic Hazard Quotients for Health Effects Other than Cancer for Hypothetical Adult Residents Consuming Deep and Bedrock Ground Water — Average and Reasonable Maximum Exposures**

| Chemical of Concern | Noncancer Hazard Quotient-Deep Ground Water | | Noncancer Hazard Quotient-Bedrock Ground Water | |
|---|---|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | | | |
| Aluminum | $4.8 \times 10^{-1}$ | **3.5** | - - | - - |
| Arsenic | $9.6 \times 10^{-1}$ | **3** | $2.7 \times 10^{-1}$ | $3.8 \times 10^{-1}$ |
| Beryllium | $1.1 \times 10^{-2}$ | $3.5 \times 10^{-2}$ | - - | - - |
| Chromium | $4.6 \times 10^{-1}$ | **1.6** | - - | - - |
| Copper | $2.9 \times 10^{-2}$ | $9.2 \times 10^{-2}$ | - - | - - |
| Manganese | **1.1** | **4.2** | **3.4** | **18.5** |
| Nickel | $9.4 \times 10^{-2}$ | $4.4 \times 10^{-1}$ | - - | - - |
| Thallium | $3.9 \times 10^{-1}$ | **1.1** | $4.3 \times 10^{-1}$ | $9.9 \times 10^{-1}$ |
| Vanadium | $2.8 \times 10^{-1}$ | $8.8 \times 10^{-1}$ | - - | - - |
| **VOLATILES** | | | | |
| Acetone | $1.8 \times 10^{-2}$ | $6.8 \times 10^{-1}$ | - - | - - |
| Benzene | - - | - - | - - | - - |
| Chloroform | $2.3 \times 10^{-1}$ | **6.8** | $9.2 \times 10^{-2}$ | $6.8 \times 10^{-1}$ |
| 1,2-Dichloroethane | - - | - - | - - | - - |
| 1,1-Dichloroethene | $3.4 \times 10^{-2}$ | **7.6** | $4.5 \times 10^{-2}$ | $7.6 \times 10^{-1}$ |
| 1,2-Dichloroethene (total) | **2.1** | **17.4** | **2.9** | **6.7** |
| 1,1,2,2-Tetrachloroethane | - - | - - | - - | - - |
| Tetrachloroethene | **1.1** | **6.8** | $9.8 \times 10^{-2}$ | $6.8 \times 10^{-1}$ |
| 1,1,2-Trichloroethane | **1** | **17.1** | **1.9** | **2.7** |
| Trichloroethene | **49.9** | **547.9** | **38** | **123.3** |
| Vinyl Chloride | - - | - - | - - | - - |
| **TOTAL** | **57.7** | **615** | **47.1** | **154.6** |

**TABLE 6-49. Summary of Cancer Risks for Hypothetical Adult Residents Consuming Deep and Bedrock Ground Water — Average and Reasonable Maximum Exposures**

| Chemical of Concern | Cancer Risk-Deep Ground Water | | Cancer Risk-Bedrock Ground Water | |
|---|---|---|---|---|
| | Average Exposure | Reasonable Maximum Exposure | Average Exposure | Reasonable Maximum Exposure |
| **INORGANICS** | | | | |
| Aluminum | - - | - - | - - | - - |
| Arsenic | $5.5 \times 10^{-5}$ | $5.7 \times 10^{-4}$ | $1.6 \times 10^{-5}$ | $7.4 \times 10^{-5}$ |
| Beryllium | $3.1 \times 10^{-5}$ | $3.2 \times 10^{-4}$ | - - | - - |
| Chromium | - - | - - | - - | - - |
| Copper | - - | - - | - - | - - |
| Manganese | - - | - - | - - | - - |
| Nickel | - - | - - | - - | |
| Thallium | - - | - - | - - | - - |
| Vanadium | - - | - - | - - | - - |
| **VOLATILES** | | | | |
| Acetone | - - | - - | - - | - - |
| Benzene | $2.1 \times 10^{-5}$ | $8.5 \times 10^{-4}$ | - - | - - |
| Chloroform | $1.8 \times 10^{-6}$ | $1.8 \times 10^{-4}$ | $7.2 \times 10^{-7}$ | $1.8 \times 10^{-5}$ |
| 1,2-Dichloroethane | $1.4 \times 10^{-5}$ | $2.7 \times 10^{-3}$ | $2.2 \times 10^{-7}$ | $2.7 \times 10^{-4}$ |
| 1,1-Dichloroethene | $2.4 \times 10^{-5}$ | $1.8 \times 10^{-2}$ | $3.1 \times 10^{-5}$ | $1.8 \times 10^{-3}$ |
| 1,2-Dichloroethene (total) | - - | - - | - - | - - |
| 1,1,2,2-Tetrachloroethane | $7.8 \times 10^{-3}$ | $1.8 \times 10^{-1}$ | $2.3 \times 10^{-3}$ | $2.8 \times 10^{-2}$ |
| Tetrachloroethene | $7.5 \times 10^{-5}$ | $1.5 \times 10^{-3}$ | $6.5 \times 10^{-6}$ | $1.5 \times 10^{-4}$ |
| 1,1,2-Trichloroethane | $3.0 \times 10^{-5}$ | $1.7 \times 10^{-3}$ | $5.5 \times 10^{-5}$ | $2.6 \times 10^{-4}$ |
| Trichloroethene | $4.2 \times 10^{-4}$ | $1.5 \times 10^{-2}$ | $3.2 \times 10^{-4}$ | $3.5 \times 10^{-3}$ |
| Vinyl Chloride | $7.0 \times 10^{-5}$ | $5.6 \times 10^{-2}$ | $8.0 \times 10^{-5}$ | $5.6 \times 10^{-3}$ |
| **TOTAL** | $8.6 \times 10^{-3}$ | $2.8 \times 10^{-1}$ | $2.8 \times 10^{-3}$ | $4.0 \times 10^{-2}$ |

## TABLE 6-50. Summary of Cancer Risks for All Exposure Pathways

| Exposure Pathway | Construction Workers | | Recreational Users | | Shellfish Consumers | | Residents (Adults) | |
|---|---|---|---|---|---|---|---|---|
| | Average | RME | Average | RME | Average | RME | Average | RME |
| Incidental ingestion of total soil | $8\times10^{-9}$ | $5\times10^{-8}$ | - - | - - | - - | - - | - - | - - |
| Dermal contact with total soil | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of surface soil | - - | - - | $8\times10^{-8}$ | $7\times10^{-7}$ | - - | - - | - - | - - |
| Dermal contact with surface soil | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of sediment | - - | - - | $1\times10^{-7}$ | **$2\times10^{-6}$** | - - | - - | - - | - - |
| Dermal contact with sediment | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of shallow ground water | $5\times10^{-8}$ | $6.4\times10^{-8}$ | - - | - - | - - | - - | - - | - - |
| Ingestion of deep ground water | - - | - - | - - | - - | - - | - - | **$8.6\times10^{-3}$** | **$2.8\times10^{-1}$** |
| Ingestion of bedrock ground water | - - | - - | - - | - - | - - | - - | **$2.8\times10^{-3}$** | **$4.0\times10^{-2}$** |
| Dermal contact with deep ground water while showering | - - | - - | **$8.0\times10^{-5}$** | **$2.4\times10^{-3}$** | - - | - - | - - | - - |
| Dermal contact with bedrock ground water while showering | - - | - - | **$2.6\times10^{-5}$** | **$3.5\times10^{-4}$** | - - | - - | - - | - - |
| Inhalation of volatiles from deep ground water while showering | - - | - - | **$1.4\times10^{-3}$** | **$3\times10^{-2}$** | - - | - - | - - | - - |
| Inhalation of volatiles from bedrock ground water while showering | - - | - - | **$4.5\times10^{-4}$** | **$4.6\times10^{-3}$** | - - | - - | - - | - - |
| Incidental ingestion of surface water (Adults) | - - | - - | $5.8\times10^{-8}$ | **$2.3\times10^{-6}$** | - - | - - | - - | - - |
| Dermal contact with deep surface water while swimming (Adults) | - - | - - | **$1.6\times10^{-6}$** | **$2.6\times10^{-5}$** | - - | - - | - - | - - |
| Incidental ingestion of surface water (Children) | - - | - - | $6.0\times10^{-8}$ | **$1.4\times10^{-6}$** | - - | - - | - - | - - |
| Dermal contact with deep surface water while swimming (Children) | - - | - - | $7.2\times10^{-7}$ | **$7.5\times10^{-6}$** | - - | - - | - - | - - |
| Ingestion of shellfish | - - | - - | - - | - - | **$2.4\times10^{-5}$** | **$2\times10^{-3}$** | - - | - - |
| **TOTALS** | $5.8\times10^{-8}$ | $1.1\times10^{-7}$ | **$2\times10^{-3}$** | **$3.7\times10^{-2}$** | **$2.4\times10^{-5}$** | **$2\times10^{-3}$** | **$1.1\times10^{-2}$** | **$3.2\times10^{-1}$** |

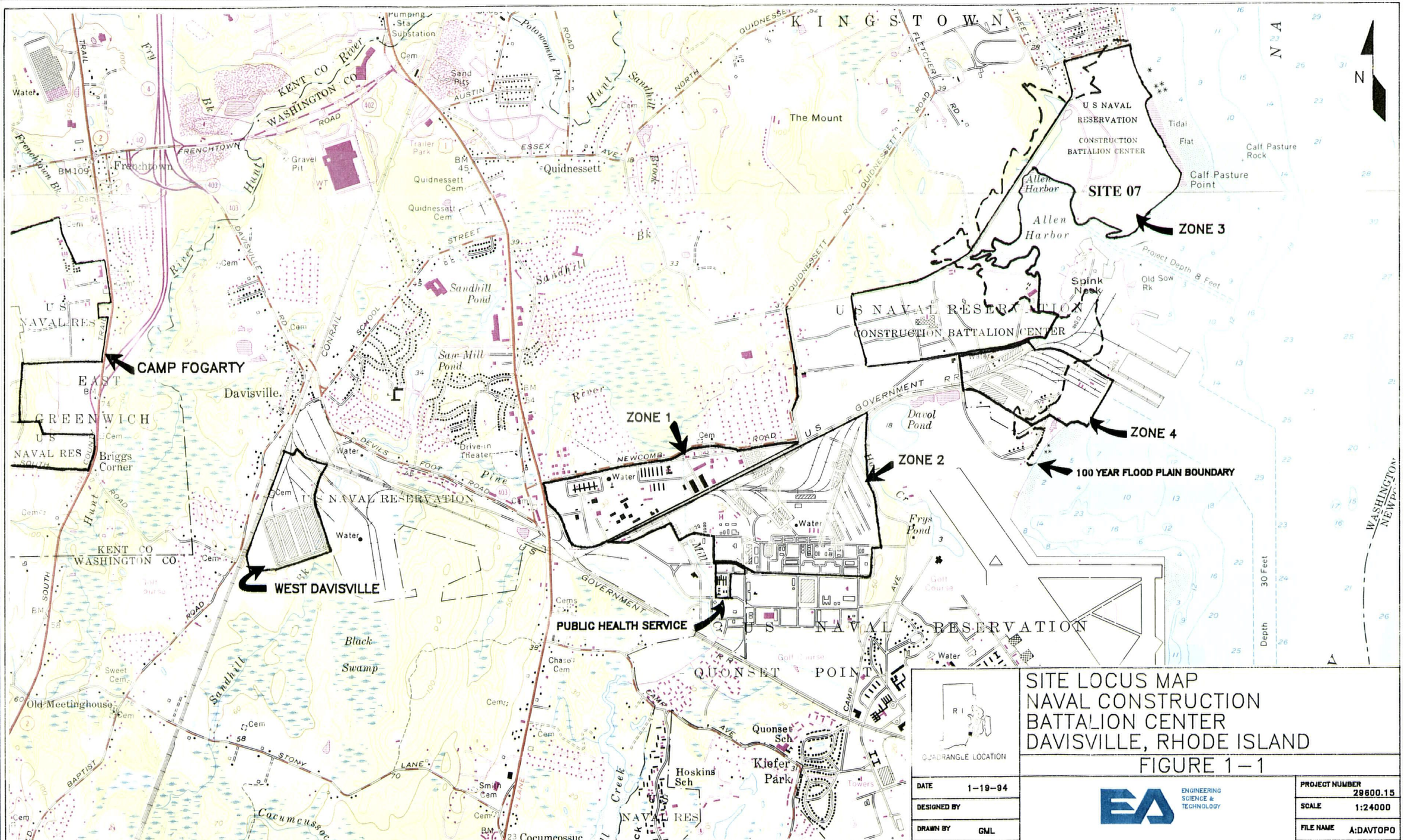
NOTES:
- - Exposure pathway not relevant to the receptor population.
Risks greater than $1x10^{-6}$ have been bolded

## TABLE 6-51. Summary of Noncancer Hazard Indices for All Exposure Pathways

| Exposure Pathway | Construction Workers | | Recreational Users | | Shellfish Consumers | | Residents (Adults) | |
|---|---|---|---|---|---|---|---|---|
| | Average | RME | Average | RME | Average | RME | Average | RME |
| Incidental ingestion of total soil | $1\times10^{-3}$ | $6\times10^{-3}$ | - - | - - | - - | - - | - - | - - |
| Dermal contact with total soil | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of surface soil | - - | - - | $7\times10^{-4}$ | $6\times10^{-3}$ | - - | - - | - - | - - |
| Dermal contact with surface soil | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of sediment | - - | - - | $9\times10^{-4}$ | $2\times10^{-2}$ | - - | - - | - - | - - |
| Dermal contact with sediment | - - | - - | - - | - - | - - | - - | - - | - - |
| Incidental ingestion of shallow ground water | $4.3\times10^{-3}$ | $3.4\times10^{-2}$ | - - | - - | - - | - - | - - | - - |
| Ingestion of deep ground water | - - | - - | - - | - - | - - | - - | **57.7** | **615** |
| Ingestion of bedrock ground water | - - | - - | - - | - - | - - | - - | **47.1** | **154.6** |
| Dermal contact with deep ground water while showering | - - | - - | $4\times10^{-1}$ | **14.7** | - - | - - | - - | - - |
| Dermal contact with bedrock ground water while showering | - - | - - | $3\times10^{-1}$ | **3.2** | - - | - - | - - | - - |
| Inhalation of volatiles from deep ground water while showering | - - | - - | **5.2** | **161.2** | - - | - - | - - | - - |
| Inhalation of volatiles from bedrock ground water while showering | - - | - - | **4.1** | **36** | - - | - - | - - | - - |
| Incidental ingestion of surface water (Adults) | - - | - - | $1.1\times10^{-3}$ | $1.3\times10^{-2}$ | - - | - - | - - | - - |
| Dermal contact with deep surface water while swimming (Adults) | - - | - - | $3.5\times10^{-2}$ | $1.7\times10^{-1}$ | - - | - - | - - | - - |
| Incidental ingestion of surface water (Children) | - - | - - | $5.0\times10^{-3}$ | $4.0\times10^{-2}$ | - - | - - | - - | - - |
| Dermal contact with deep surface water while swimming (Children) | - - | - - | $7.1\times10^{-2}$ | $2.5\times10^{-1}$ | - - | - - | - - | - - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ingestion of shellfish | - - | - - | - - | - - | 7 | 176 | - - | - - |
| **TOTALS** | $5.3 \times 10^{-3}$ | $4.0 \times 10^{-2}$ | **10.2** | **215.6** | **7** | **176** | **104.8** | **769.6** |

NOTES:
- - Exposure pathway not relevant to the receptor population.
HI > 1 have been bolded




QUADRANGLE LOCATION

# SITE LOCUS MAP
# NAVAL CONSTRUCTION BATTALION CENTER
# DAVISVILLE, RHODE ISLAND

## FIGURE 1–1

BASE MAP: U.S.G.S. EAST GREENWICH AND WICKFORD QUADRANGLE – RHODE ISLAND
7.5 MINUTE SERIES (TOPOGRAPHIC) 1942, PHOTOREVISED 1970 & 1975.

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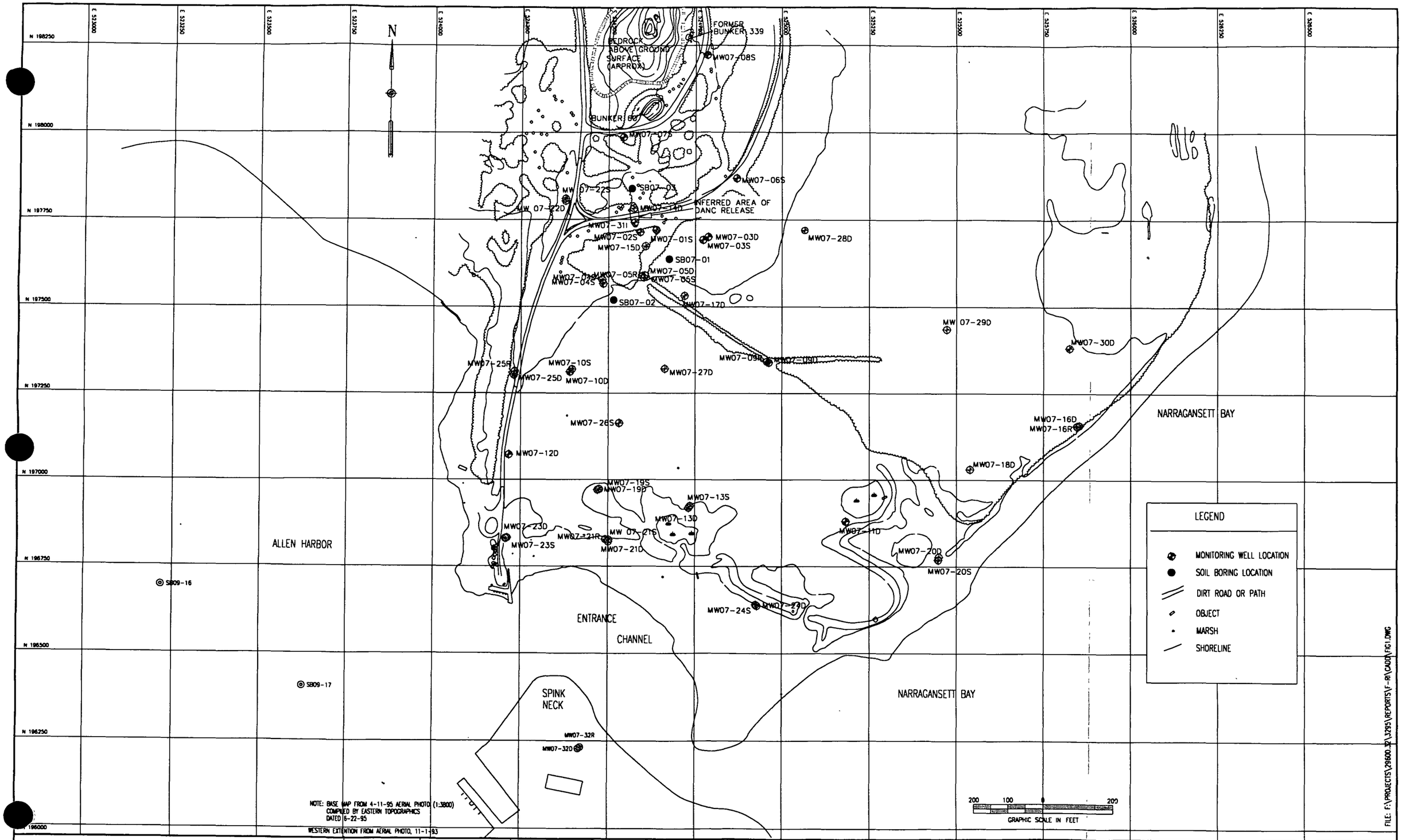
| SCALE | 1:24000 |
| FILE NAME | A:DAVTOPO |
| DRAWING NUMBER | |
| SHEET NUMBER | |

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| JAS | RWC | 4/8/98 | 29600.32 | FIG1 |
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| JAS | JAS | AS SHOWN | - | 1-2 |

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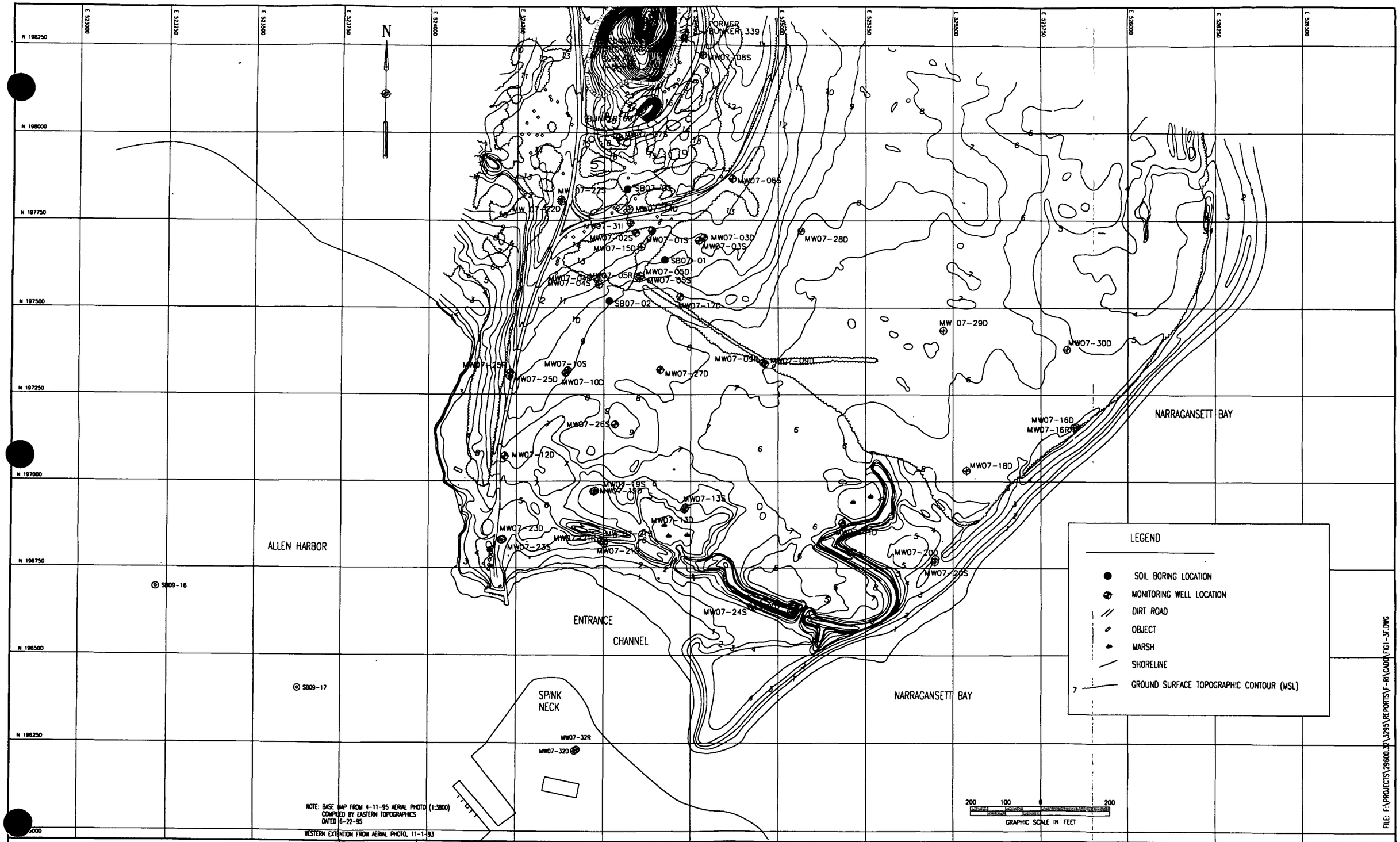
SITE MAP

FIGURE 1-2

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| JAS | RWC | 4/8/98 | 29600.32 | FIG1-3F |
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| JAS | JAS | AS SHOWN | – | 1-3 |

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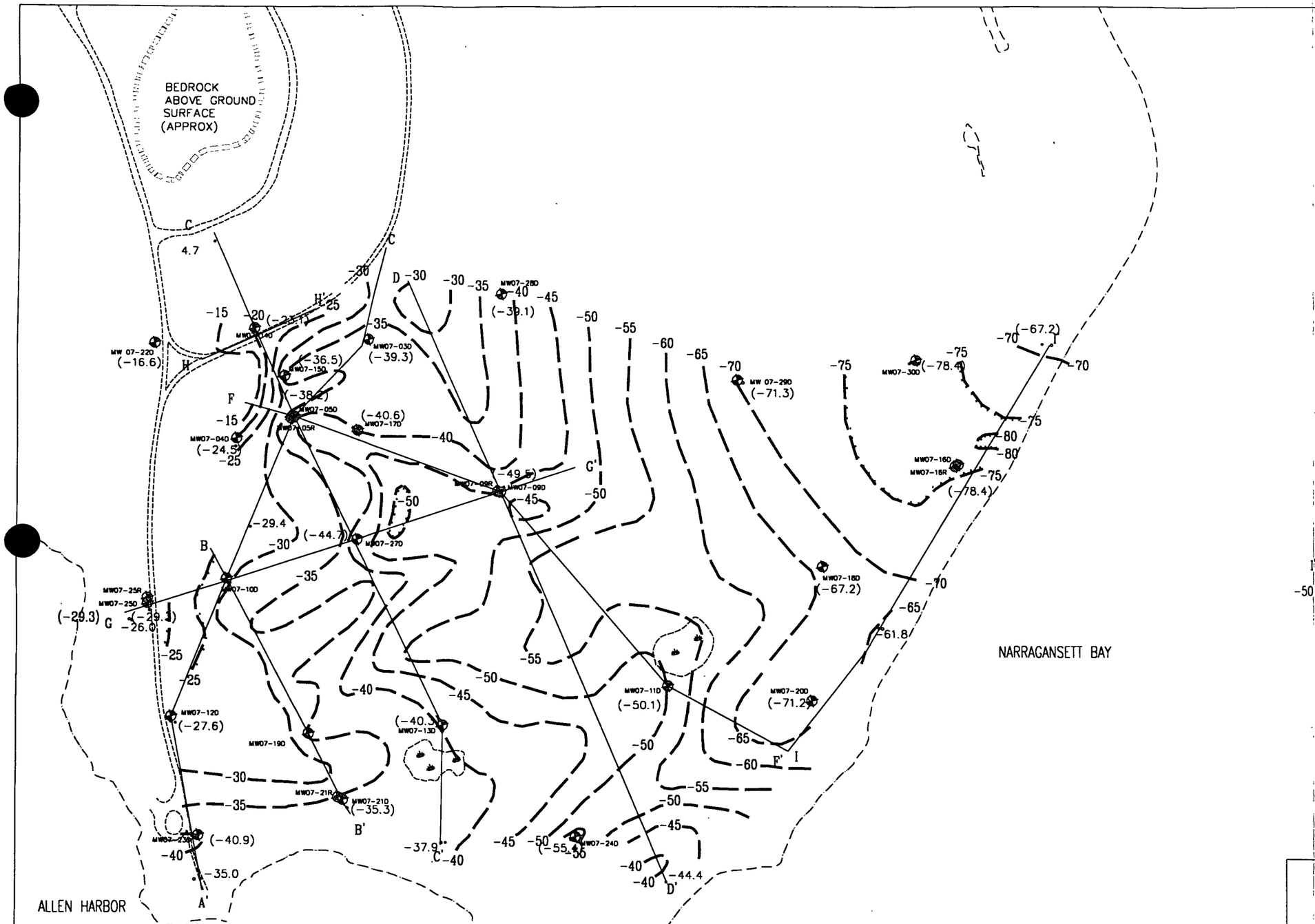
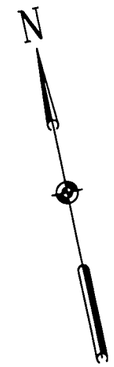
SITE TOPOGRAPHIC MAP

FIGURE 1-3




LEGEND

- MONITORING WELL LOCATION
- OBJECT
- MARSH
- SHORELINE
- SEISMIC REFRACTION SURVEY LINE
- BEDROCK ELEVATION (5' CONTOUR) (MSL)
- (-50.1) TOP OF BEDROCK SURFACE ELEVATION (MSL)

100 75 50 25 0 100 200
APPROXIMATE GRAPHIC SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD\FIG2-1.DWG

NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

2) SEISMIC DATA PROVIDED BY GEOPHYSICAL APPLICATIONS,INC

3) BEDROCK SURFACE CONTOURS BASED UPON INTERPRETIVE DATA ALONG THE SEISMIC REFRACTION SURVEY LINES AND ELEVATIONS OF THE BEDROCK SURFACE ENCOUNTERED AT VARIOUS BORINGS/WELLS.

| REVISIONS | | | |
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| NO. | DATE | BY | DESCRIPTION |
| 1 | 6/4/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

# INTERPRETIVE CONTOUR MAP OF THE UPPER SURFACE OF THE BEDROCK AND SEISMIC REFRACTION SURVEY LINES

IR PROGRAM SITE 07, CALF PASTURE POINT

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| | |
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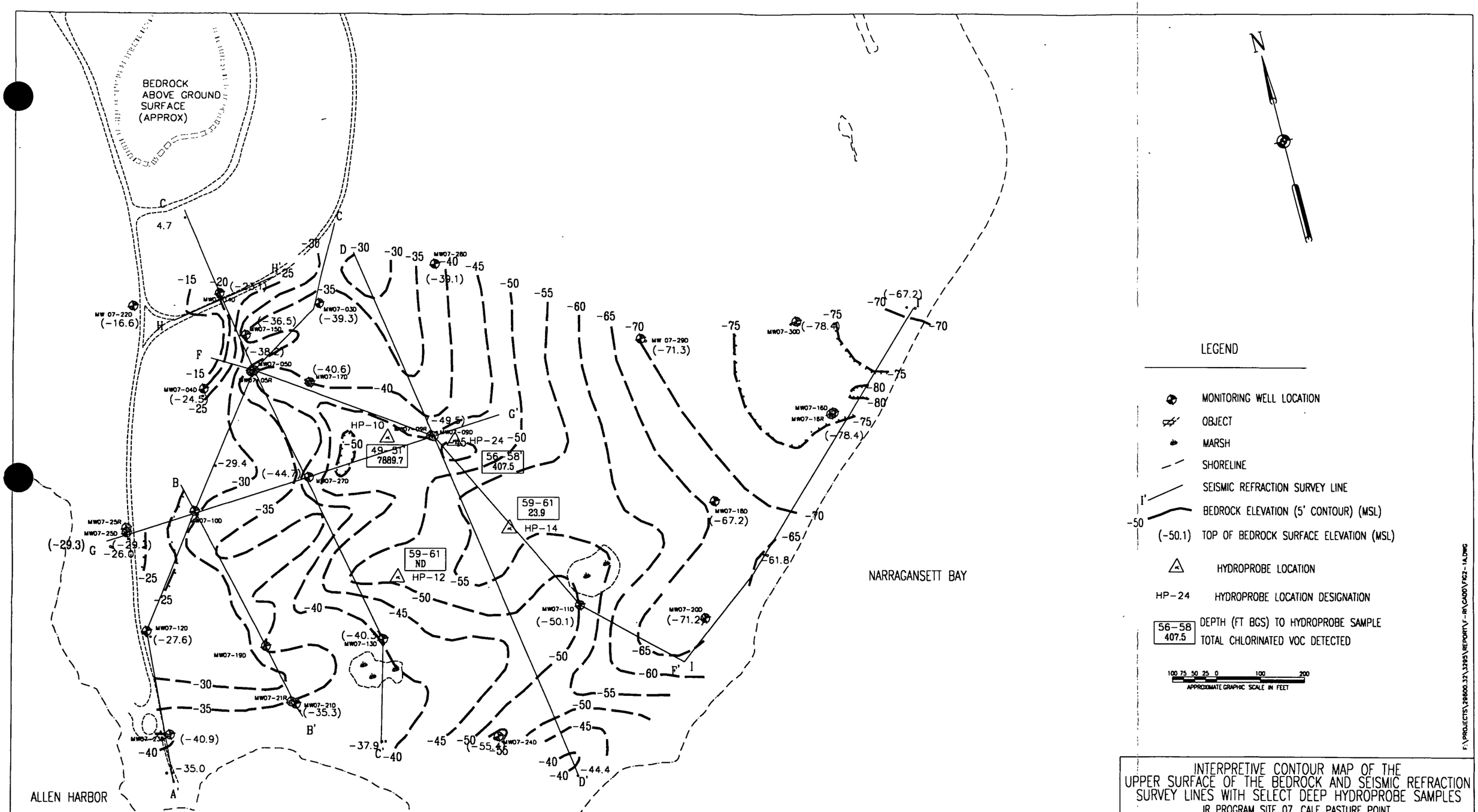
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG2-1 |
| LAYER NAME | |
| FIGURE NUMBER | 2-1 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

2) SEISMIC DATA PROVIDED BY GEOPHYSICAL APPLICATIONS,INC

3) BEDROCK SURFACE CONTOURS BASED UPON INTERPRETIVE DATA ALONG THE SEISMIC REFRACTION SURVEY LINES AND ELEVATIONS OF THE BEDROCK SURFACE ENCOUNTERED AT VARIOUS BORINGS/WELLS.

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
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# INTERPRETIVE CONTOUR MAP OF THE UPPER SURFACE OF THE BEDROCK AND SEISMIC REFRACTION SURVEY LINES WITH SELECT DEEP HYDROPROBE SAMPLES

IR PROGRAM SITE 07, CALF PASTURE POINT

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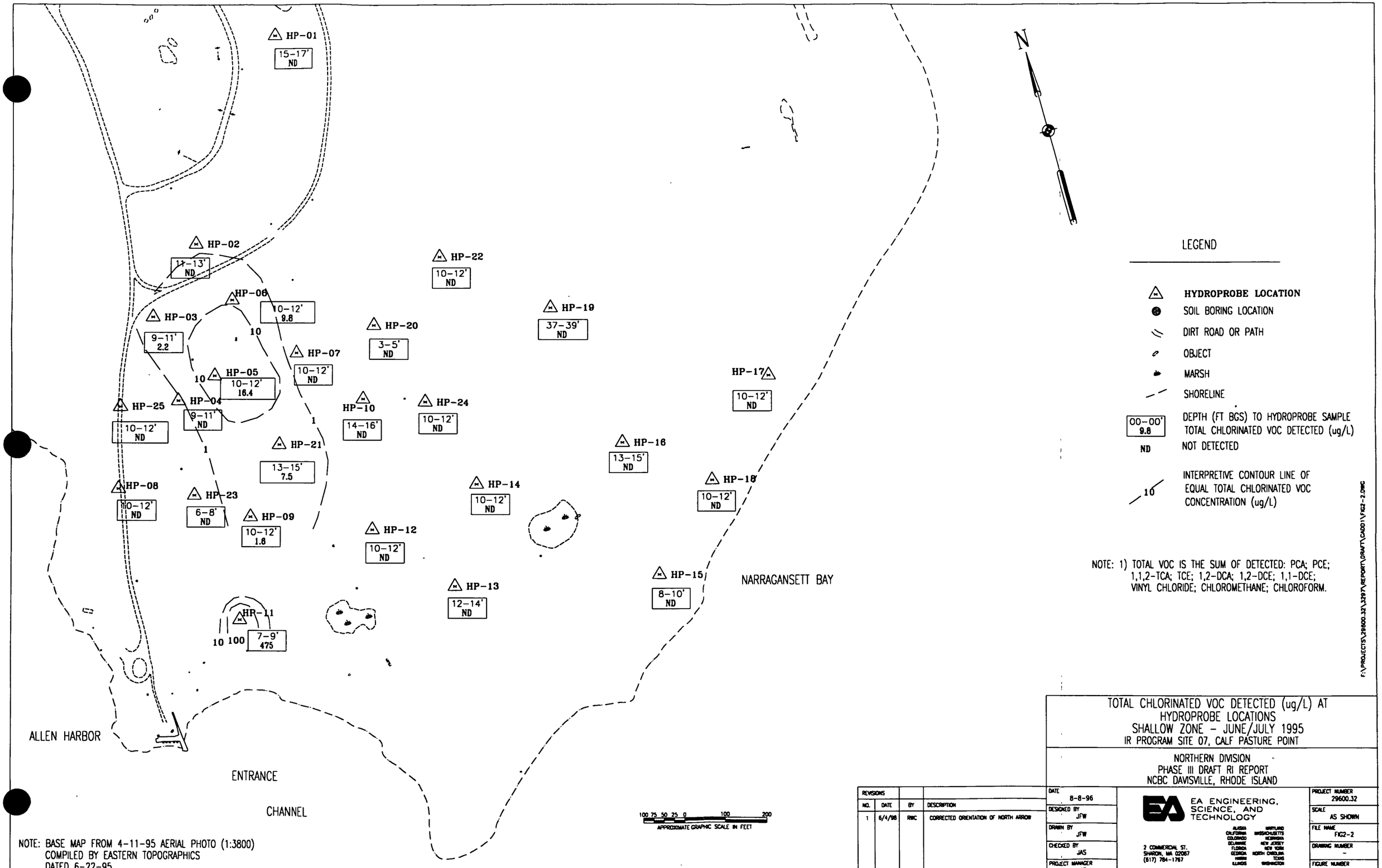
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG2-1A |
| LAYER NAME | |
| FIGURE NUMBER | 2-1A |

F:\PROJECTS\29600.32\3295\REPORT\F-RI\CADD\FIG2-1A.DWG




NOTE: 1) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\329?\REPORT\DRAFT\CA001\FIG2-2.DWG

TOTAL CHLORINATED VOC DETECTED (ug/L) AT HYDROPROBE LOCATIONS
SHALLOW ZONE - JUNE/JULY 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

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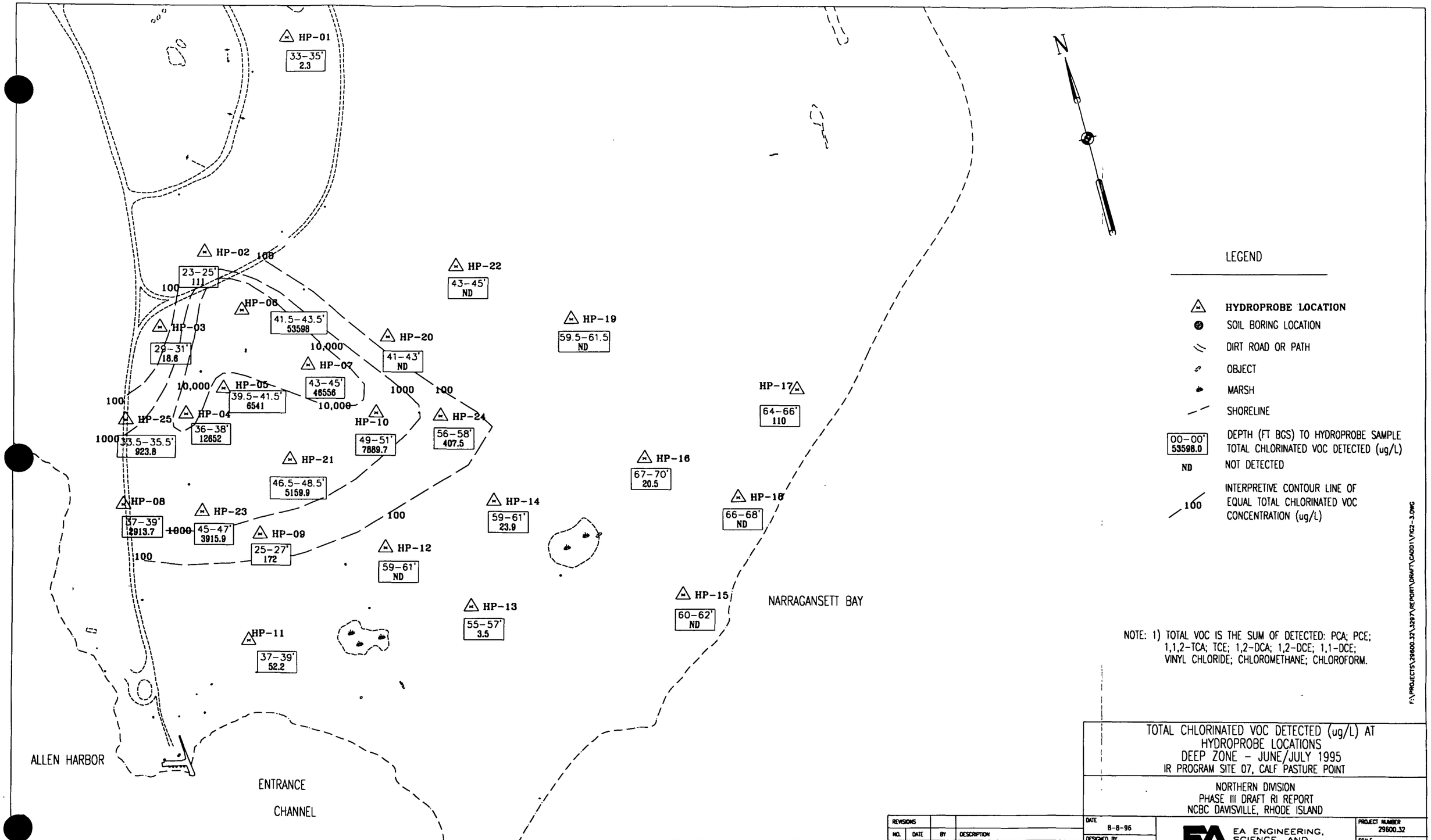
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG2-2
DRAWING NUMBER -
FIGURE NUMBER 2-2




NOTE: 1) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG2-3.DWG

TOTAL CHLORINATED VOC DETECTED (ug/L) AT HYDROPROBE LOCATIONS
DEEP ZONE - JUNE/JULY 1995
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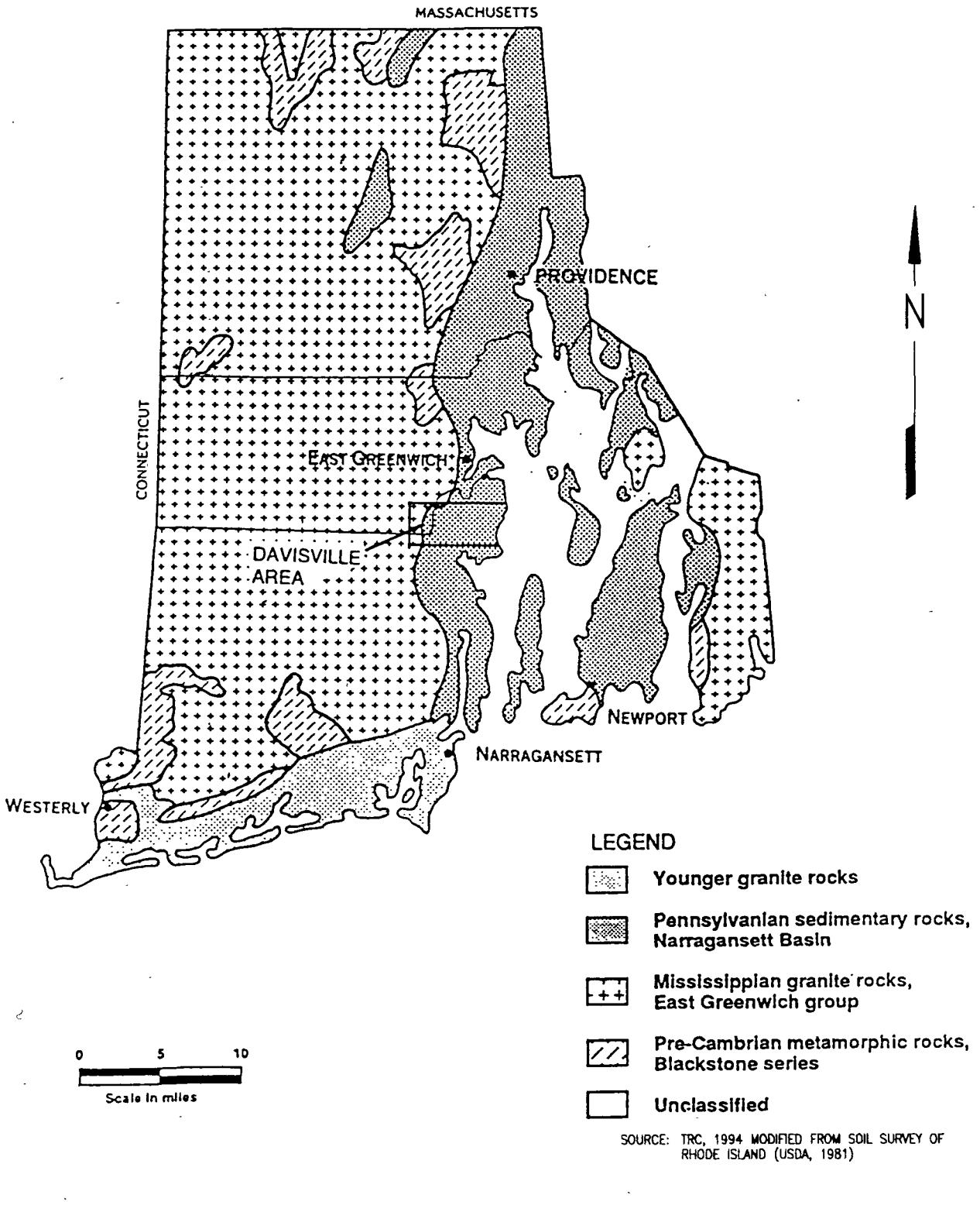
| SCALE | AS SHOWN |
| FILE NAME | FIG2-3 |
| DRAWING NUMBER | - |
| FIGURE NUMBER | 2-3 |




SOURCE: TRC, 1994 MODIFIED FROM SOIL SURVEY OF RHODE ISLAND (USDA, 1981)

FILE: F:\296003\2\3291\DWG\A-TB-1

| | | | | | | | |
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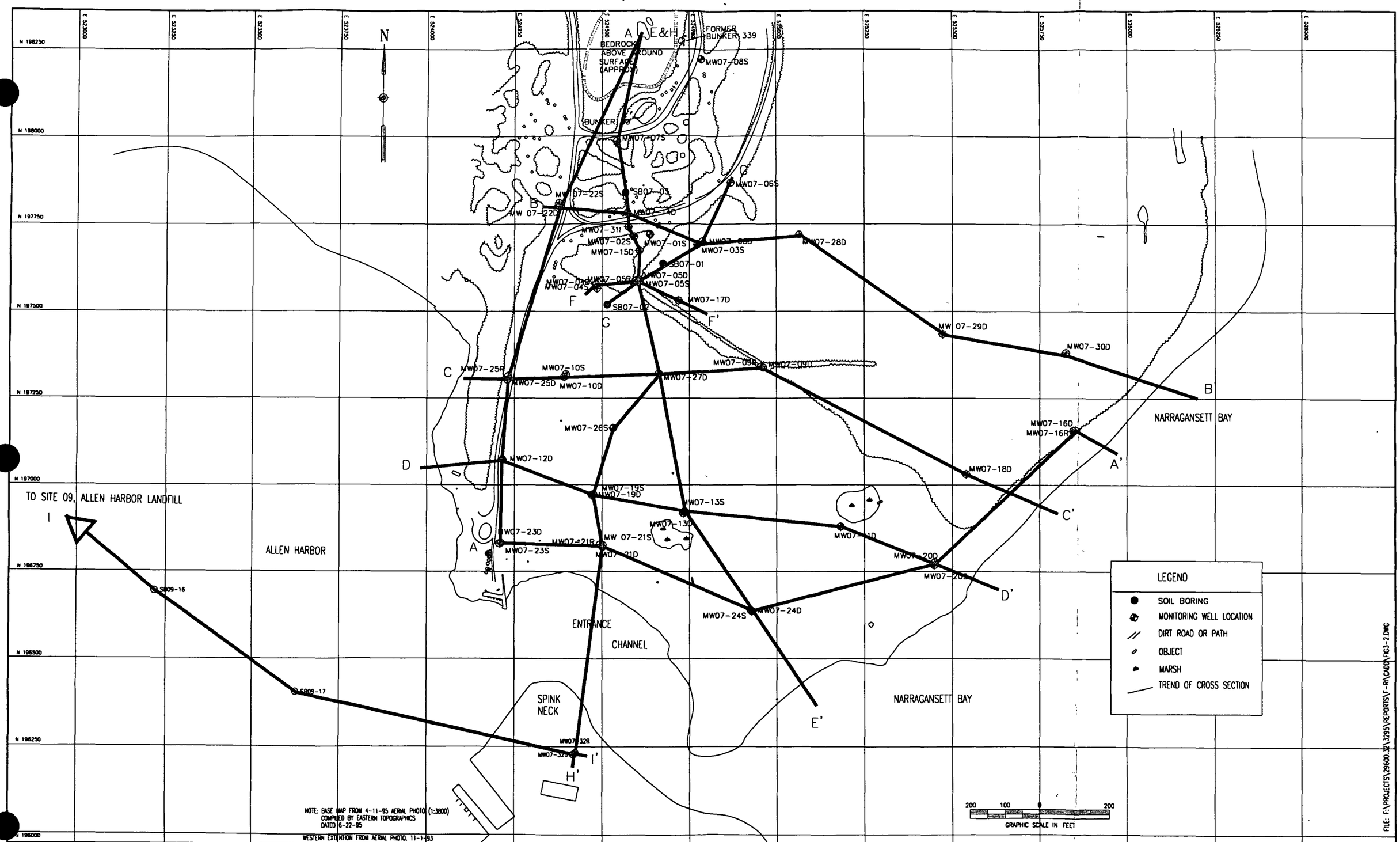
| PROJECT MGR JAS | DESIGNED BY JAS | DRAWN BY MSM | CHECKED BY JAS | SCALE AS SHOWN | DATE 5-19-95 | PROJECT NO 296.0032 | FIGURE 3-1 |

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| JAS | RWC | 4/8/98 | 29600.32 | FIG3-2 |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | - | 3-2 |

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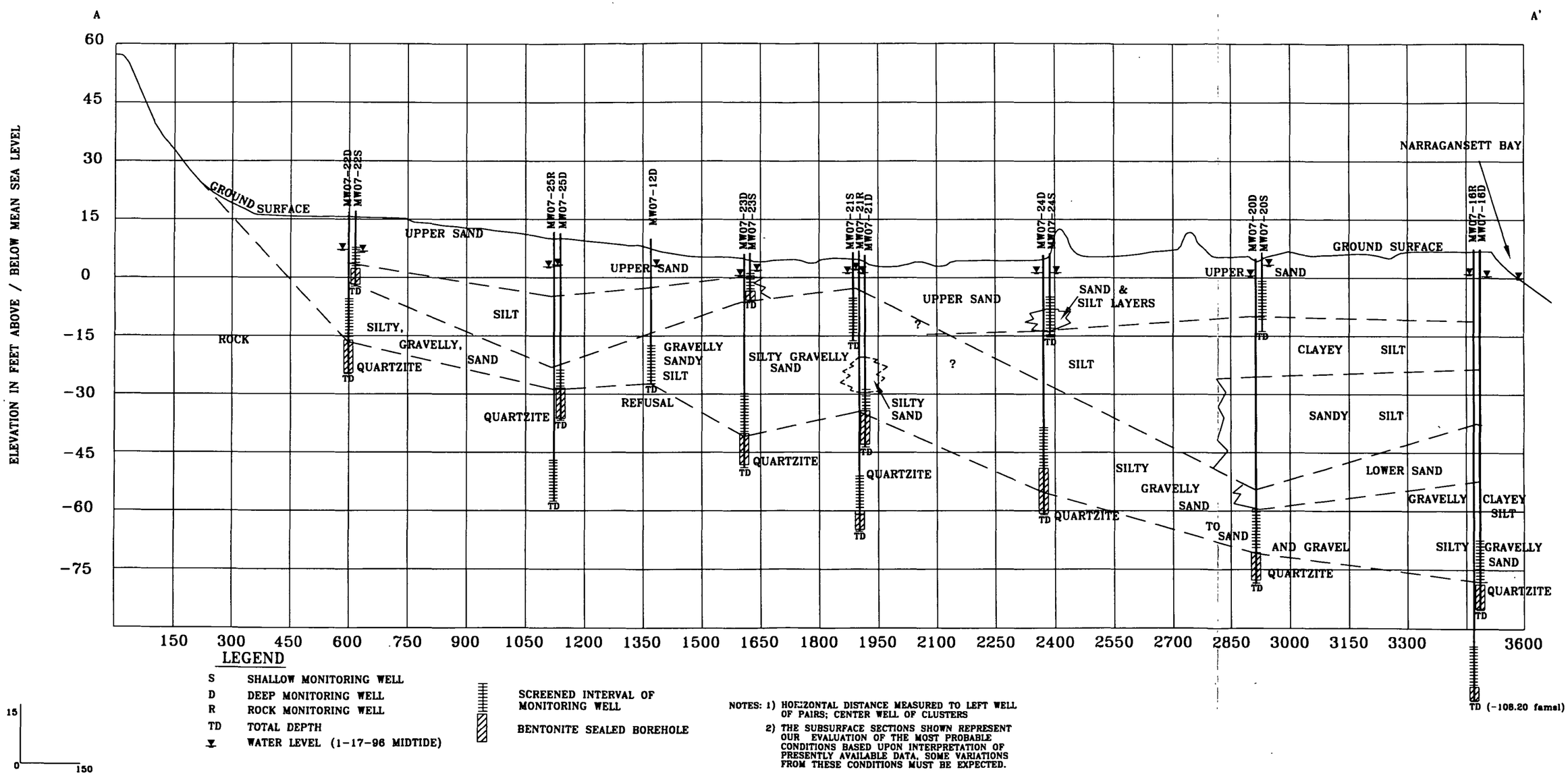
NCBC DAVISVILLE, RHODE ISLAND

LOCATION OF GEOLOGIC CROSS SECTIONS

FIGURE 3-2




## LEGEND

- S — SHALLOW MONITORING WELL
- D — DEEP MONITORING WELL
- R — ROCK MONITORING WELL
- TD — TOTAL DEPTH
- ▼ — WATER LEVEL (1-17-96 MIDTIDE)
- SCREENED INTERVAL OF MONITORING WELL
- BENTONITE SEALED BOREHOLE

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

15
0
150
SCALE IN FEET

F:\PROJECTS\29600.32\29SFA\REPORTS\DRAFT\CADD\FIG3-3.DWG

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GEOLOGIC CROSS SECTION A-A'
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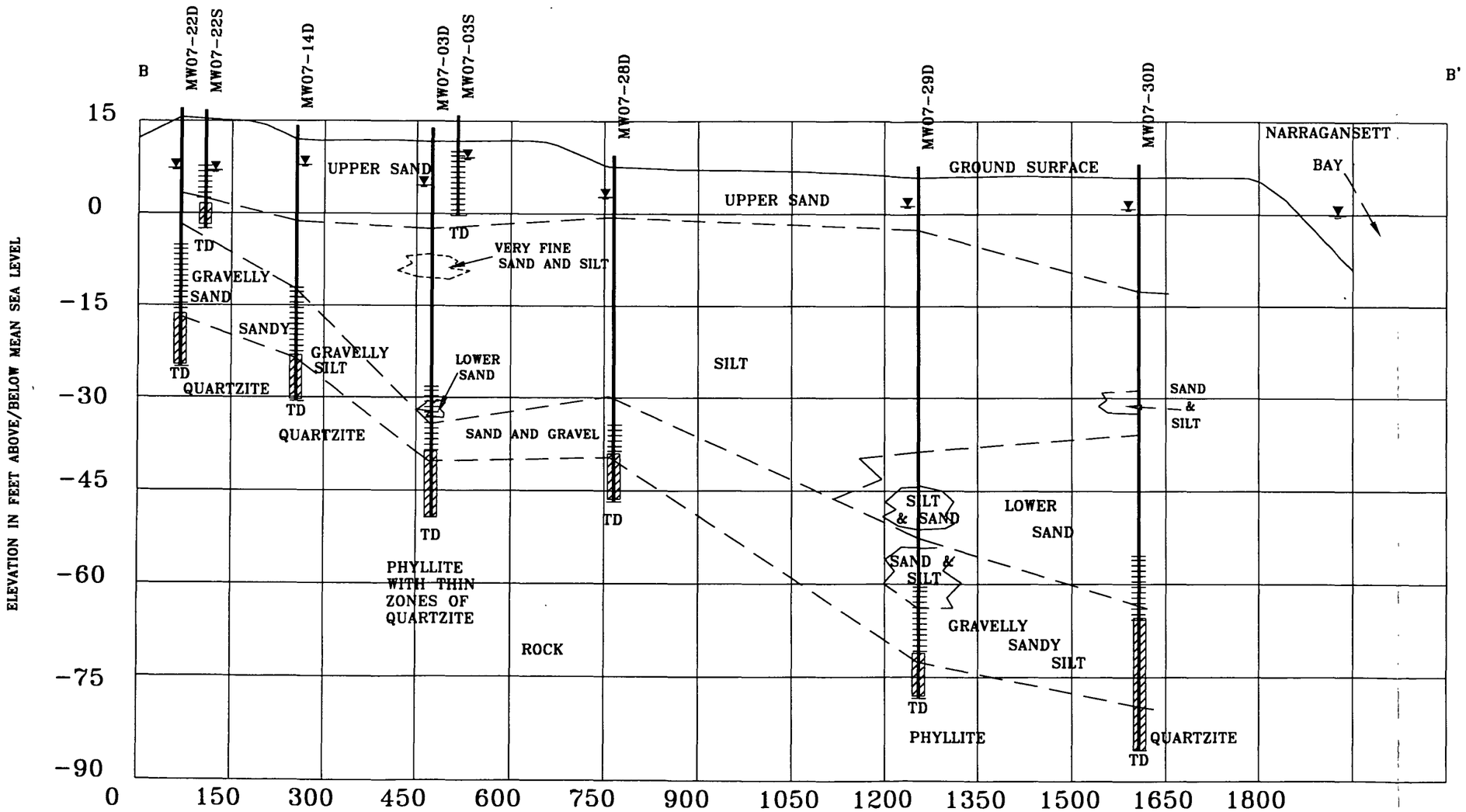
FIGURE 3-3




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

15

0 150

SCALE IN FEET

F:\PROJECTS\29600.32\2937\REPORTS\DRAFT\CAD01\FIG3-4.DWG

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|---|---|---|---|
| JBM | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| PWH | NAL | AS SHOWN | CROSSB-B |

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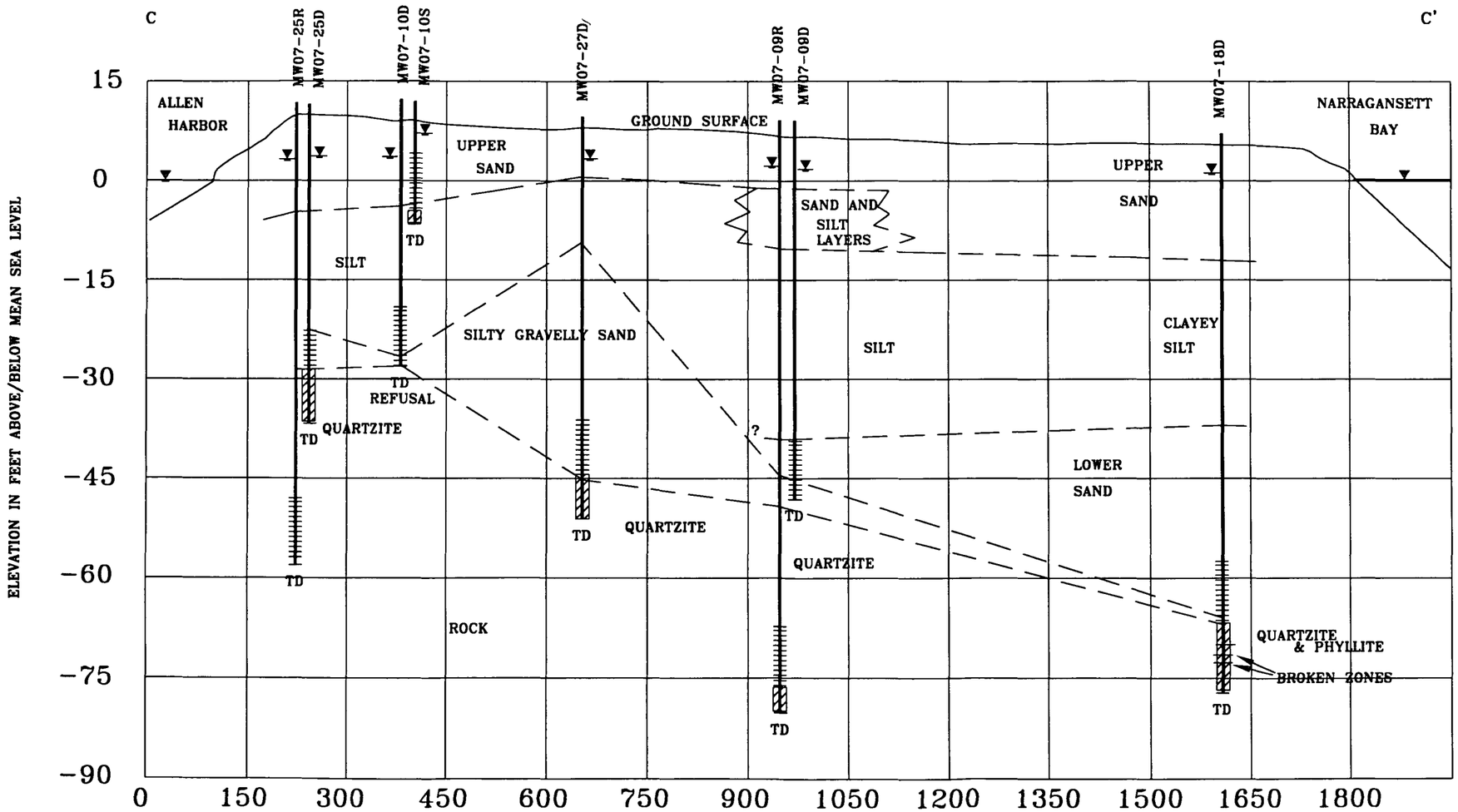
GEOLOGIC CROSS SECTION B-B'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-4

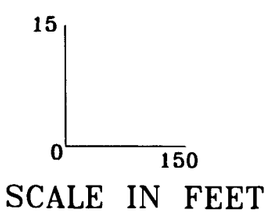



## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| ≡ | SCREENED INTERVAL OF MONITORING WELL |
| ▨ | BENTONITE SEALED BOREHOLE |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.




F:\PROJECTS\29600.32\DSF\REPORTS\DRAFT\CAD\FIG-5.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

| DESIGNED BY | DRAWN BY | DATE | PROJECT NO. |
|---|---|---|---|
| JLS | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | CROSSC-C |

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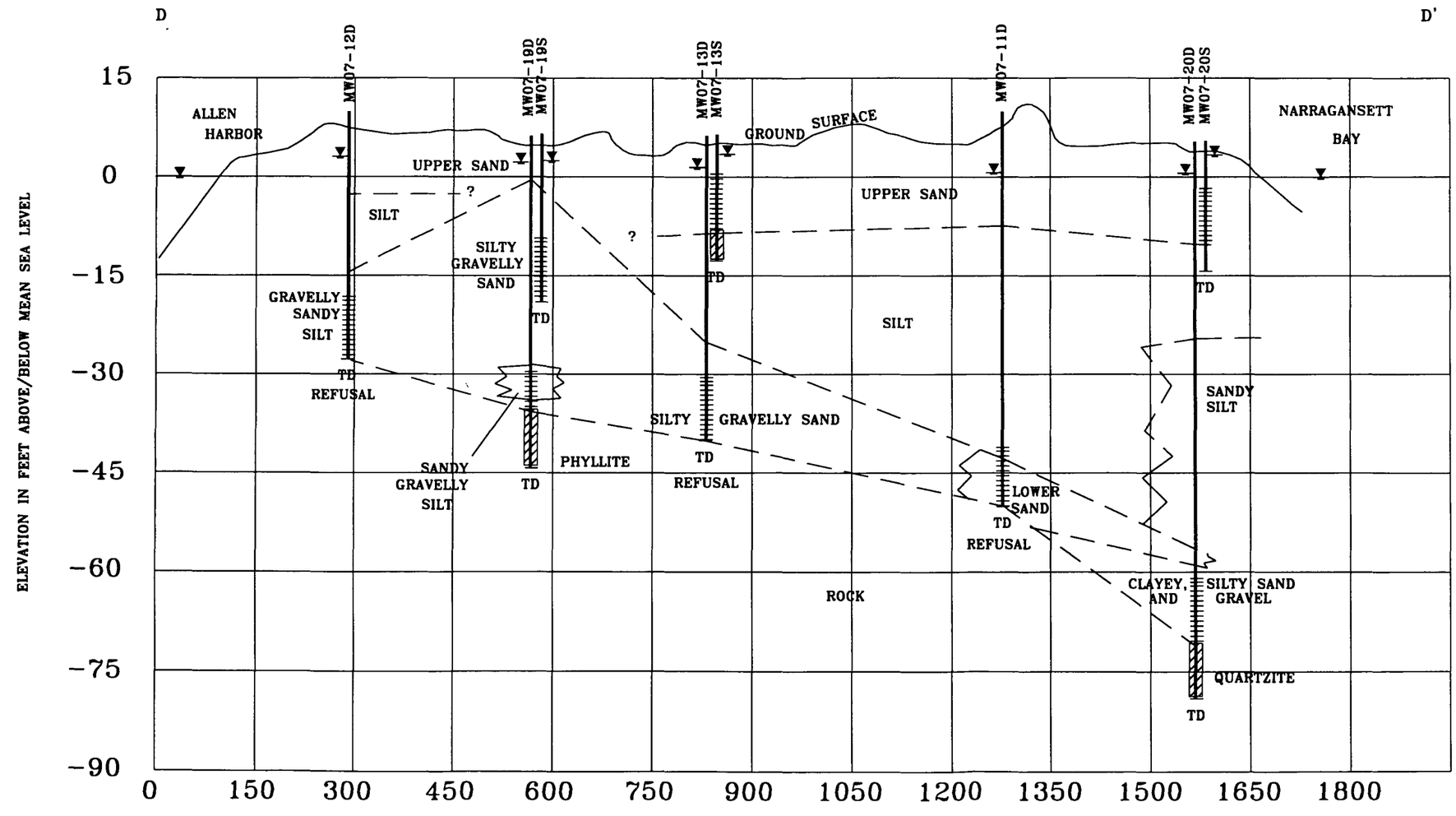
NCBC DAVISVILLE, RHODE ISLAND

GEOLOGIC CROSS SECTION C-C'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-5

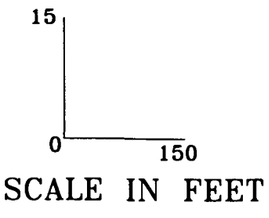



## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.




F:\PROJECTS\29600.32\2597\REPORTS\DRAFT\CLD01\F023-6.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

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|---|---|---|---|
| JLS | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | CROSSD-D |

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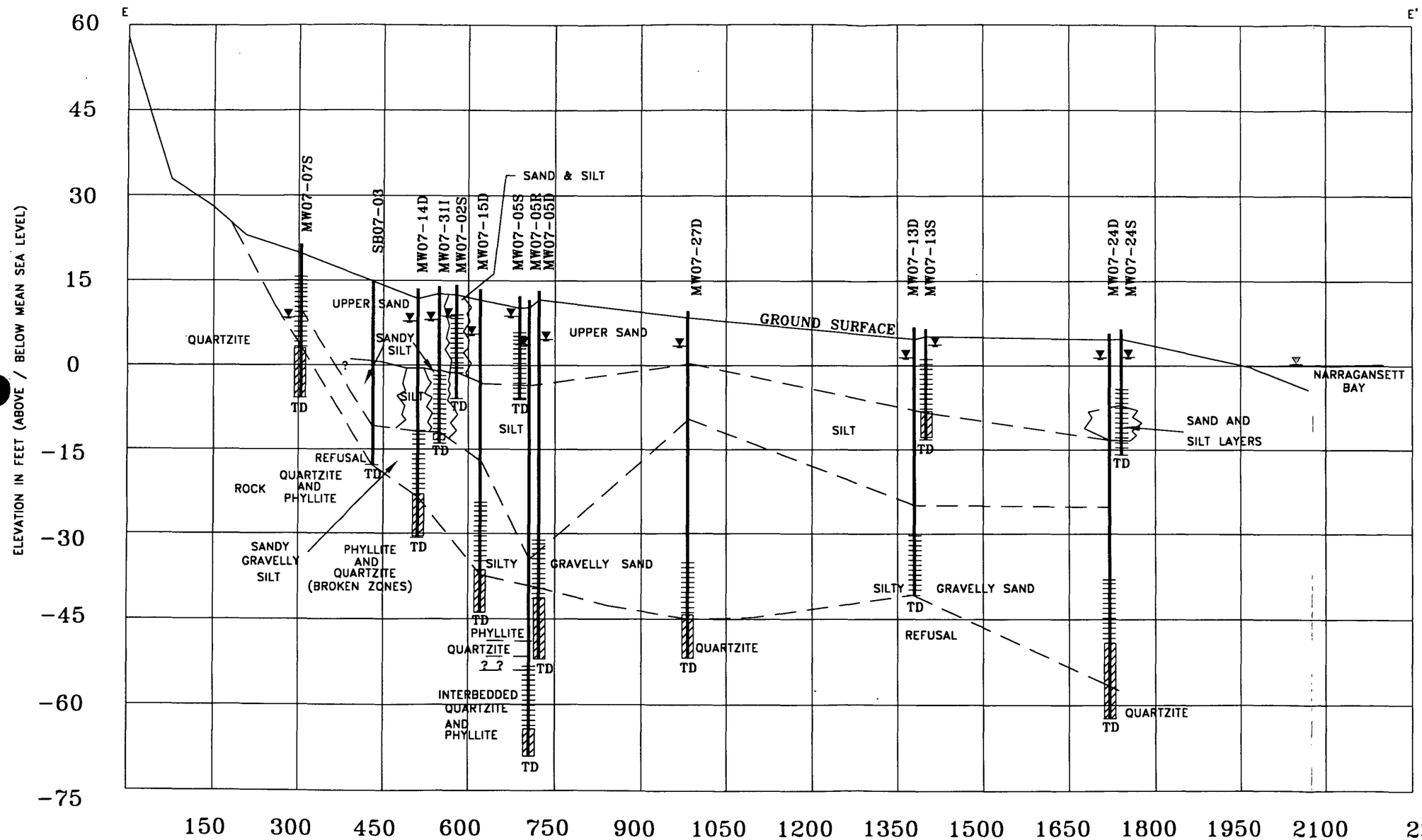
GEOLOGIC CROSS SECTION D-D'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-6




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MID) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS

15
0 150
SCALE IN FEET

F:\PROJECTS\29600.32\2SSFA\REPORTS\DRAFT\CAS01\FIG3-7.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

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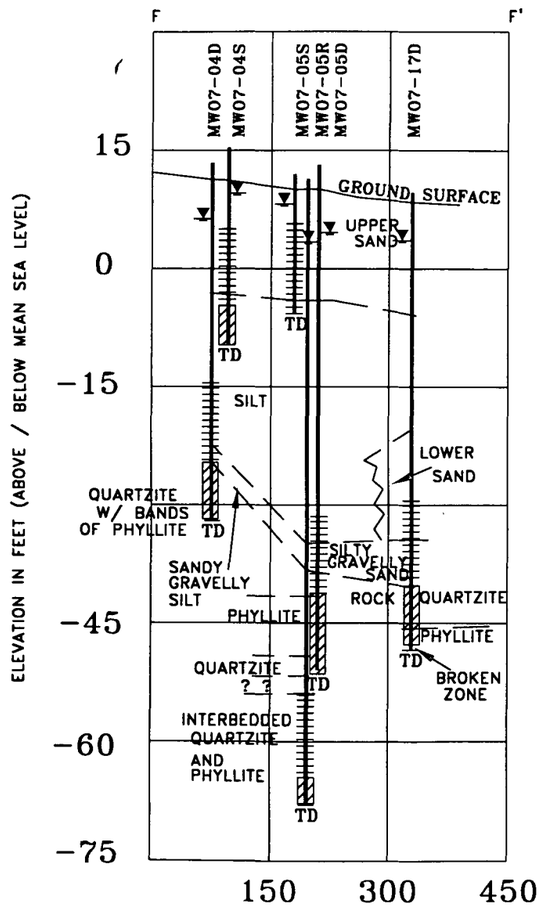
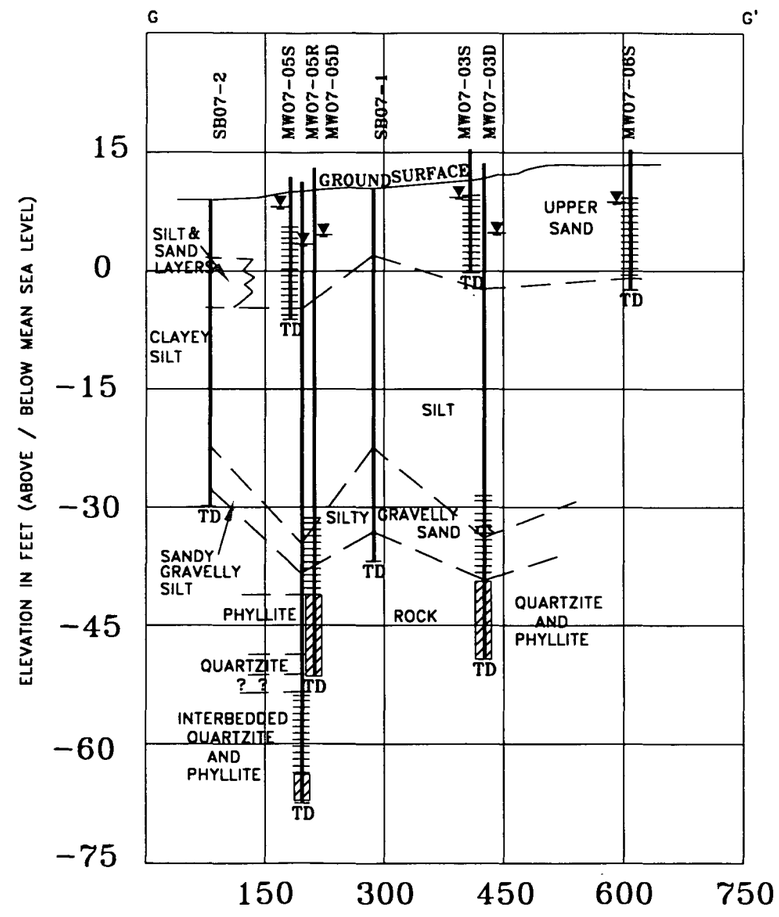
|---|---|---|---|
| JLS | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | CROSSE-E |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

GEOLOGIC CROSS SECTION E-E'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-7




## LEGEND

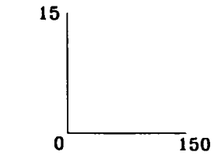
| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

5) SOIL BORINGS AT SITE 07 WERE BACKFILLED WITH CEMENT/ BENTONITE GROUT FROM TOTAL DEPTH TO LAND SURFACE.

4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS




SCALE IN FEET

F:\PROJECTS\29600.32\DRFT\REPORTS\DRAFT\CADD\FIG3-8.DWG

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|---|---|---|---|
| JLS | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | CROSSF-G |

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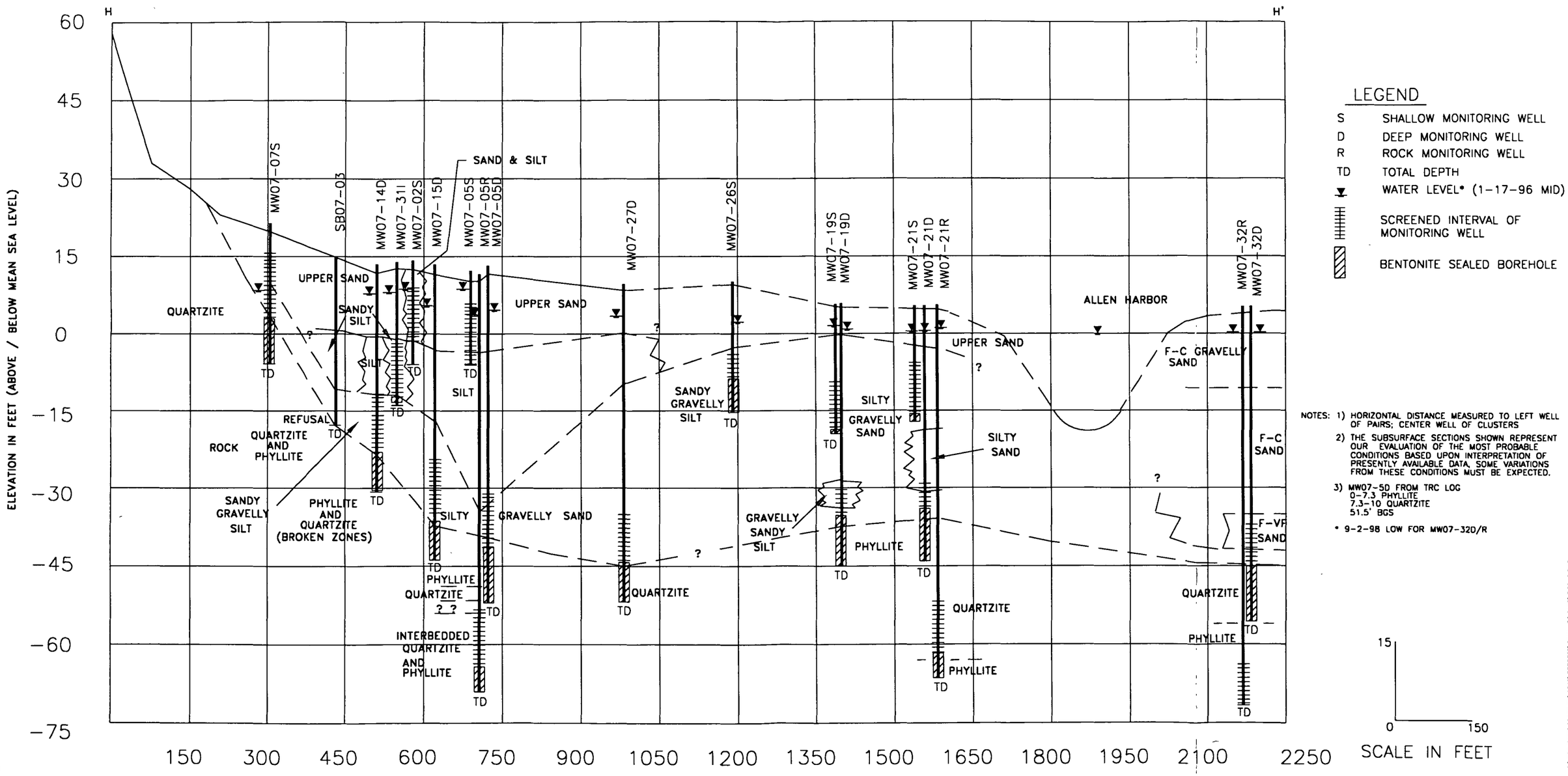
NCBC DAVISVILLE, RHODE ISLAND

GEOLOGIC CROSS SECTIONS F-F' & G-G'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-8




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL* (1-17-96 MID) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS

* 9-2-98 LOW FOR MW07-32D/R

F:\PROJECTS\29600.32\3295\REPORTS\FINAL_RI\CADD\FIG3-9.DWG

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| DESIGNED BY | DRAWN BY | DATE | PROJECT NO. |
|---|---|---|---|
| JLS | JFW | 9/9/98 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | CROSSH-H |

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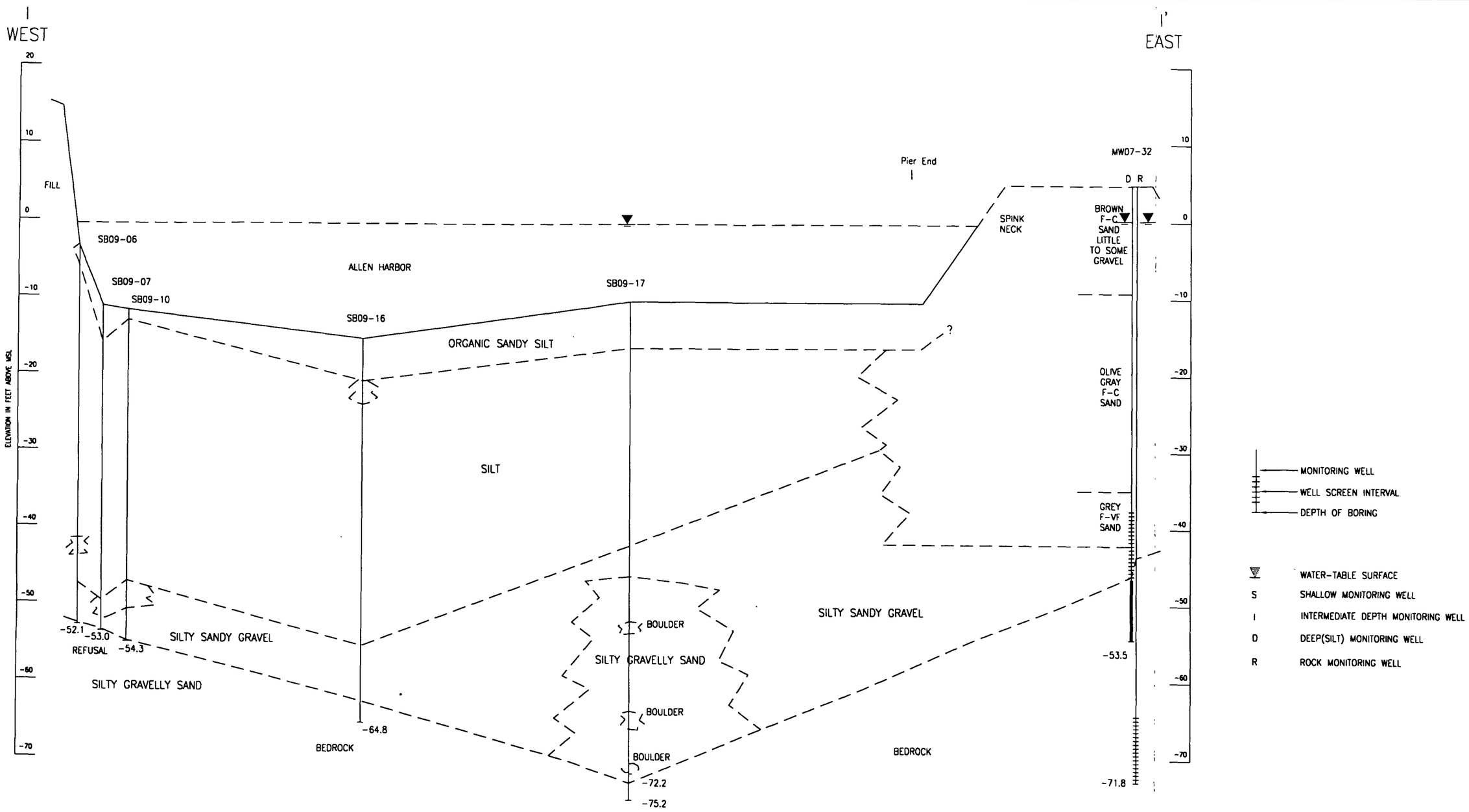
NCBC DAVISVILLE, RHODE ISLAND

GEOLOGIC CROSS SECTION H-H'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-9

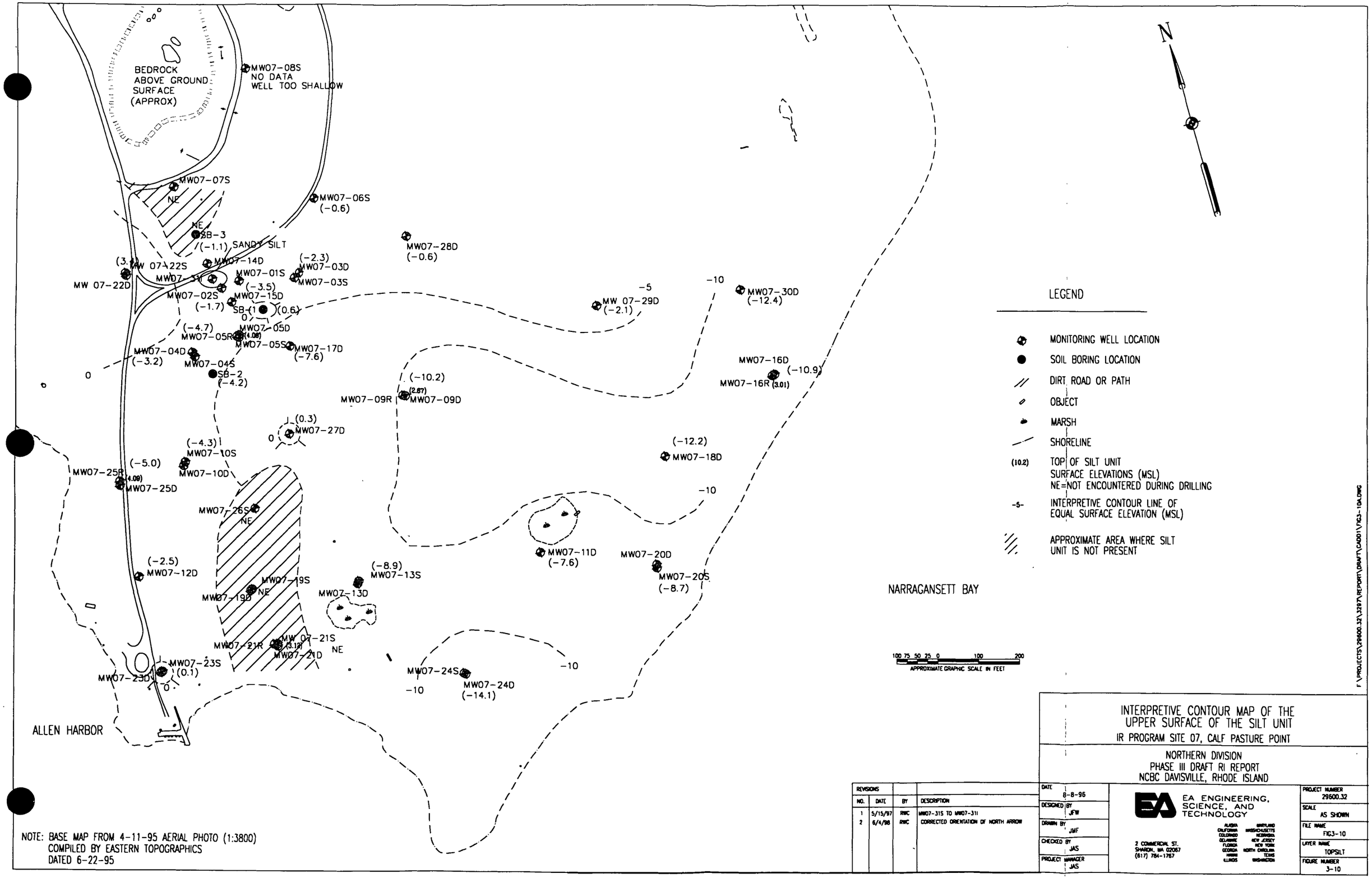



NOTE:
THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

HORIZONTAL SCALE: 1"=200'

FILE: F:\PROJECTS\29600.32\3295\REPORTS\FINAL_RI\CADD\FIG3-9A.DWG

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EA ENGINEERING, SCIENCE, AND TECHNOLOGY | NORTHERN DIVISION<br>PHASE III RI REPORT<br>CALF PASTURE POINT, IR PROGRAM SITE 07<br>NCBC DAVISVILLE, RHODE ISLAND | GEOLOGICAL CROSS SECTION I-I' | DESIGNED BY<br>JAS | DRAWN BY<br>MSM/FDV | DATE<br>9/9/98 | PROJECT NO.<br>29600.32 | FILE NAME<br>FIG3-9A |
| | | | CHECKED BY<br>JAS | PROJECT MGR.<br>JAS | SCALE<br>AS SHOWN | DRAWING NO.<br>– | FIGURE<br>3-9A |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | MW07-31S TO MW07-31I |
| 2 | 6/4/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

INTERPRETIVE CONTOUR MAP OF THE UPPER SURFACE OF THE SILT UNIT

IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JMF |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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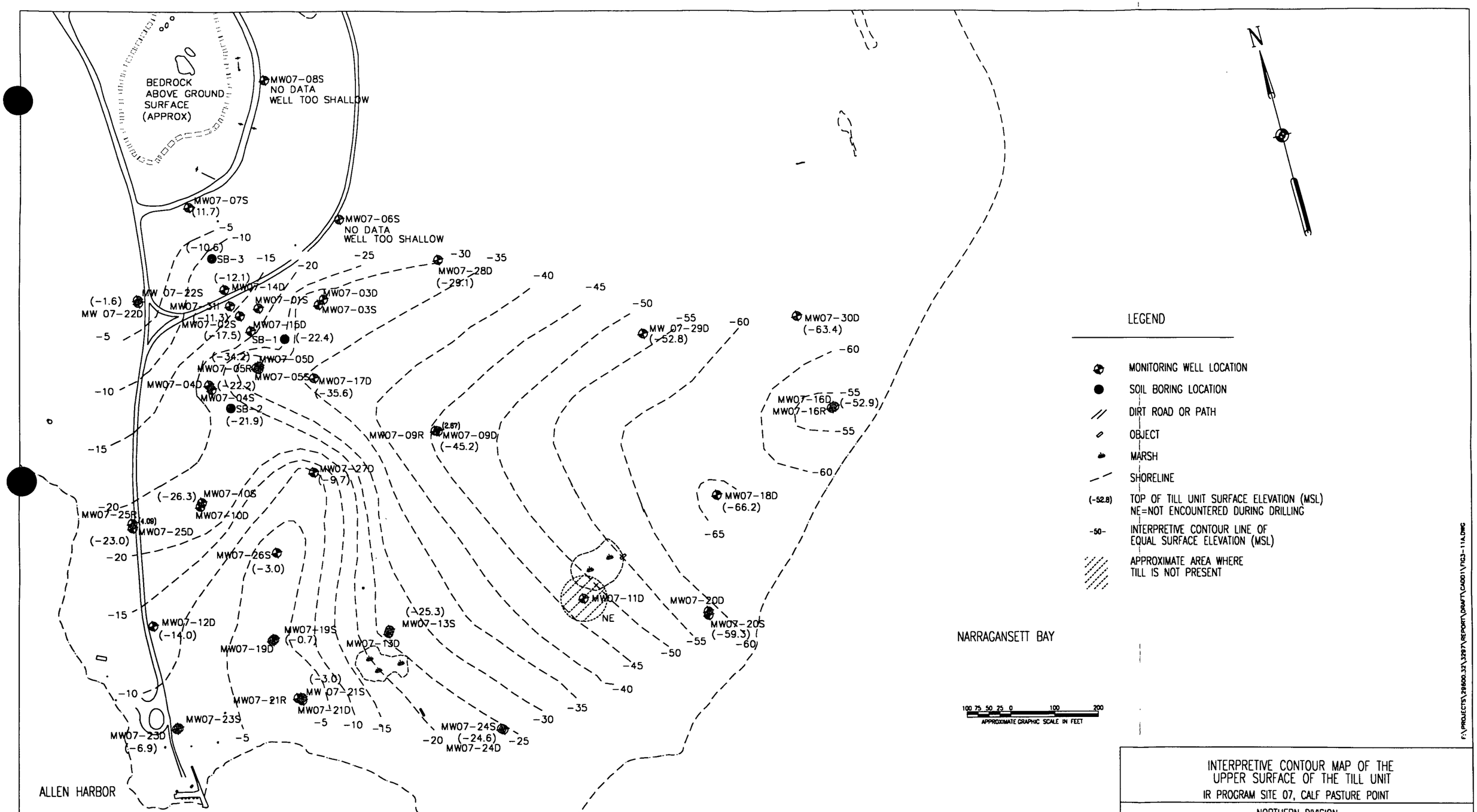
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-10 |
| LAYER NAME | TOPSILT |
| FIGURE NUMBER | 3-10 |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\3287\REPORT\DRAFT\CAD01\FIG3-11A.DWG

INTERPRETIVE CONTOUR MAP OF THE UPPER SURFACE OF THE TILL UNIT

IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | MW07-31S TO MW07-31I |
| 2 | 6/4/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JMF |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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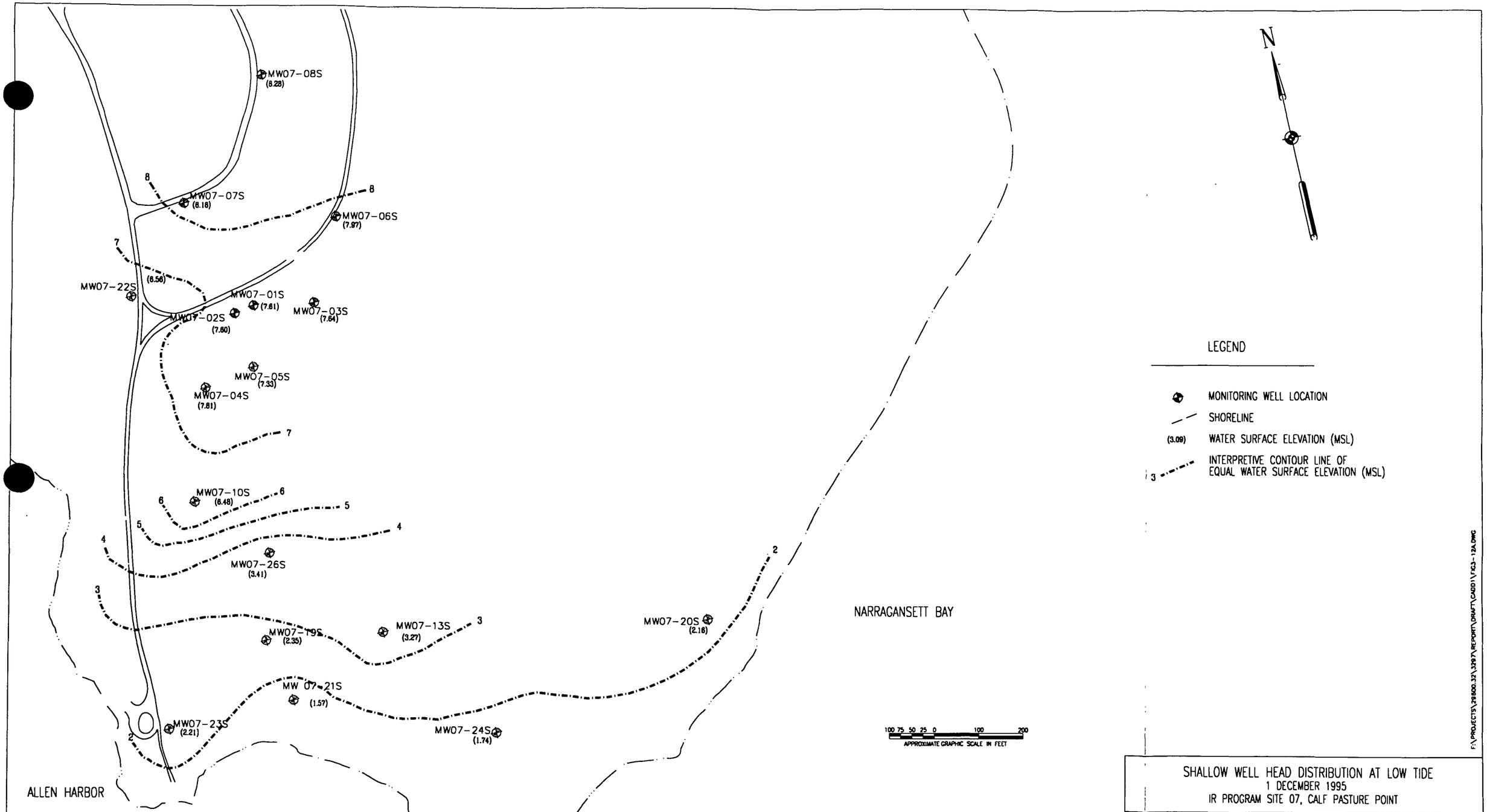
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-11 |
| LAYER NAME | TOPTILL |
| FIGURE NUMBER | 3-11 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-12A.DWG

SHALLOW WELL HEAD DISTRIBUTION AT LOW TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | MOVED MW07-31 TO DEEP FIGURE |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 8-8-96
DESIGNED BY JFW
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

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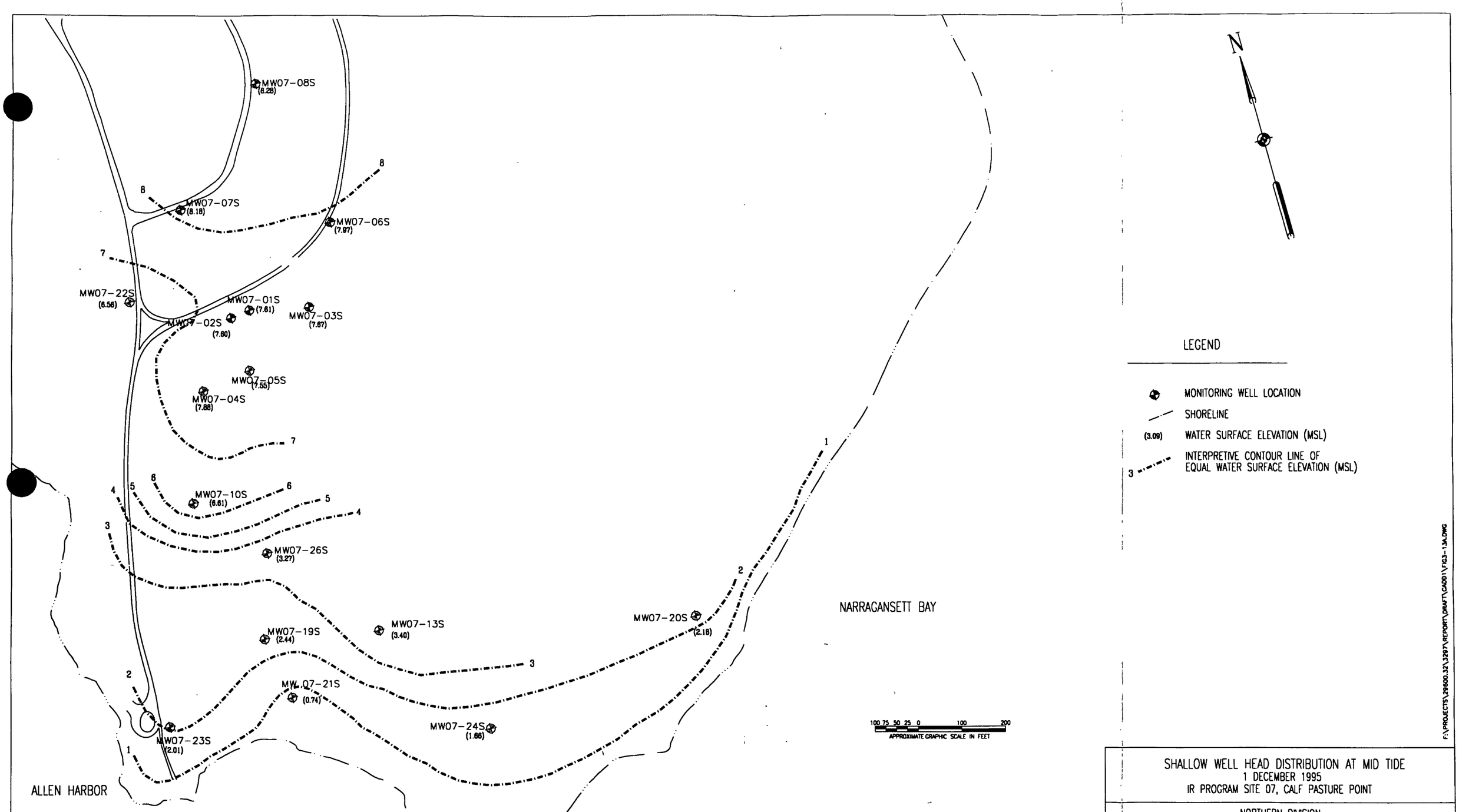
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG3-12
LAYER NAME 12-1-SHAL-LOW
FIGURE NUMBER 3-12




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CAD01\FIG3-13A.DWG

SHALLOW WELL HEAD DISTRIBUTION AT MID TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | MOVED MW07-31 TO DEEP FIGURE |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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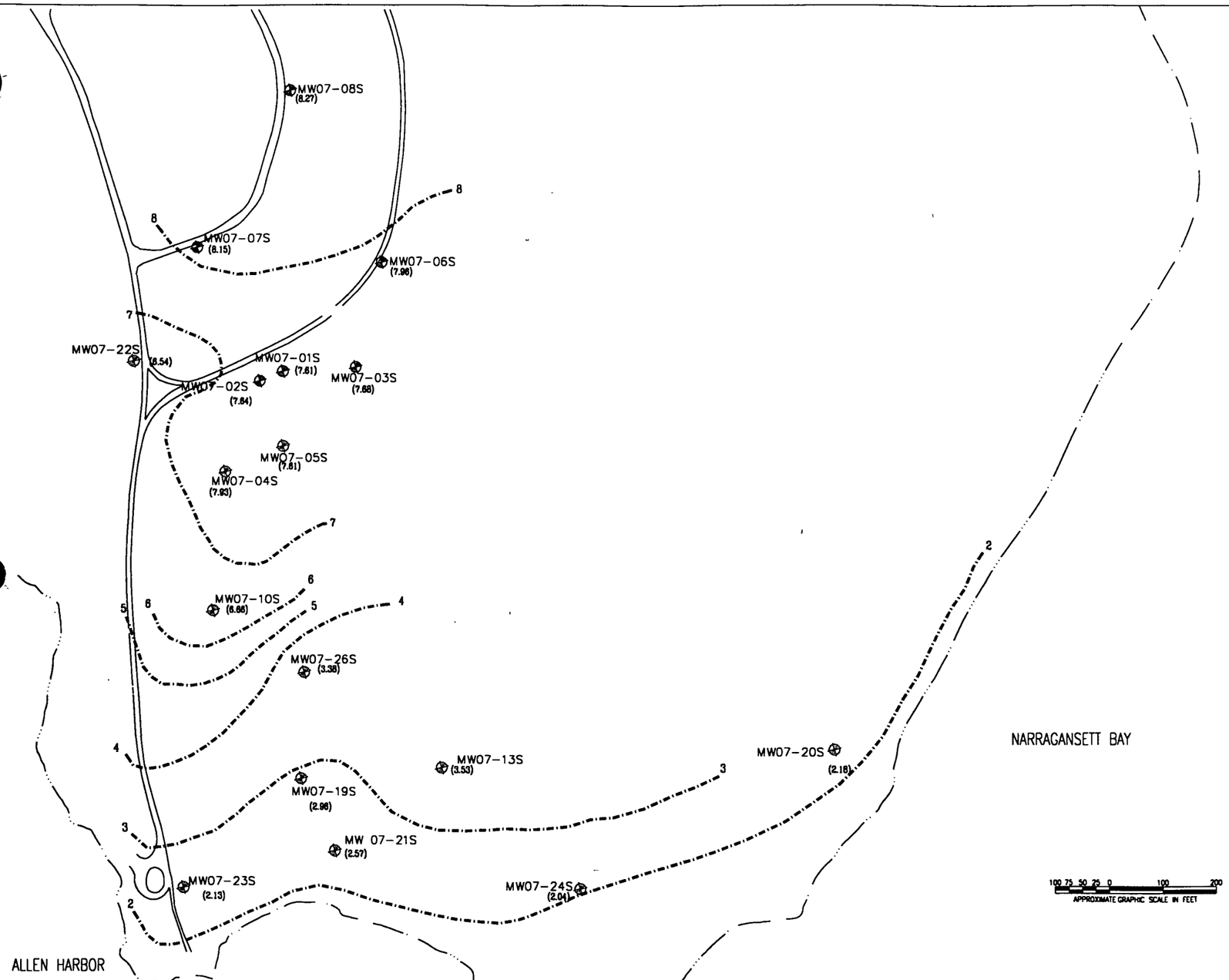
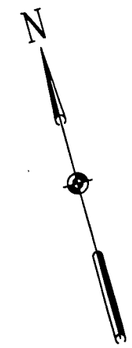
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-13 |
| LAYER NAME | 12-1-SHAL-MID |
| FIGURE NUMBER | 3-13 |




LEGEND

- MONITORING WELL LOCATION
- SHORELINE
- (3.09) WATER SURFACE ELEVATION (MSL)
- 3 INTERPRETIVE CONTOUR LINE OF EQUAL WATER SURFACE ELEVATION (MSL)

100 75 50 25 0 100 200
APPROXIMATE GRAPHIC SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-14A.DWG

NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

SHALLOW WELL HEAD DISTRIBUTION AT HIGH TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | MOVED MW07-31 TO DEEP FIGURE |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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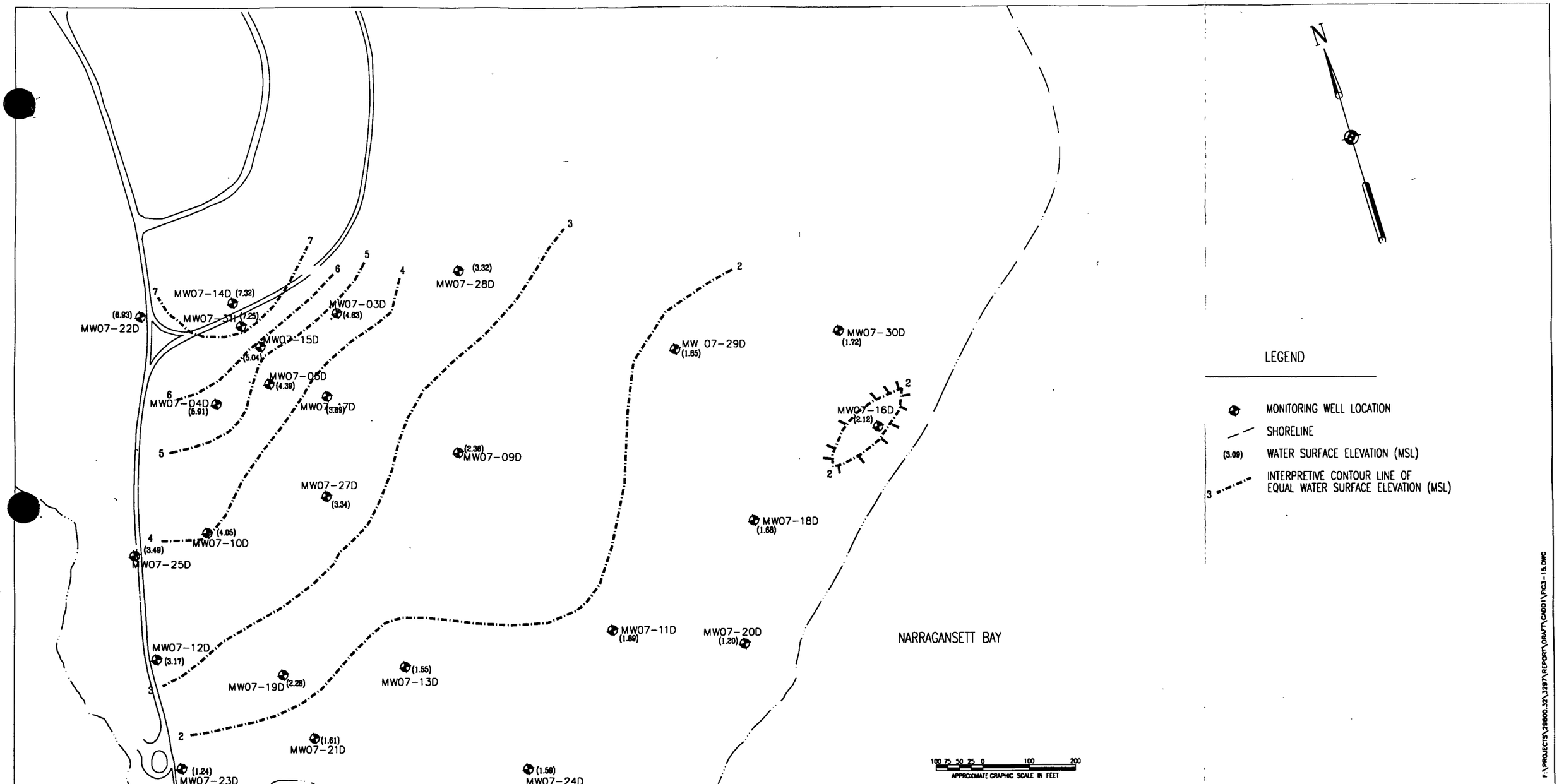
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-14 |
| LAYER NAME | 12-1-SHAL-HI |
| FIGURE NUMBER | 3-14 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-15.DWG

DEEP WELL HEAD DISTRIBUTION AT LOW TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RWC | ADDED MW07-31L, ADJUSTED 7 FT CONTOUR |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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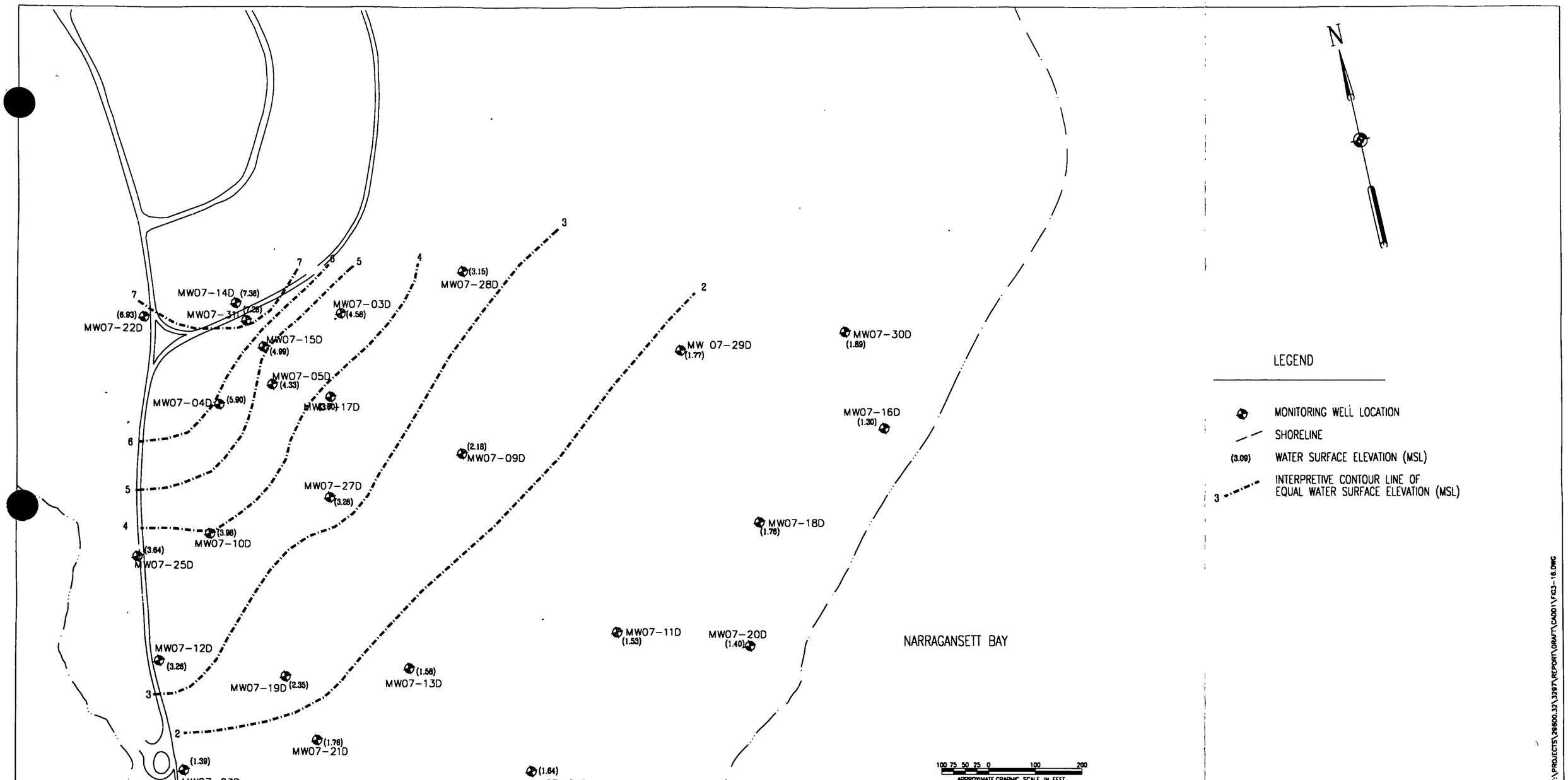
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-15 |
| LAYER NAME | 12-1-DEEP-LOW |
| FIGURE NUMBER | 3-15 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-16.DWG

DEEP WELL HEAD DISTRIBUTION AT MID TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RWC | ADDED MW07-31I, ADJUSTED 7 FT CONTOUR |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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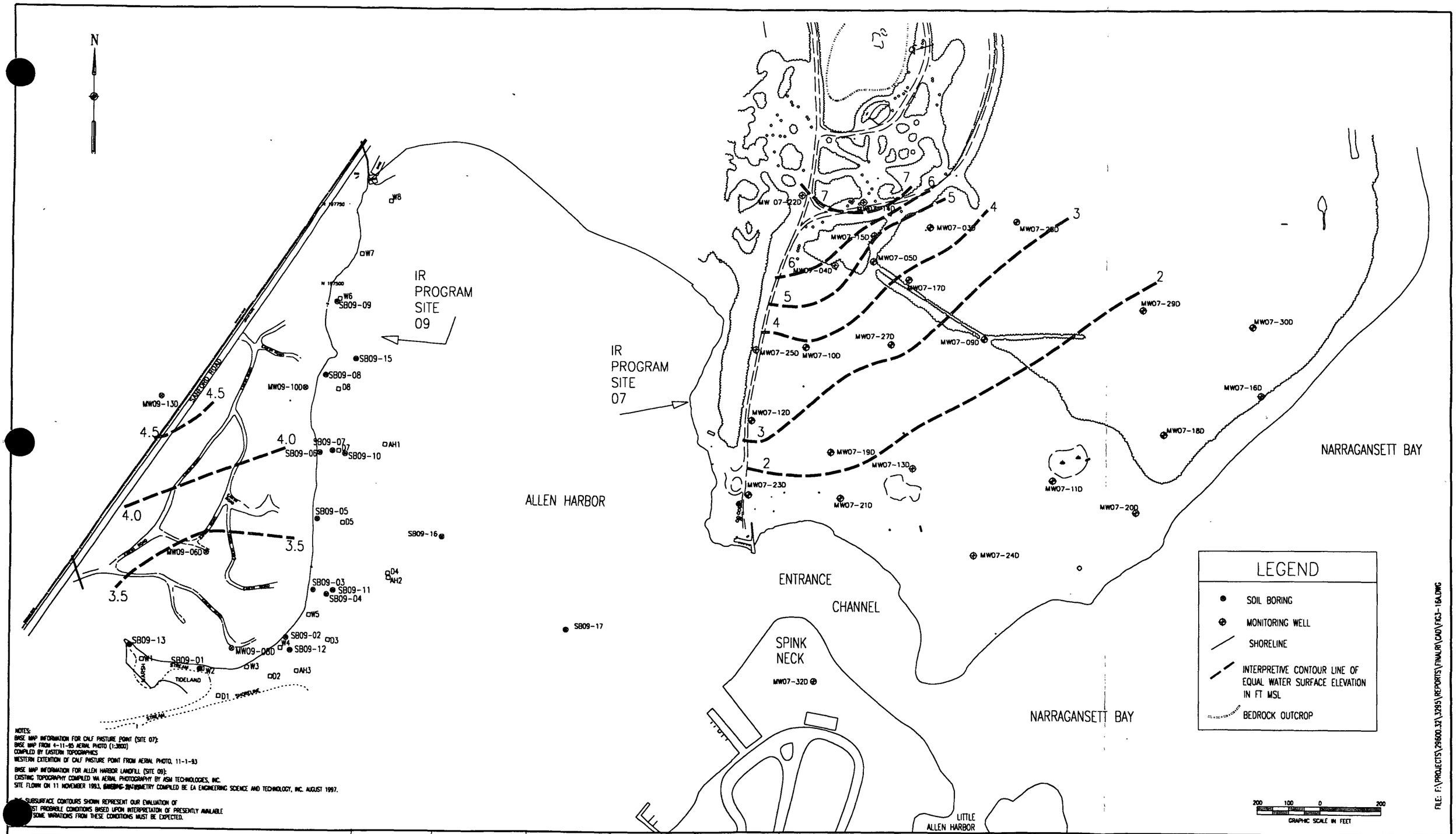
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-16 |
| LAYER NAME | 12-1-DEEP-MID |
| FIGURE NUMBER | 3-16 |




NOTES:
BASE MAP INFORMATION FOR CALF PASTURE POINT (SITE 07):
BASE MAP FROM 4-11-85 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
WESTERN EXTENTION OF CALF PASTURE POINT FROM AERIAL PHOTO, 11-1-93
BASE MAP INFORMATION FOR ALLEN HARBOR LANDFILL (SITE 09):
EXISTING TOPOGRAPHY COMPILED VIA AERIAL PHOTOGRAPHY BY ASM TECHNOLOGIES, INC.
SITE FLOWN ON 11 NOVEMBER 1993, BATHYMETRY COMPILED BE EA ENGINEERING SCIENCE AND TECHNOLOGY, INC. AUGUST 1997.

THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

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| DESIGNED BY | DRAWN BY | DATE | PROJECT NO. | FILE NAME |
|---|---|---|---|---|
| JAS | RWC | 6/4/98 | 29600.32 | FIG3-16A |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | - | 3-16A |

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PHASE III RI REPORT
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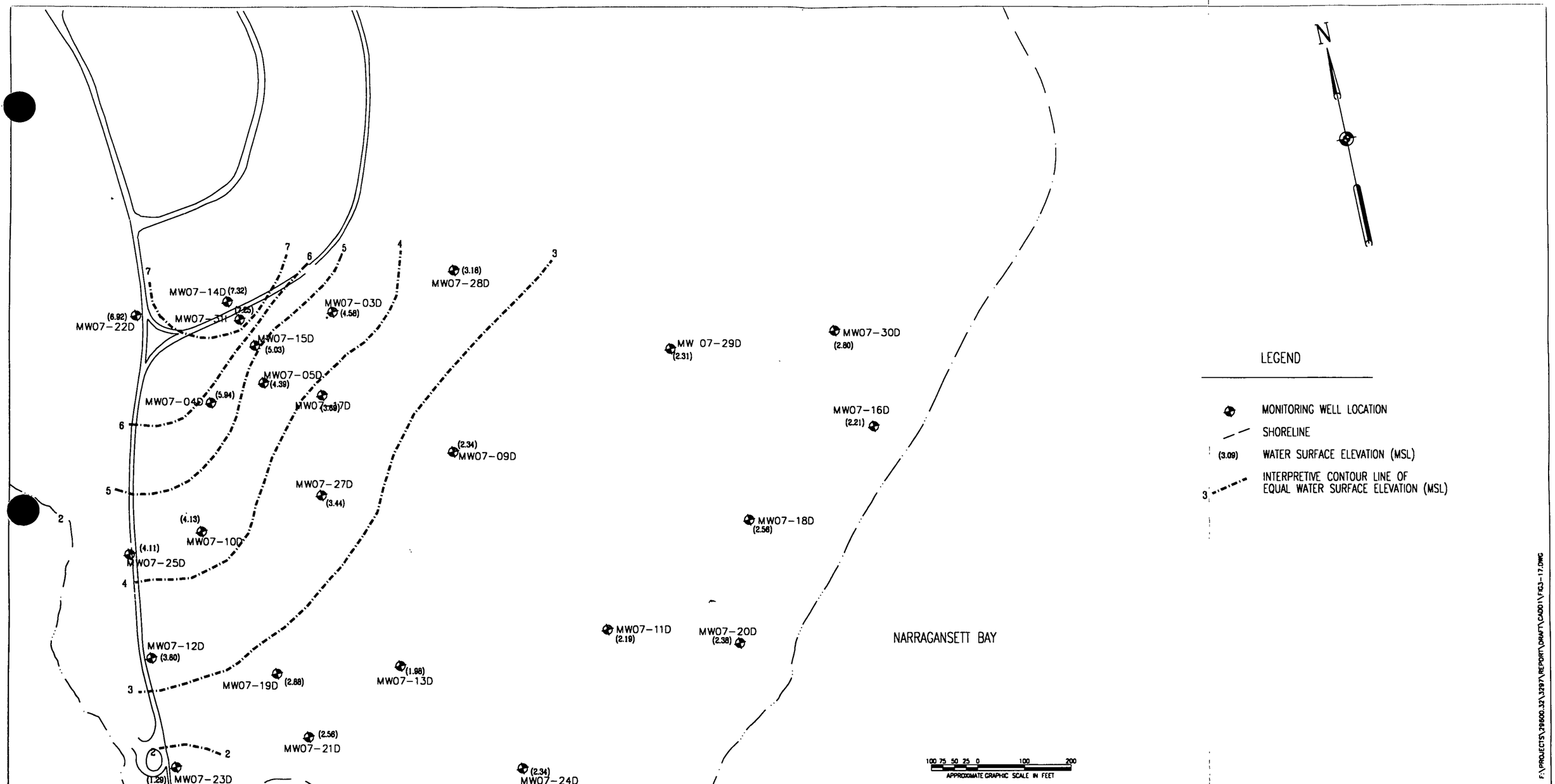
CONSOLIDATED DEEP HEAD DISTRIBUTION AT MID-TIDE
1 DECEMBER 1995 - SITE 07
19 APRIL 1995 - SITE 09
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 3-16A




: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95

2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-17.DWG

DEEP WELL HEAD DISTRIBUTION AT HIGH TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RWC | ADDED MW07-31I, ADJUSTED 7 FT CONTOUR |
| 2 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 8-8-96
DESIGNED BY JFW
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

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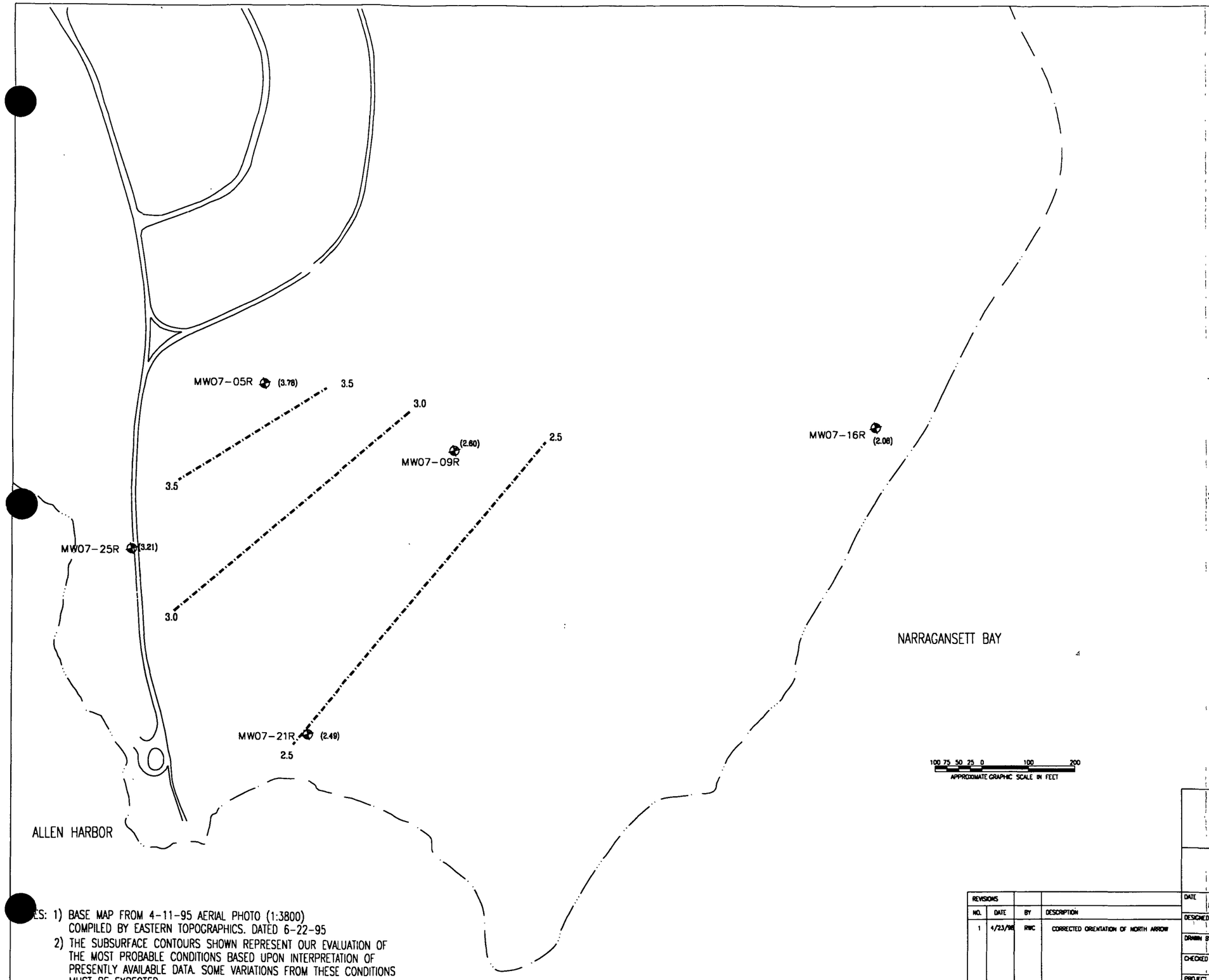
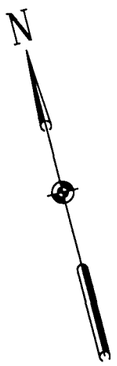
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG3-17
LAYER NAME 12-1-DEEP-HI
FIGURE NUMBER 3-17




LEGEND

- MONITORING WELL LOCATION
- SHORELINE
- (3.09) WATER SURFACE ELEVATION (MSL)
- 3 INTERPRETIVE CONTOUR LINE OF EQUAL WATER SURFACE ELEVATION (MSL)

NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-18.DWG

BEDROCK WELL HEAD DISTRIBUTION AT LOW TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 4/23/96 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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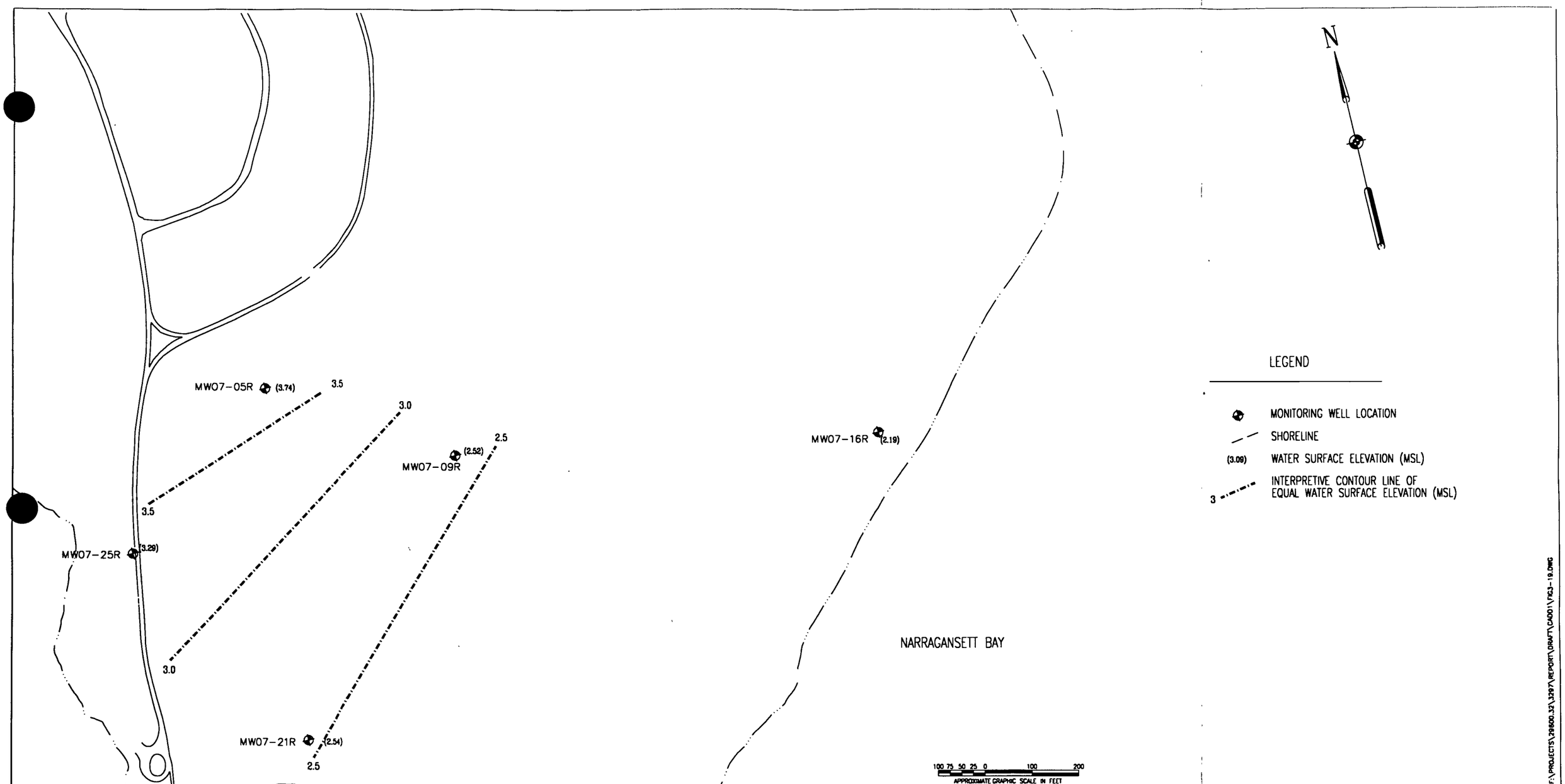
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-18 |
| LAYER NAME | 12-1-ROCK-LOW |
| FIGURE NUMBER | 3-18 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CA001\FIG3-19.DWG

BEDROCK WELL HEAD DISTRIBUTION AT MID TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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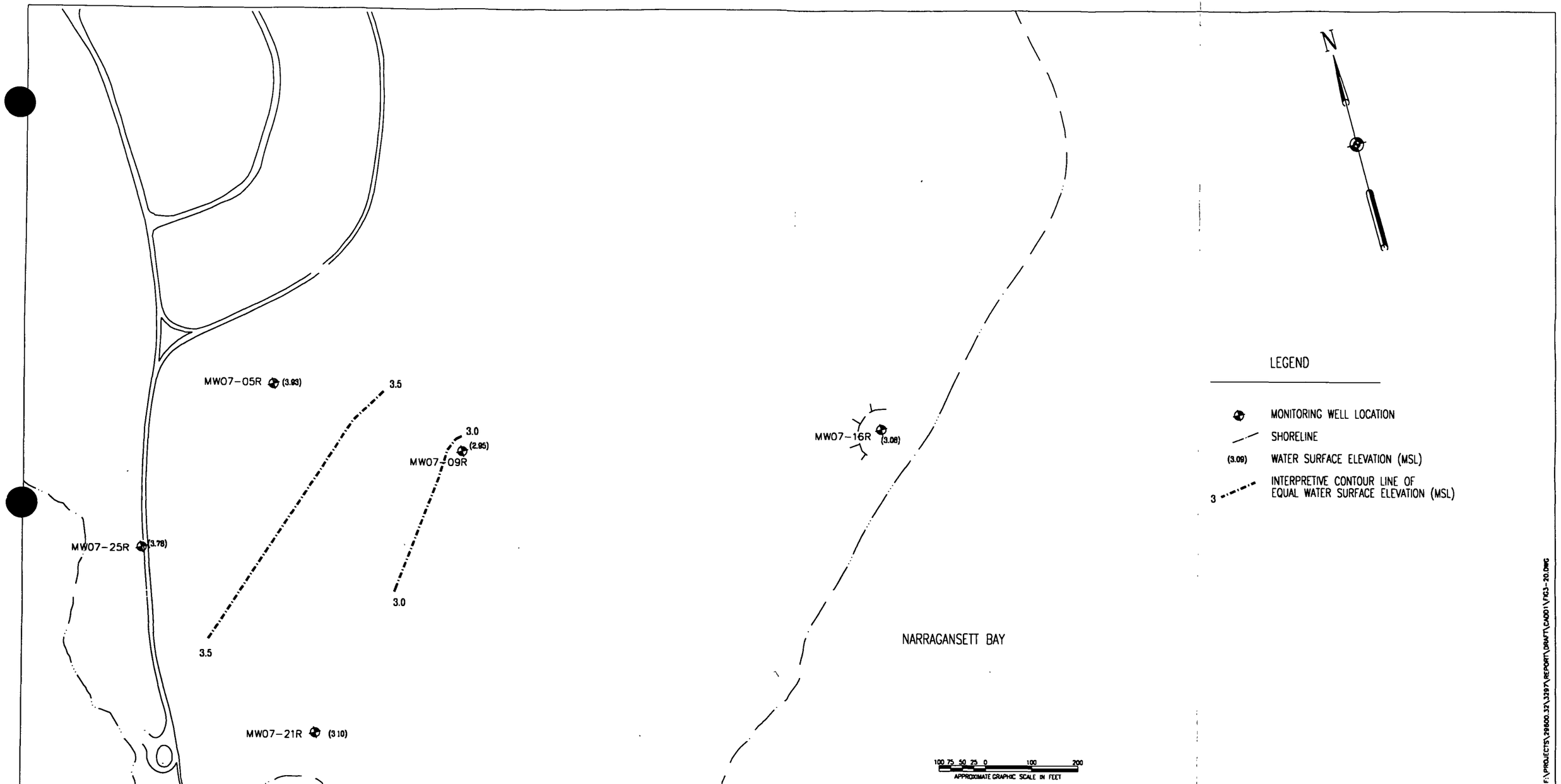
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-19 |
| LAYER NAME | 12-1-ROCK-MID |
| FIGURE NUMBER | 3-19 |




NOTES: 1) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS. DATED 6-22-95
2) THE SUBSURFACE CONTOURS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG3-20.DWG

BEDROCK WELL HEAD DISTRIBUTION AT HIGH TIDE
1 DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

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NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 4/23/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 8-8-96 |
| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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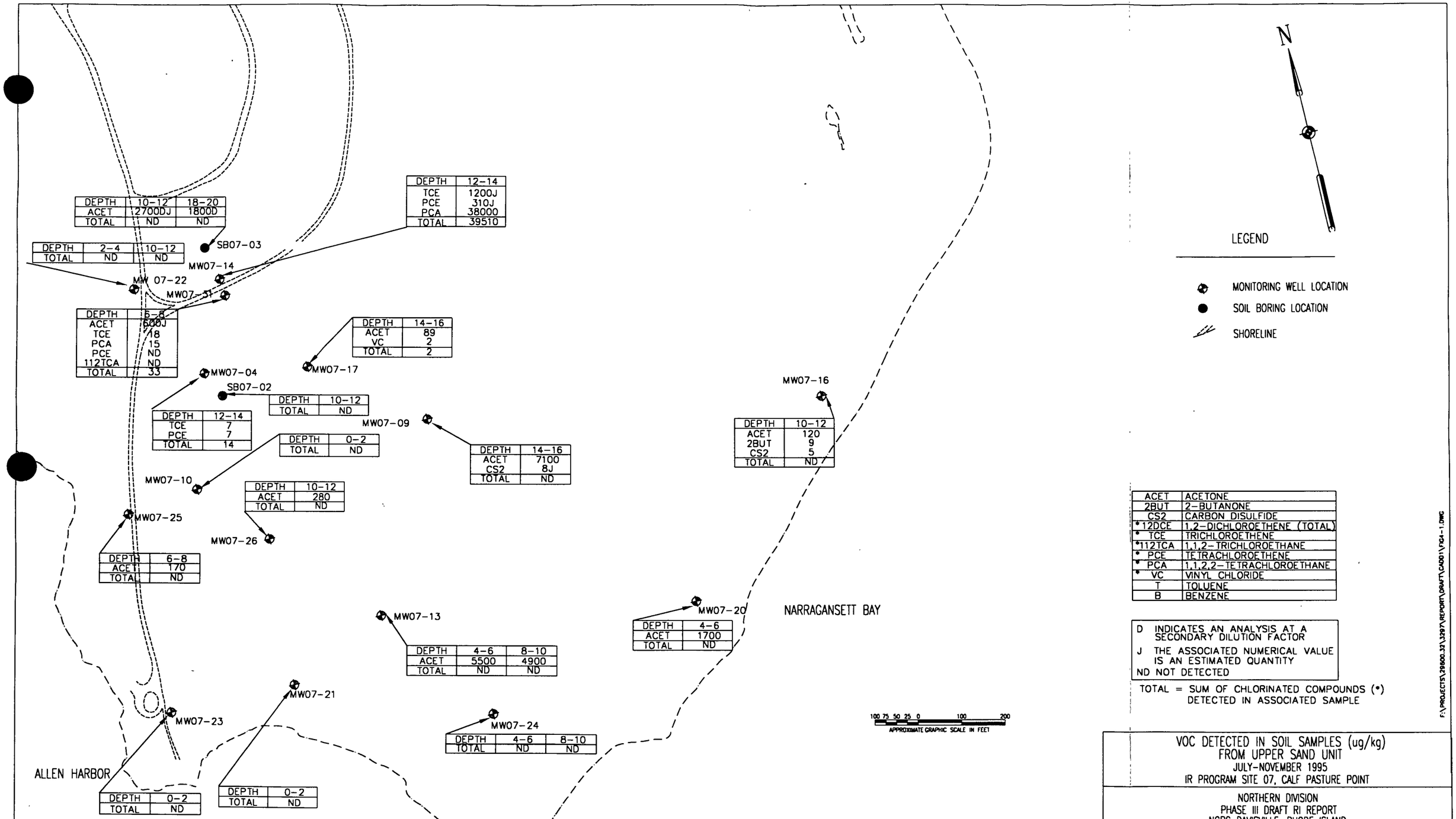
FLORIDA NEW YORK
GEORGIA NORTH CAROLINA
INDIANA TEXAS
ILLINOIS WASHINGTON

| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG3-20 |
| LAYER NAME | 12-1-ROCK-HI |
| FIGURE NUMBER | 3-20 |




| DEPTH | 10-12 | 18-20 |
|---|---|---|
| ACET | 2700DJ | 1800D |
| TOTAL | ND | ND |

| DEPTH | 12-14 |
|---|---|
| TCE | 1200J |
| PCE | 310J |
| PCA | 38000 |
| TOTAL | 39510 |

| DEPTH | 2-4 | 10-12 |
|---|---|---|
| TOTAL | ND | ND |

| DEPTH | 6-8 |
|---|---|
| ACET | 600J |
| TCE | 18 |
| PCA | 15 |
| PCE | ND |
| 112TCA | ND |
| TOTAL | 33 |

| DEPTH | 14-16 |
|---|---|
| ACET | 89 |
| VC | 2 |
| TOTAL | 2 |

| DEPTH | 10-12 |
|---|---|
| TOTAL | ND |

| DEPTH | 12-14 |
|---|---|
| TCE | 7 |
| PCE | 7 |
| TOTAL | 14 |

| DEPTH | 0-2 |
|---|---|
| TOTAL | ND |

| DEPTH | 14-16 |
|---|---|
| ACET | 7100 |
| CS2 | 8J |
| TOTAL | ND |

| DEPTH | 10-12 |
|---|---|
| ACET | 280 |
| TOTAL | ND |

| DEPTH | 10-12 |
|---|---|
| ACET | 120 |
| 2BUT | 9 |
| CS2 | 5 |
| TOTAL | ND |

| DEPTH | 6-8 |
|---|---|
| ACET | 170 |
| TOTAL | ND |

| DEPTH | 4-6 |
|---|---|
| ACET | 1700 |
| TOTAL | ND |

| DEPTH | 4-6 | 8-10 |
|---|---|---|
| ACET | 5500 | 4900 |
| TOTAL | ND | ND |

| DEPTH | 4-6 | 8-10 |
|---|---|---|
| TOTAL | ND | ND |

| DEPTH | 0-2 |
|---|---|
| TOTAL | ND |

| DEPTH | 0-2 |
|---|---|
| TOTAL | ND |

| | |
|---|---|
| ACET | ACETONE |
| 2BUT | 2-BUTANONE |
| CS2 | CARBON DISULFIDE |
| *12DCE | 1,2-DICHLOROETHENE (TOTAL) |
| * TCE | TRICHLOROETHENE |
| *112TCA | 1,1,2-TRICHLOROETHANE |
| * PCE | TETRACHLOROETHENE |
| * PCA | 1,1,2,2-TETRACHLOROETHANE |
| * VC | VINYL CHLORIDE |
| T | TOLUENE |
| B | BENZENE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED QUANTITY

ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS (*) DETECTED IN ASSOCIATED SAMPLE

NOTES:1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG4-1.DWG

VOC DETECTED IN SOIL SAMPLES (ug/kg)
FROM UPPER SAND UNIT
JULY-NOVEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 6/4/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 8-8-96
DESIGNED BY JFW
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

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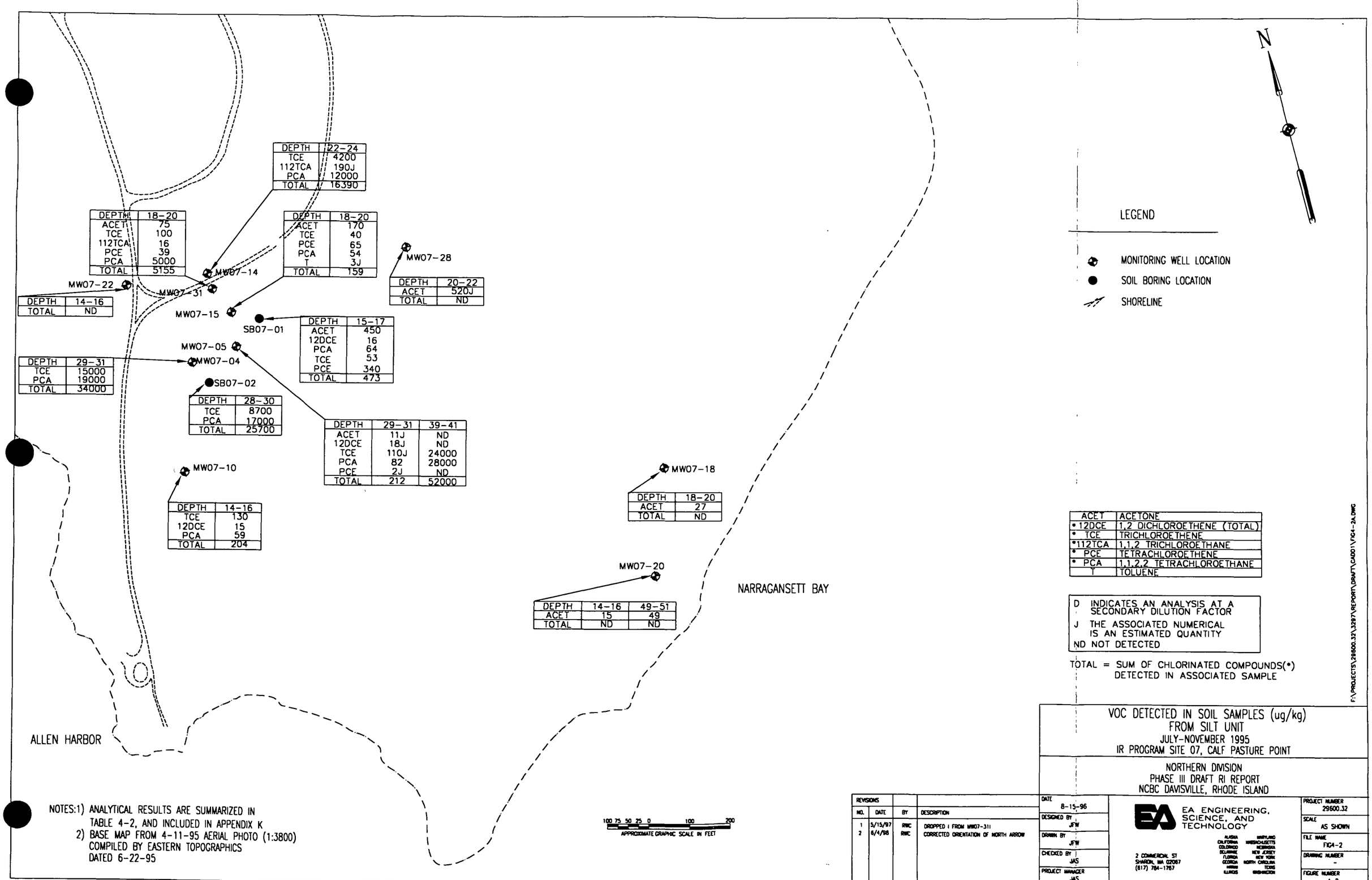
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG4-1
DRAWING NUMBER -
FIGURE NUMBER 4-1




| | |
|---|---|
| ACET | ACETONE |
| * 12DCE | 1,2 DICHLOROETHENE (TOTAL) |
| * TCE | TRICHLOROETHENE |
| *112TCA | 1,1,2 TRICHLOROETHANE |
| * PCE | TETRACHLOROETHENE |
| * PCA | 1,1,2,2 TETRACHLOROETHANE |
| T | TOLUENE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL IS AN ESTIMATED QUANTITY

ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS(*) DETECTED IN ASSOCIATED SAMPLE

NOTES:1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD\FIG4-2A.DWG

VOC DETECTED IN SOIL SAMPLES (ug/kg)
FROM SILT UNIT
JULY-NOVEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/15/97 | RWC | DROPPED I FROM MW07-311 |
| 2 | 6/4/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 8-15-96
DESIGNED BY JFW
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

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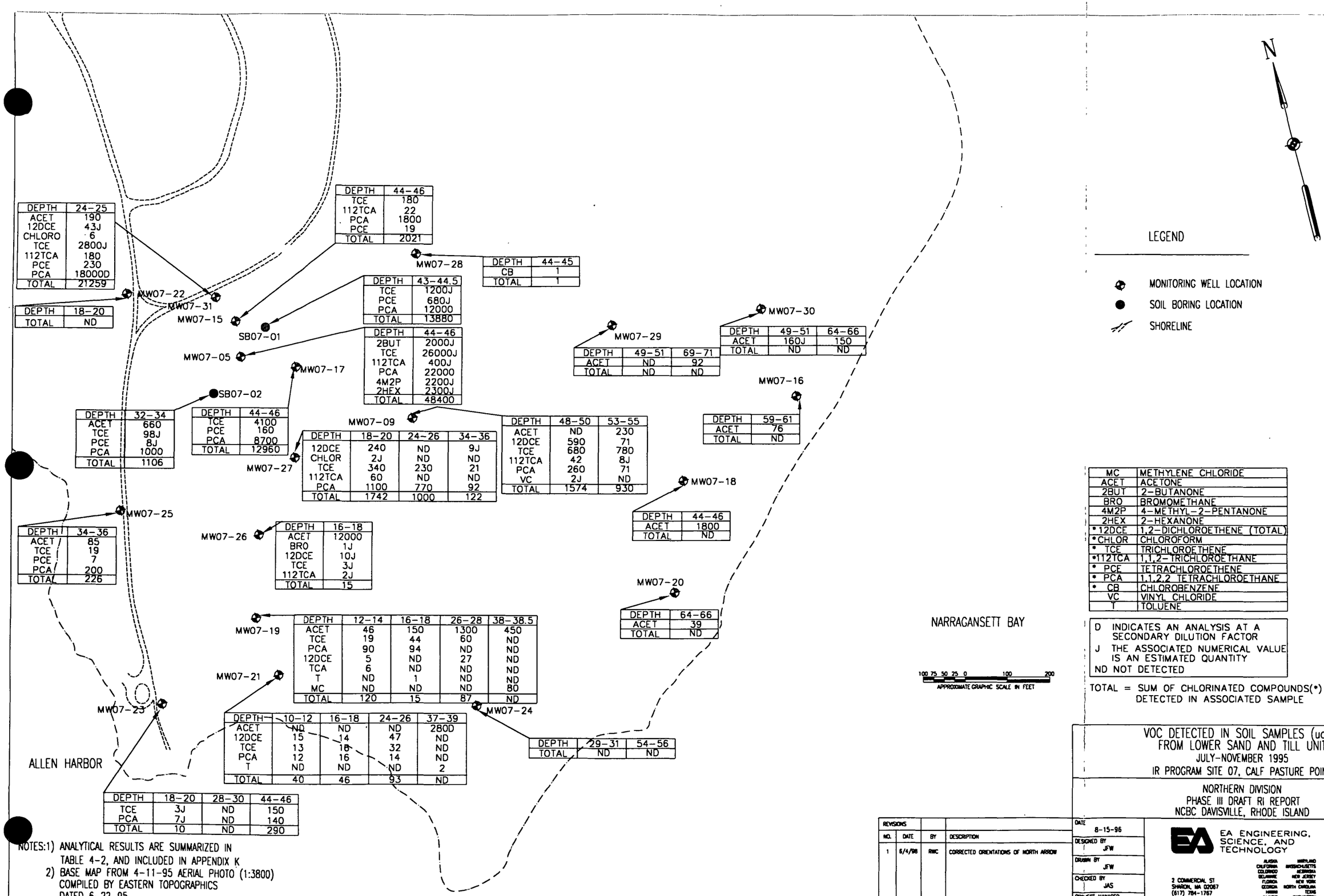
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG4-2
DRAWING NUMBER -
FIGURE NUMBER 4-2




| DEPTH | 24-25 |
|---|---|
| ACET | 190 |
| 12DCE | 43J |
| CHLORO | 6 |
| TCE | 2800J |
| 112TCA | 180 |
| PCE | 230 |
| PCA | 18000D |
| TOTAL | 21259 |

| DEPTH | 18-20 |
|---|---|
| TOTAL | ND |

| DEPTH | 44-46 |
|---|---|
| TCE | 180 |
| 112TCA | 22 |
| PCA | 1800 |
| PCE | 19 |
| TOTAL | 2021 |

| DEPTH | 44-45 |
|---|---|
| CB | 1 |
| TOTAL | 1 |

| DEPTH | 43-44.5 |
|---|---|
| TCE | 1200J |
| PCE | 680J |
| PCA | 12000 |
| TOTAL | 13880 |

| DEPTH | 44-46 |
|---|---|
| 2BUT | 2000J |
| TCE | 26000J |
| 112TCA | 400J |
| PCA | 22000 |
| 4M2P | 2200J |
| 2HEX | 2300J |
| TOTAL | 48400 |

| DEPTH | 49-51 | 69-71 |
|---|---|---|
| ACET | ND | 92 |
| TOTAL | ND | ND |

| DEPTH | 49-51 | 64-66 |
|---|---|---|
| ACET | 160J | 150 |
| TOTAL | ND | ND |

| DEPTH | 32-34 |
|---|---|
| ACET | 660 |
| TCE | 98J |
| PCE | 8J |
| PCA | 1000 |
| TOTAL | 1106 |

| DEPTH | 44-46 |
|---|---|
| TCE | 4100 |
| PCE | 160 |
| PCA | 8700 |
| TOTAL | 12960 |

| DEPTH | 18-20 | 24-26 | 34-36 |
|---|---|---|---|
| 12DCE | 240 | ND | 9J |
| CHLOR | 2J | ND | ND |
| TCE | 340 | 230 | 21 |
| 112TCA | 60 | ND | ND |
| PCA | 1100 | 770 | 92 |
| TOTAL | 1742 | 1000 | 122 |

| DEPTH | 48-50 | 53-55 |
|---|---|---|
| ACET | ND | 230 |
| 12DCE | 590 | 71 |
| TCE | 680 | 780 |
| 112TCA | 42 | 8J |
| PCA | 260 | 71 |
| VC | 2J | ND |
| TOTAL | 1574 | 930 |

| DEPTH | 59-61 |
|---|---|
| ACET | 76 |
| TOTAL | ND |

| DEPTH | 44-46 |
|---|---|
| ACET | 1800 |
| TOTAL | ND |

| DEPTH | 34-36 |
|---|---|
| ACET | 85 |
| TCE | 19 |
| PCE | 7 |
| PCA | 200 |
| TOTAL | 226 |

| DEPTH | 16-18 |
|---|---|
| ACET | 12000 |
| BRO | 1J |
| 12DCE | 10J |
| TCE | 3J |
| 112TCA | 2J |
| TOTAL | 15 |

| DEPTH | 64-66 |
|---|---|
| ACET | 39 |
| TOTAL | ND |

| DEPTH | 12-14 | 16-18 | 26-28 | 38-38.5 |
|---|---|---|---|---|
| ACET | 46 | 150 | 1300 | 450 |
| TCE | 19 | 44 | 60 | ND |
| PCA | 90 | 94 | ND | ND |
| 12DCE | 5 | ND | 27 | ND |
| TCA | 6 | ND | ND | ND |
| T | ND | 1 | ND | ND |
| MC | ND | ND | ND | 80 |
| TOTAL | 120 | 15 | 87 | ND |

| DEPTH | 10-12 | 16-18 | 24-26 | 37-39 |
|---|---|---|---|---|
| ACET | ND | ND | ND | 280D |
| 12DCE | 15 | 14 | 47 | ND |
| TCE | 13 | 18 | 32 | ND |
| PCA | 12 | 16 | 14 | ND |
| T | ND | ND | ND | 2 |
| TOTAL | 40 | 46 | 93 | ND |

| DEPTH | 29-31 | 54-56 |
|---|---|---|
| TOTAL | ND | ND |

| DEPTH | 18-20 | 28-30 | 44-46 |
|---|---|---|---|
| TCE | 3J | ND | 150 |
| PCA | 7J | ND | 140 |
| TOTAL | 10 | ND | 290 |

NOTES:1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

| | |
|---|---|
| MC | METHYLENE CHLORIDE |
| ACET | ACETONE |
| 2BUT | 2-BUTANONE |
| BRO | BROMOMETHANE |
| 4M2P | 4-METHYL-2-PENTANONE |
| 2HEX | 2-HEXANONE |
| •12DCE | 1,2-DICHLOROETHENE (TOTAL) |
| •CHLOR | CHLOROFORM |
| • TCE | TRICHLOROETHENE |
| •112TCA | 1,1,2-TRICHLOROETHANE |
| • PCE | TETRACHLOROETHENE |
| • PCA | 1,1,2,2 TETRACHLOROETHANE |
| • CB | CHLOROBENZENE |
| VC | VINYL CHLORIDE |
| T | TOLUENE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR
J THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED QUANTITY
ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS(•) DETECTED IN ASSOCIATED SAMPLE

VOC DETECTED IN SOIL SAMPLES (ug/kg)
FROM LOWER SAND AND TILL UNITS
JULY-NOVEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 6/4/98 | RWC | CORRECTED ORIENTATIONS OF NORTH ARROW |

DATE 8-15-96
DESIGNED BY JFW
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

EA ENGINEERING, SCIENCE, AND TECHNOLOGY
2 COMMERCIAL ST
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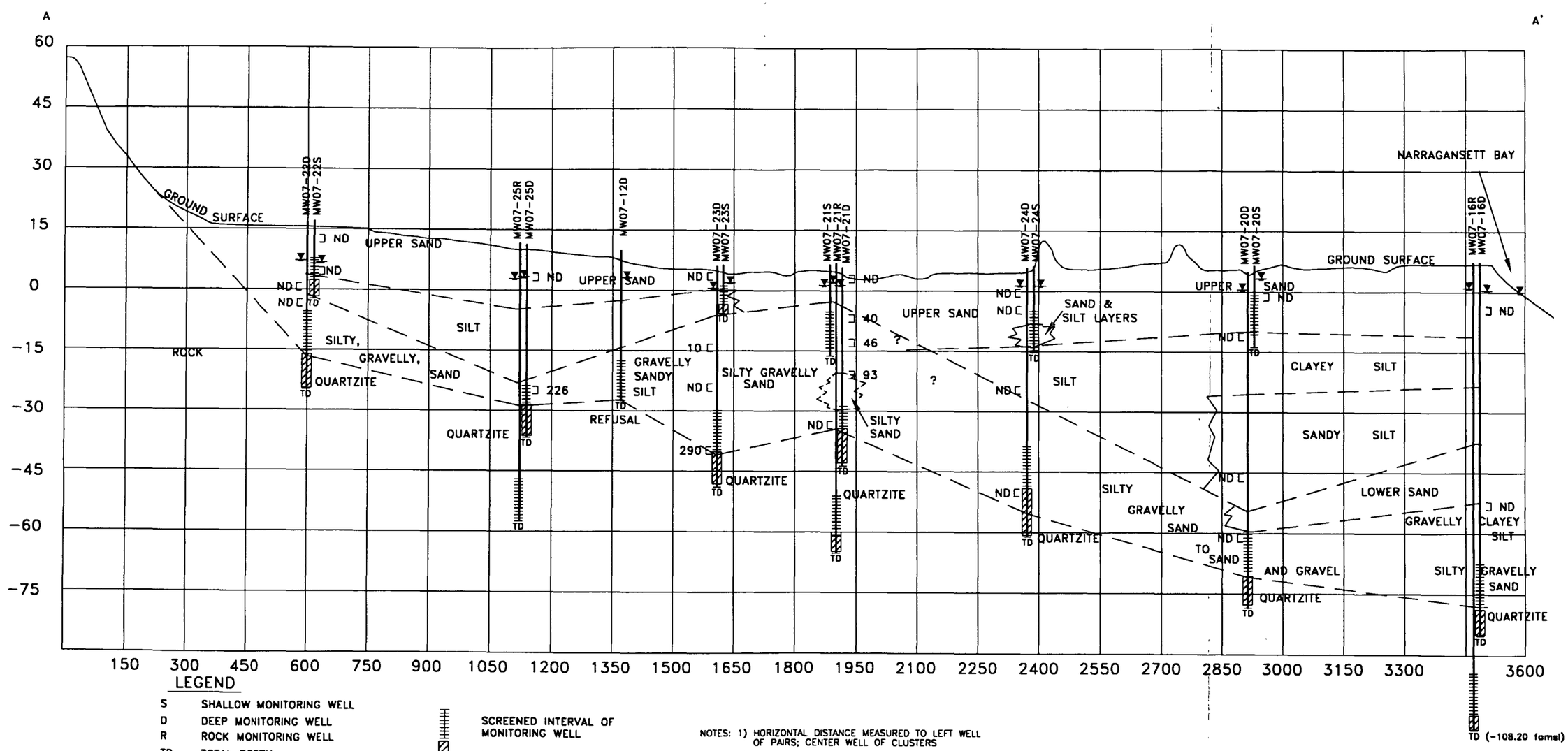
(617) 784-1767
ALASKA CALIFORNIA COLORADO DELAWARE FLORIDA GEORGIA HAWAII ILLINOIS MARYLAND MASSACHUSETTS NEBRASKA NEW JERSEY NEW YORK NORTH CAROLINA TEXAS WASHINGTON

PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG4-3
DRAWING NUMBER -
FIGURE NUMBER 4-3

FILE: F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD\FIG4-3.DWG




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| 290 | TOTAL CHLORINATED VOC DETECTED (ug/kg) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| C | SAMPLE INTERVAL |
| ND | NOT DETECTED |

15
0
150
SCALE IN FEET

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) SOIL SAMPLES COLLECTED JULY-AUGUST AND OCTOBER-NOVEMBER, 1995

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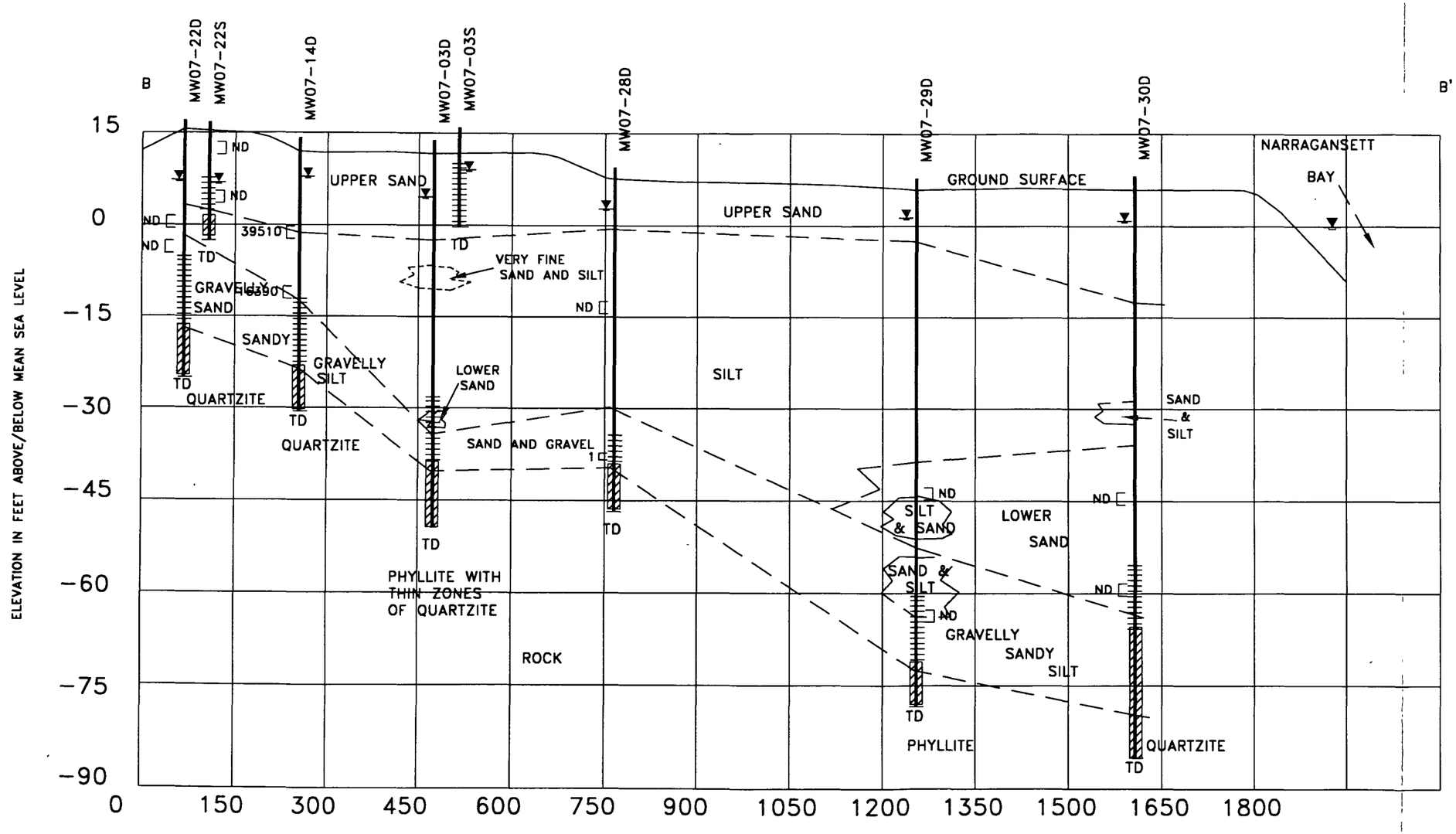
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| JAS | JAS | AS SHOWN | SOILDATA |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETECTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTION A-A'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-4




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| ⊞ | SCREENED INTERVAL OF MONITORING WELL |
| ▨ | BENTONITE SEALED BOREHOLE |
| ⊏ | SAMPLE INTERVAL |
| 290 | TOTAL CHLORINATED VOC DETECTED (ug/kg) |
| ND | NOT DETECTED |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) SOIL SAMPLES COLLECTED JULY-AUGUST AND OCTOBER-NOVEMBER, 1995

15
0
150
SCALE IN FEET

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| PWH | NAL | AS SHOWN | SOILDATA |

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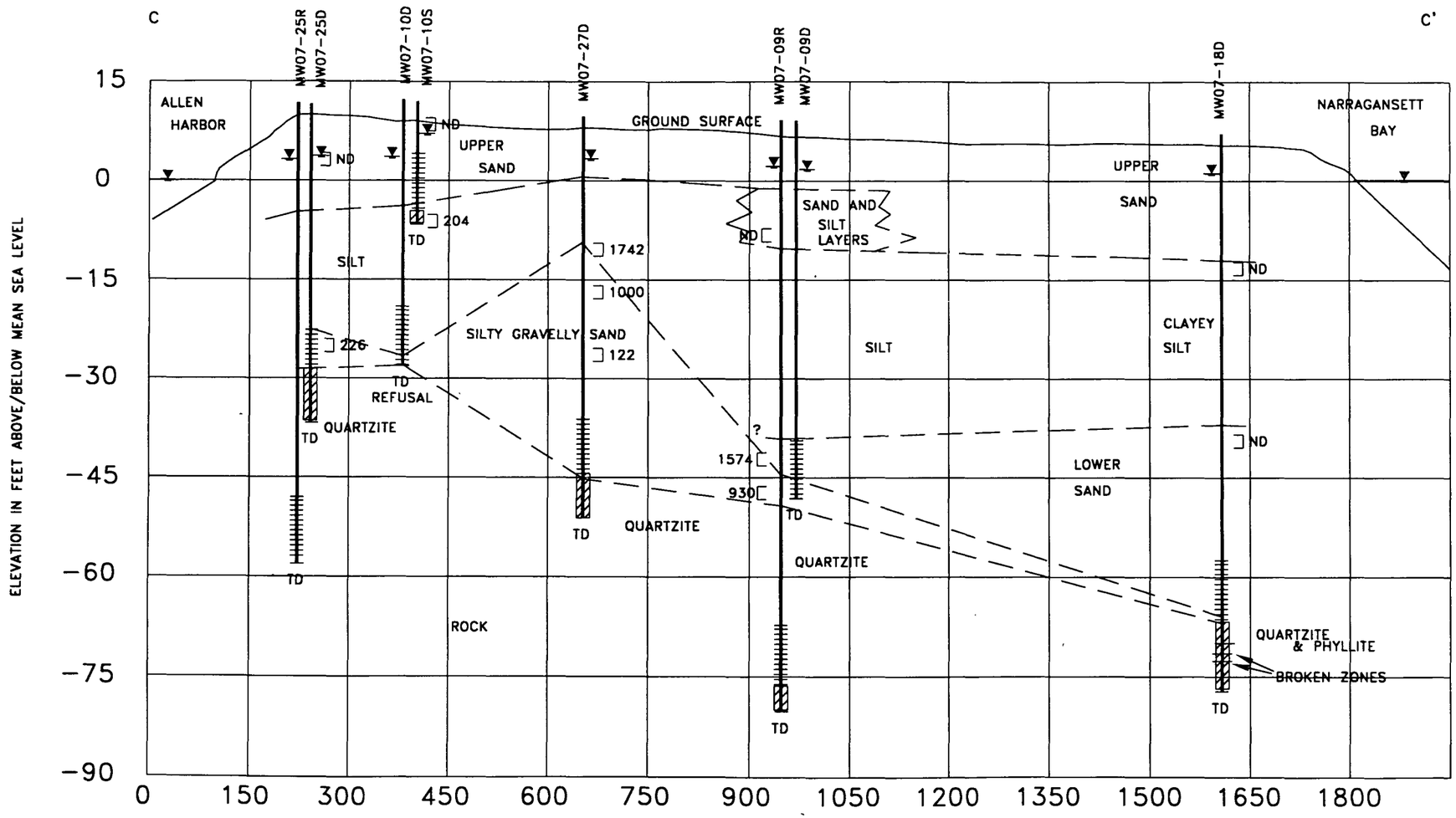
TOTAL CHLORINATED VOC DETECTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTION B-B'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-5




## LEGEND

- S SHALLOW MONITORING WELL
- D DEEP MONITORING WELL
- R ROCK MONITORING WELL
- TD TOTAL DEPTH
- WATER LEVEL (1-17-96 MIDTIDE)
- SCREENED INTERVAL OF MONITORING WELL
- BENTONITE SEALED BOREHOLE
- SAMPLE INTERVAL
- 290 TOTAL CHLORINATED VOC DETECTED (ug/kg)
- ND NOT DETECTED

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) SOIL SAMPLES COLLECTED JULY-AUGUST AND OCTOBER-NOVEMBER, 1995

15
0 150
SCALE IN FEET

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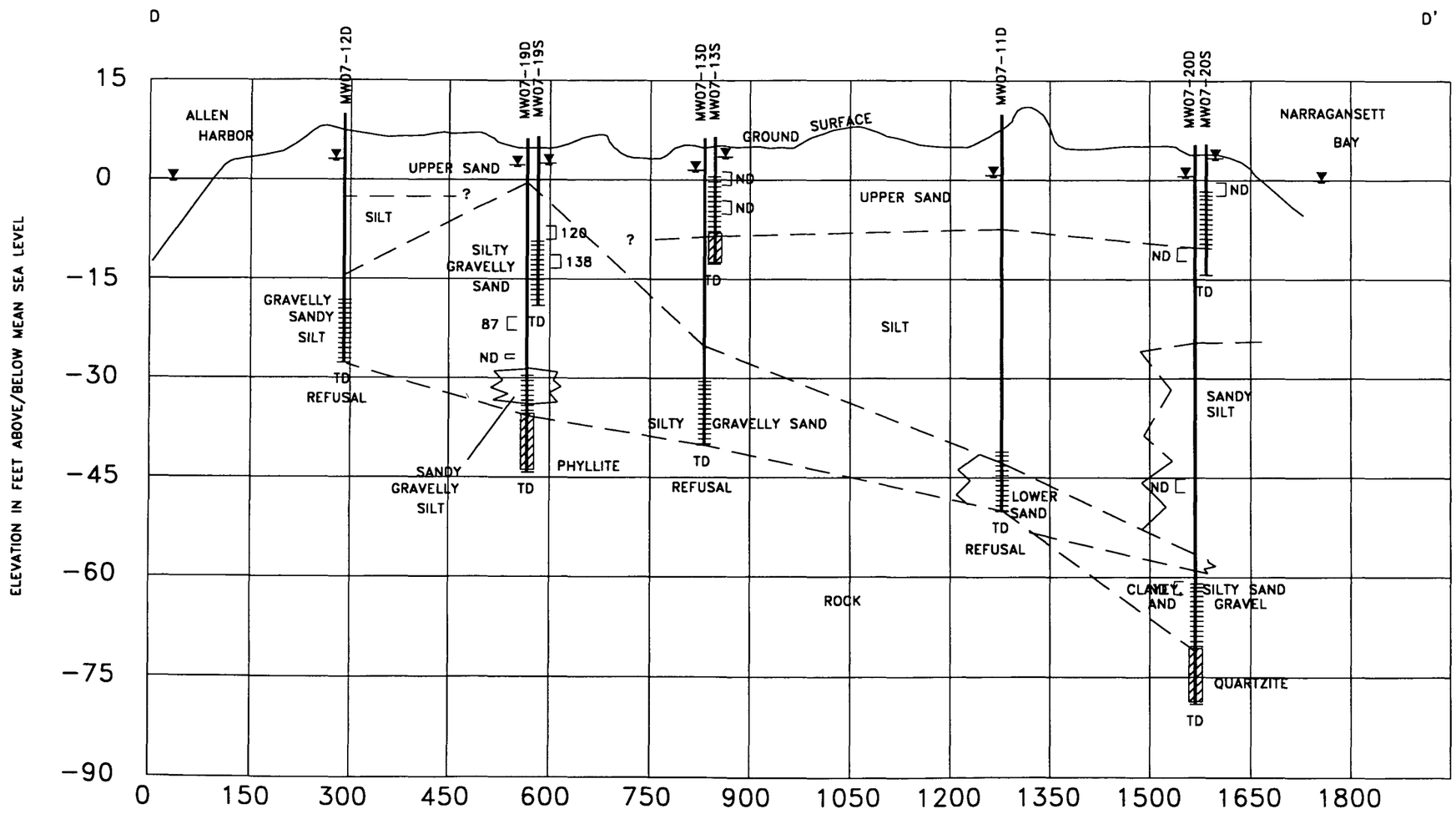
| JAS | JAS | AS SHOWN | SOILDATA |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETECTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTION C-C'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-6



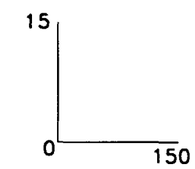

## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| ▤ | SCREENED INTERVAL OF MONITORING WELL |
| ▨ | BENTONITE SEALED BOREHOLE |
| ⊏ | SAMPLE INTERVAL |
| ND | NOT DETECTED |
| 290 | TOTAL CHLORINATED VOC DETECTED (ug/kg) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) SOIL SAMPLES COLLECTED JULY-AUGUST AND OCTOBER-NOVEMBER, 1995




SCALE IN FEET

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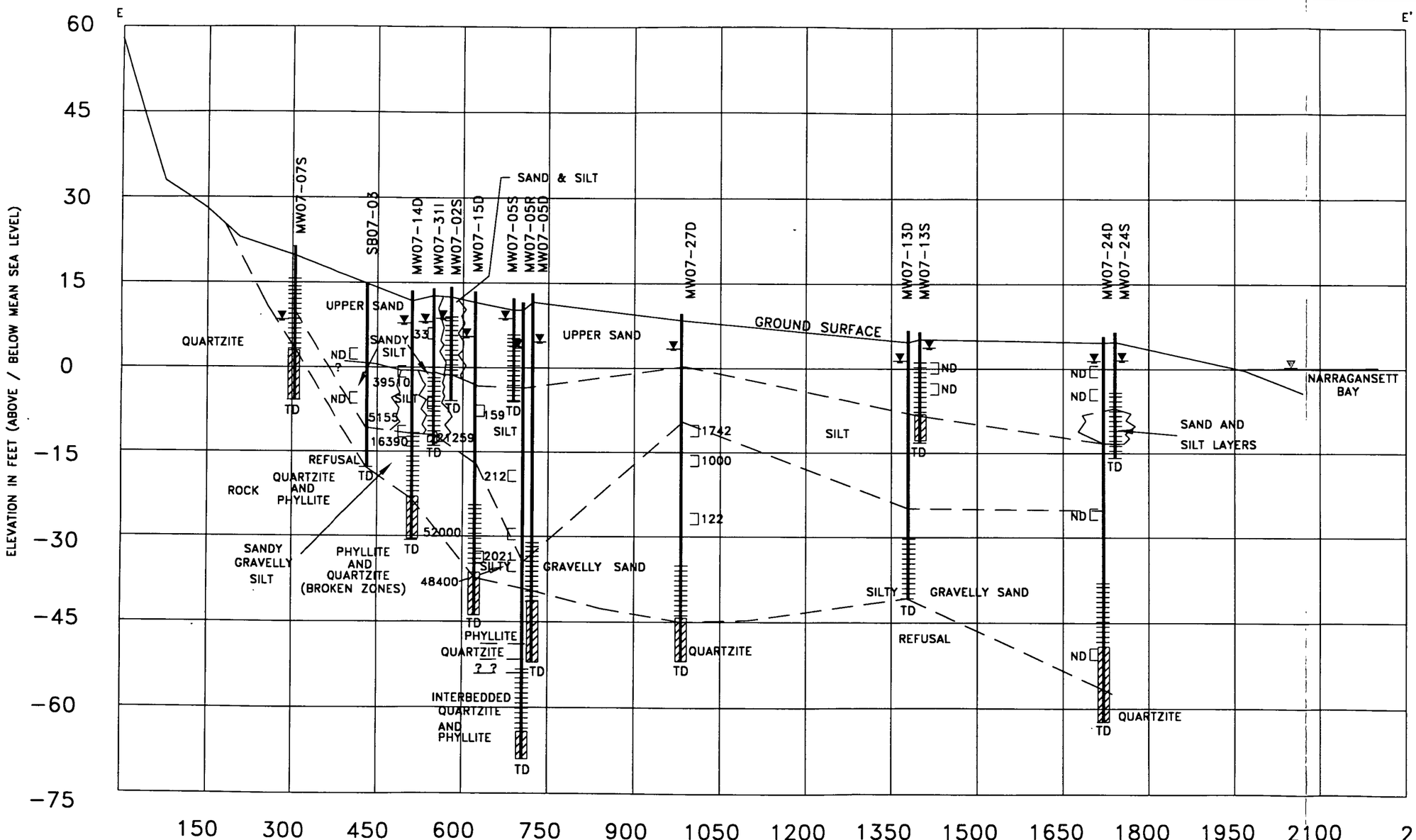
| JAS | JAS | AS SHOWN | SOILDATA |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETECTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTION D-D'
IR PROGRAM SITE 07, CALF PASTURE POINT

FIGURE 4-7

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|---|---|---|---|---|---|---|
| | CHECKED BY JAS | PROJECT MGR. JAS | SCALE AS SHOWN | LAYER NAME SOILDATA | | |

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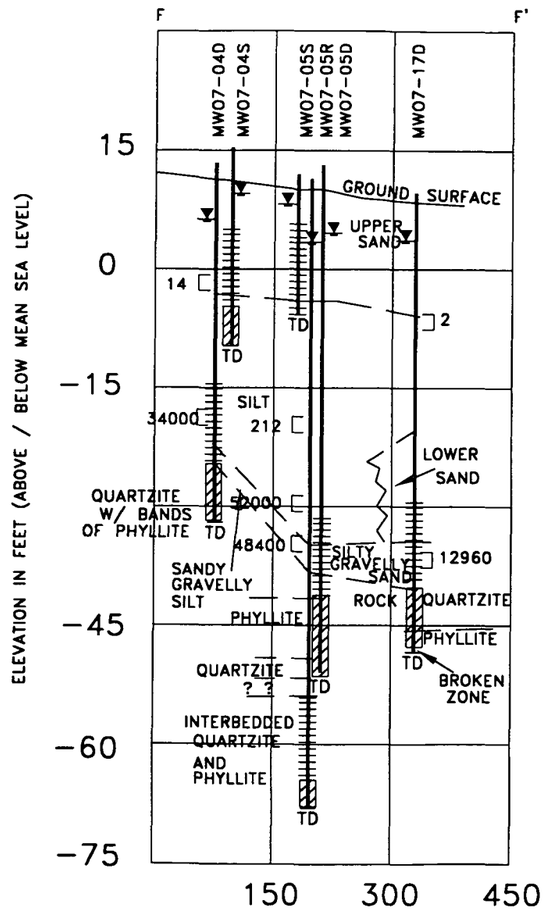
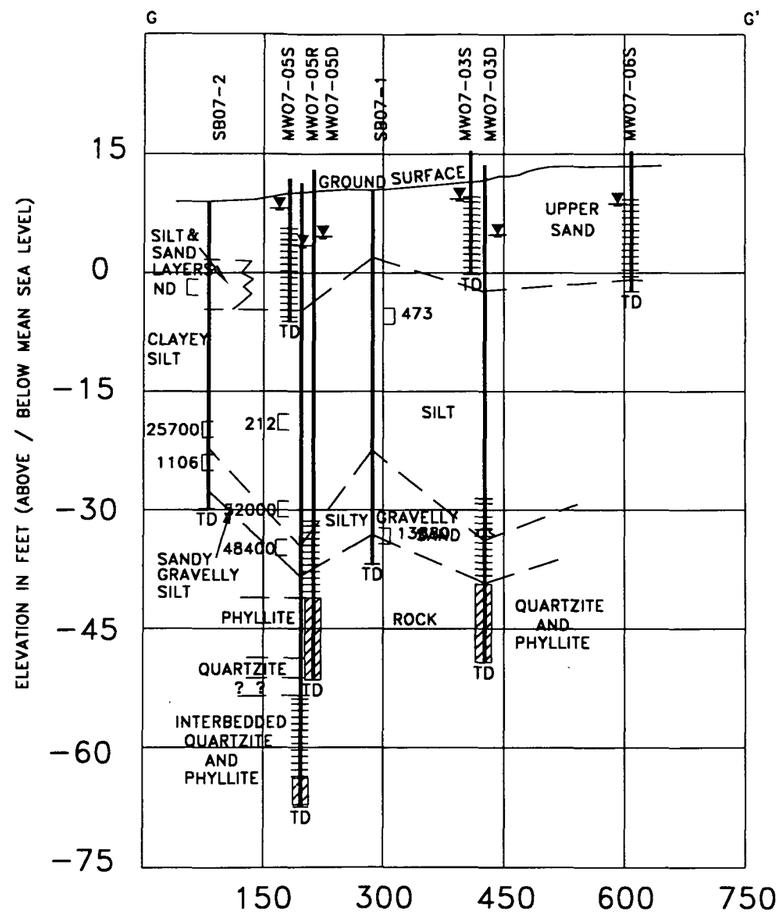
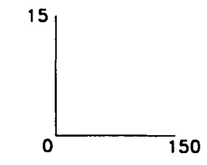



## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ⊏ | SAMPLE INTERVAL |
| ND | NOT DETECTED |
| 290 | TOTAL CHLORINATED VOC DETECTED (ug/kg) |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA, SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) SOIL BORINGS AT SITE 07 WERE BACKFILLED WITH CEMENT/ BENTONITE GROUT FROM TOTAL DEPTH TO LAND SURFACE.
4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS
5) SOIL SAMPLES COLLECTED FROM JULY-AUGUST AND OCTOBER-NOVEMBER, 1995




SCALE IN FEET

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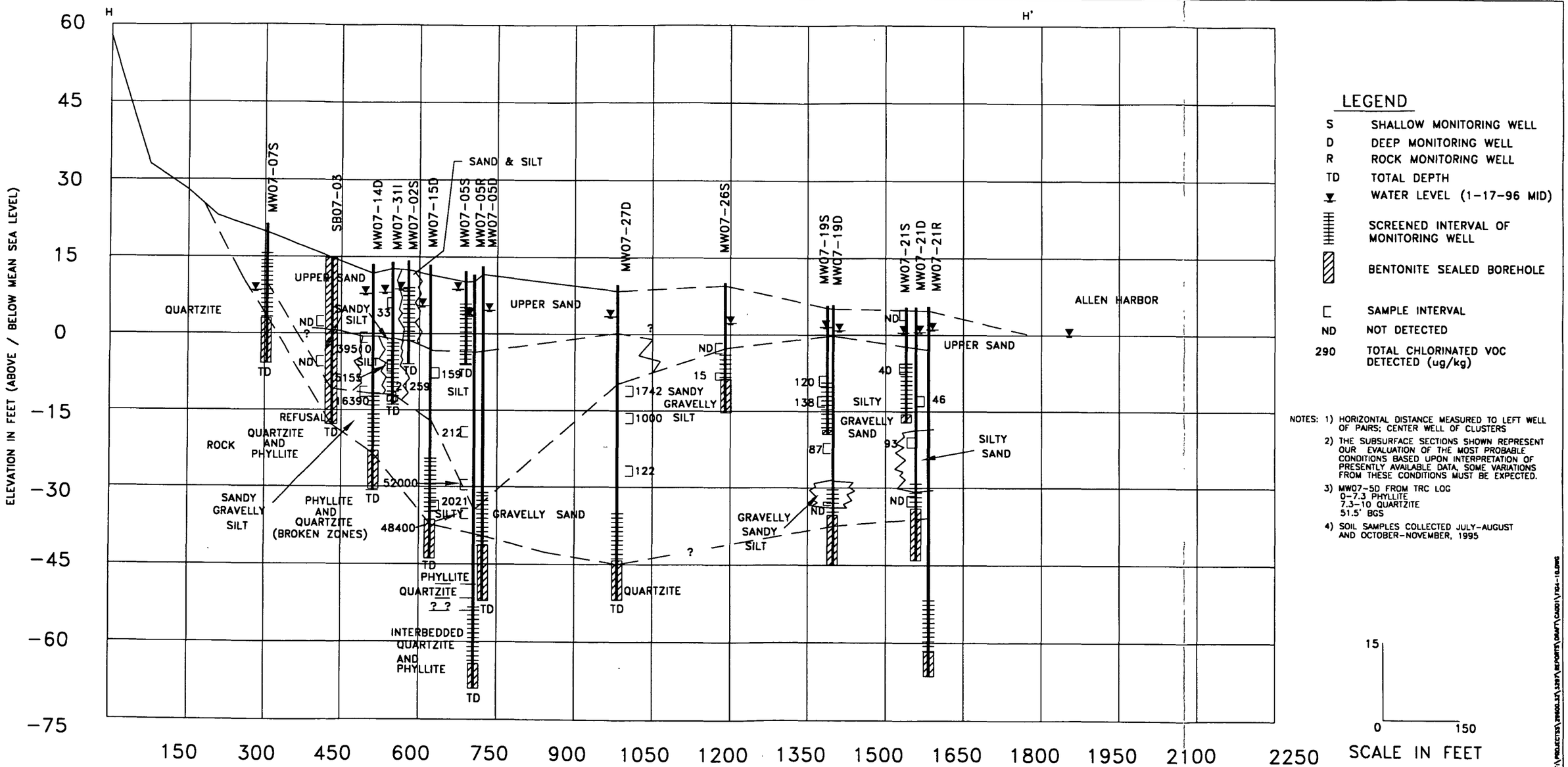
NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETCTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTIONS F-F' & G-G'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-9

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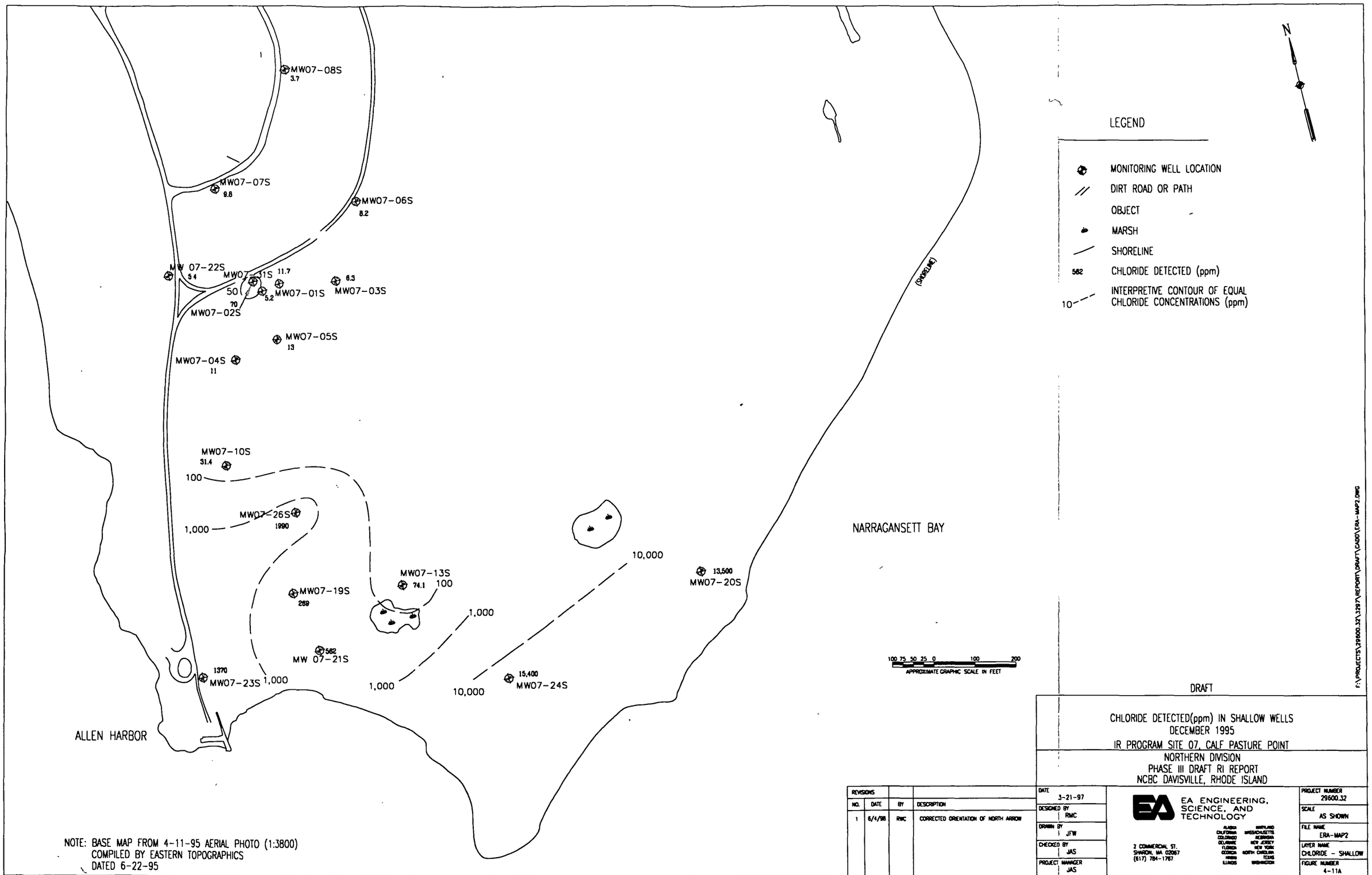
| JAS | JAS | AS SHOWN | SOILDATA |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETECTED IN SOIL SAMPLES
GEOLOGIC CROSS SECTION H-H'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-10


N
LEGEND
MONITORING WELL LOCATION
DIRT ROAD OR PATH
OBJECT
MARSH
SHORELINE
562 CHLORIDE DETECTED (ppm)
10 INTERPRETIVE CONTOUR OF EQUAL CHLORIDE CONCENTRATIONS (ppm)
MW07-08S 3.7
MW07-07S 9.8
MW07-06S 8.2
MW 07-22S 5.4
MW07-31S 11.7
50
70
5.2
MW07-01S
6.3
MW07-03S
MW07-02S
MW07-05S 13
MW07-04S 11
MW07-10S 31.4
100
MW07-26S 1990
1,000
MW07-13S 74.1
100
MW07-19S 269
1,000
10,000
13,500
MW07-20S
562
MW 07-21S
1370
MW07-23S
1,000
1,000
10,000
15,400
MW07-24S
(SHORELINE)
NARRAGANSETT BAY
ALLEN HARBOR
100 75 50 25 0 100 200
APPROXIMATE GRAPHIC SCALE IN FEET
NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95
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DRAFT
CHLORIDE DETECTED(ppm) IN SHALLOW WELLS
DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT
NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND
REVISIONS
NO. DATE BY DESCRIPTION
1 6/4/98 RWC CORRECTED ORIENTATION OF NORTH ARROW
DATE 3-21-97
DESIGNED BY RWC
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS
EA ENGINEERING, SCIENCE, AND TECHNOLOGY
2 COMMERCIAL ST.
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CALIFORNIA MASSACHUSETTS
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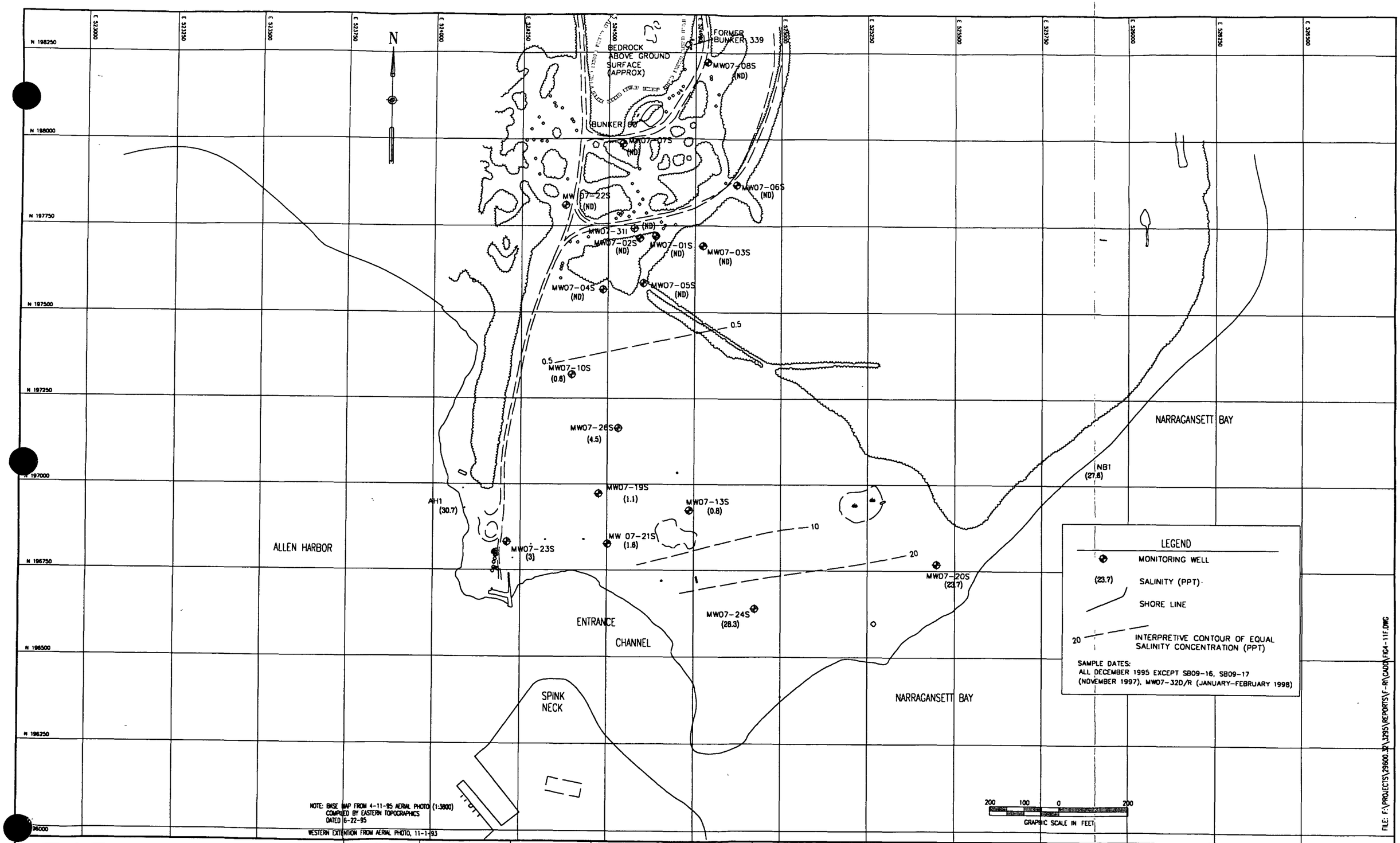
FLORIDA NEW YORK
GEORGIA NORTH CAROLINA
HAWAII TEXAS
ILLINOIS WASHINGTON
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME ERA-MAP2
LAYER NAME CHLORIDE - SHALLOW
FIGURE NUMBER 4-11A

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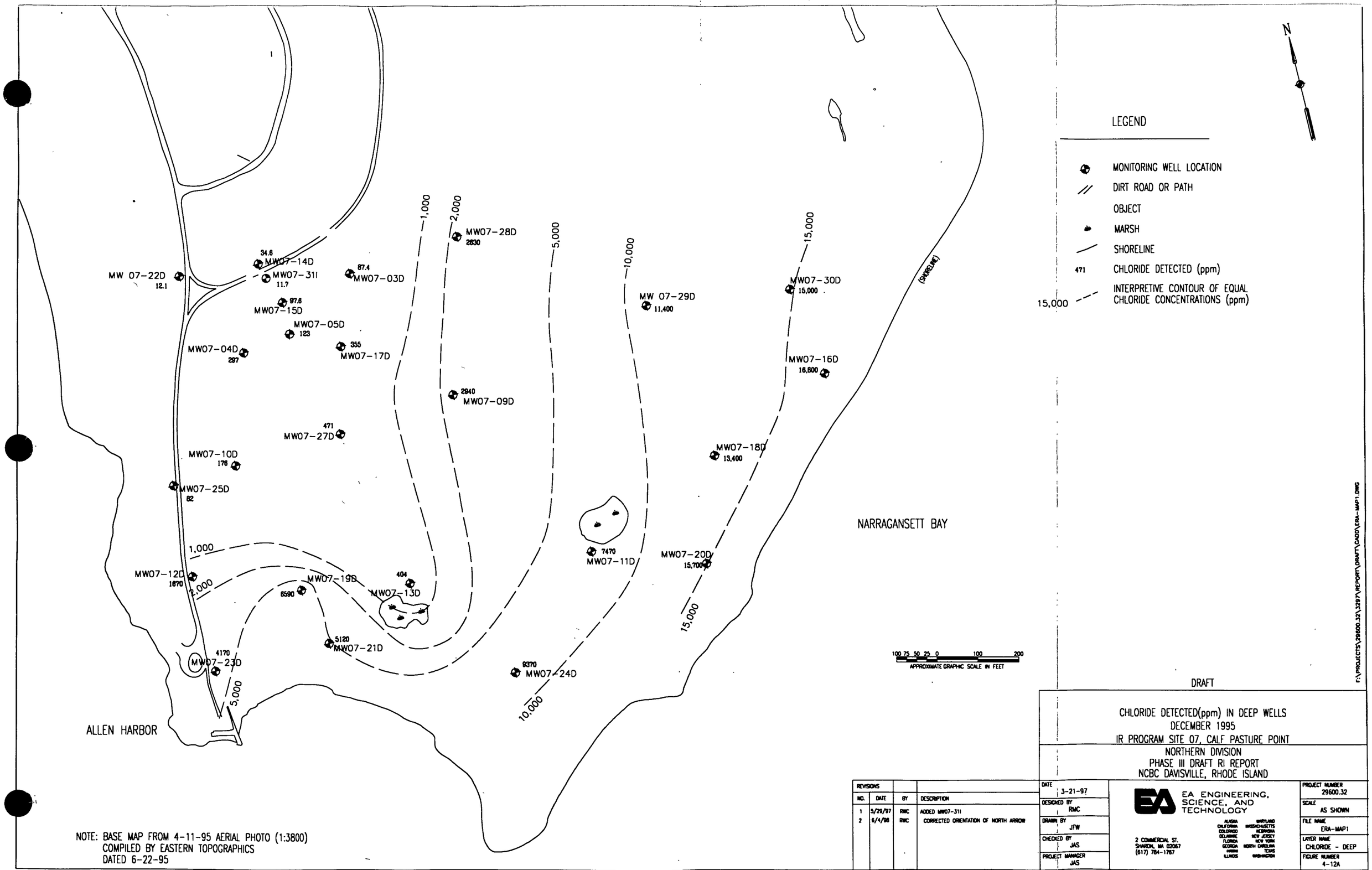
| JAS | RWC | 7/7/98 | 29600.32 | FIG4-11F |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | – | 4-11B |

NORTHERN DIVISION
CALF PASTURE POINT, IR PROGRAM SITE 07
NCBC DAVISVILLE, RHODE ISLAND

SALINITY DETECTED IN GROUND-WATER SAMPLES FROM SHALLOW MONITORING WELLS, ALLEN HARBOR, AND NARRAGANSETT BAY
FIGURE 4-11B




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

DRAFT

CHLORIDE DETECTED(ppm) IN DEEP WELLS
DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

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| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RMC | ADDED MW07-31I |
| 2 | 6/4/98 | RMC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 3-21-97 |
| DESIGNED BY | RMC |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | ERA-MAP1 |
| LAYER NAME | CHLORIDE - DEEP |
| FIGURE NUMBER | 4-12A |

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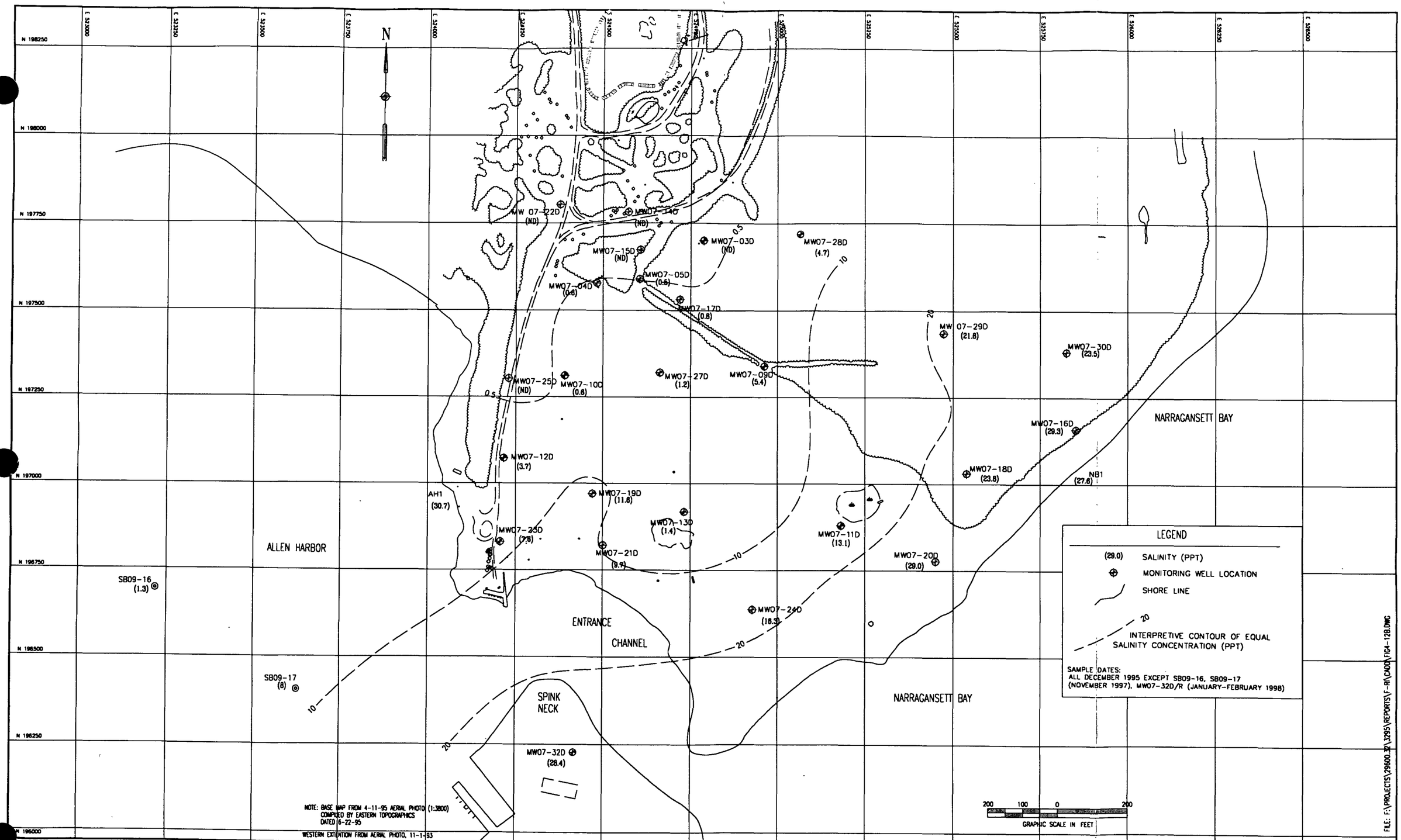


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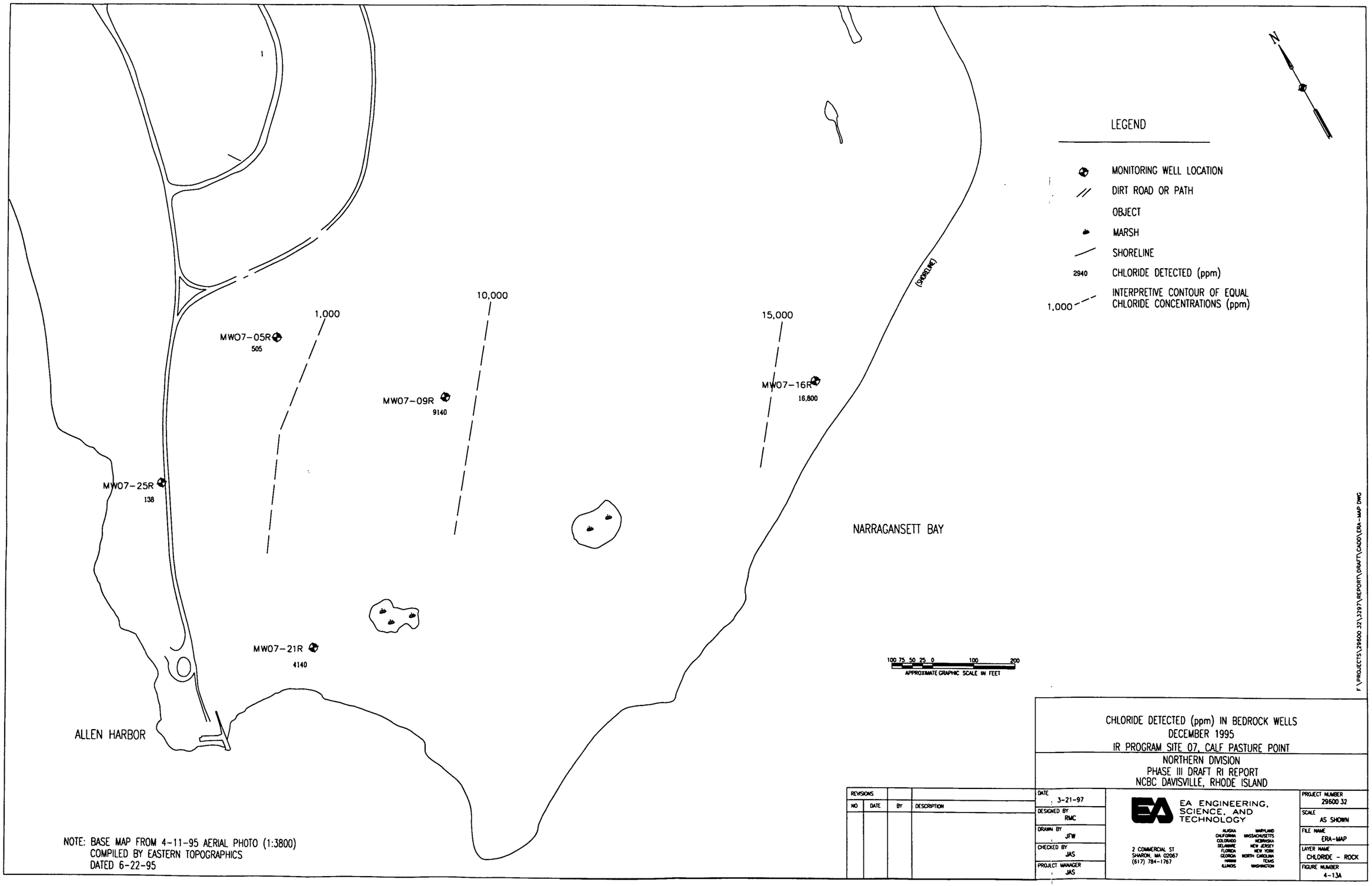
|---|---|---|---|---|
| JAS | RWC | 7/7/98 | 29600.32 | FIG4-12F |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | – | 4-12B |

NORTHERN DIVISION
CALF PASTURE POINT, IR PROGRAM SITE 07
NCBC DAVISVILLE, RHODE ISLAND

SALINITY DETECTED IN GROUND-WATER SAMPLES FROM DEEP MONITORING WELLS AND SOIL BORINGS, ALLEN HARBOR AND NARRAGANSETT BAY

FIGURE 4-12B




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

CHLORIDE DETECTED (ppm) IN BEDROCK WELLS
DECEMBER 1995
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO | DATE | BY | DESCRIPTION |

DATE 3-21-97
DESIGNED BY RMC
DRAWN BY JFW
CHECKED BY JAS
PROJECT MANAGER JAS

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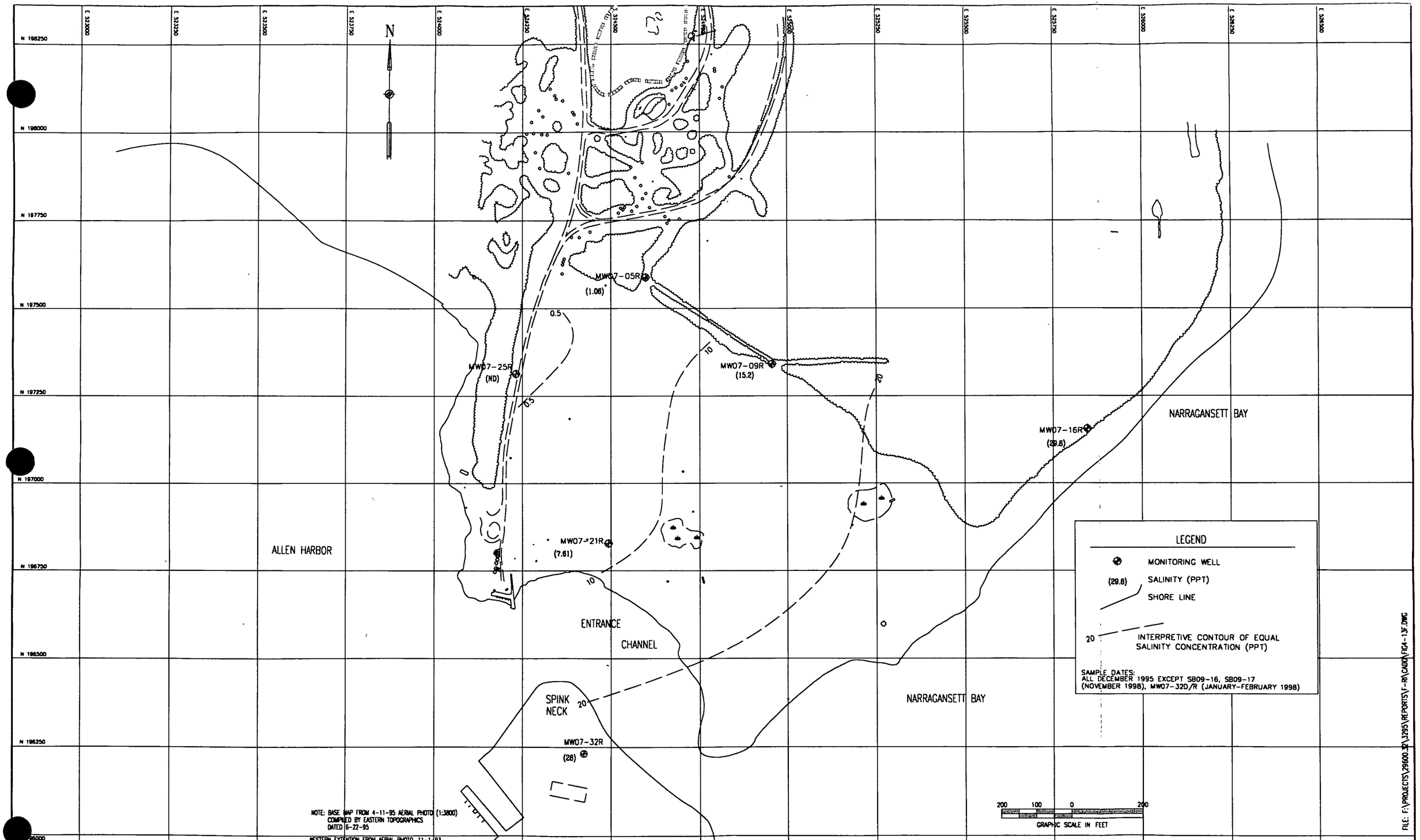
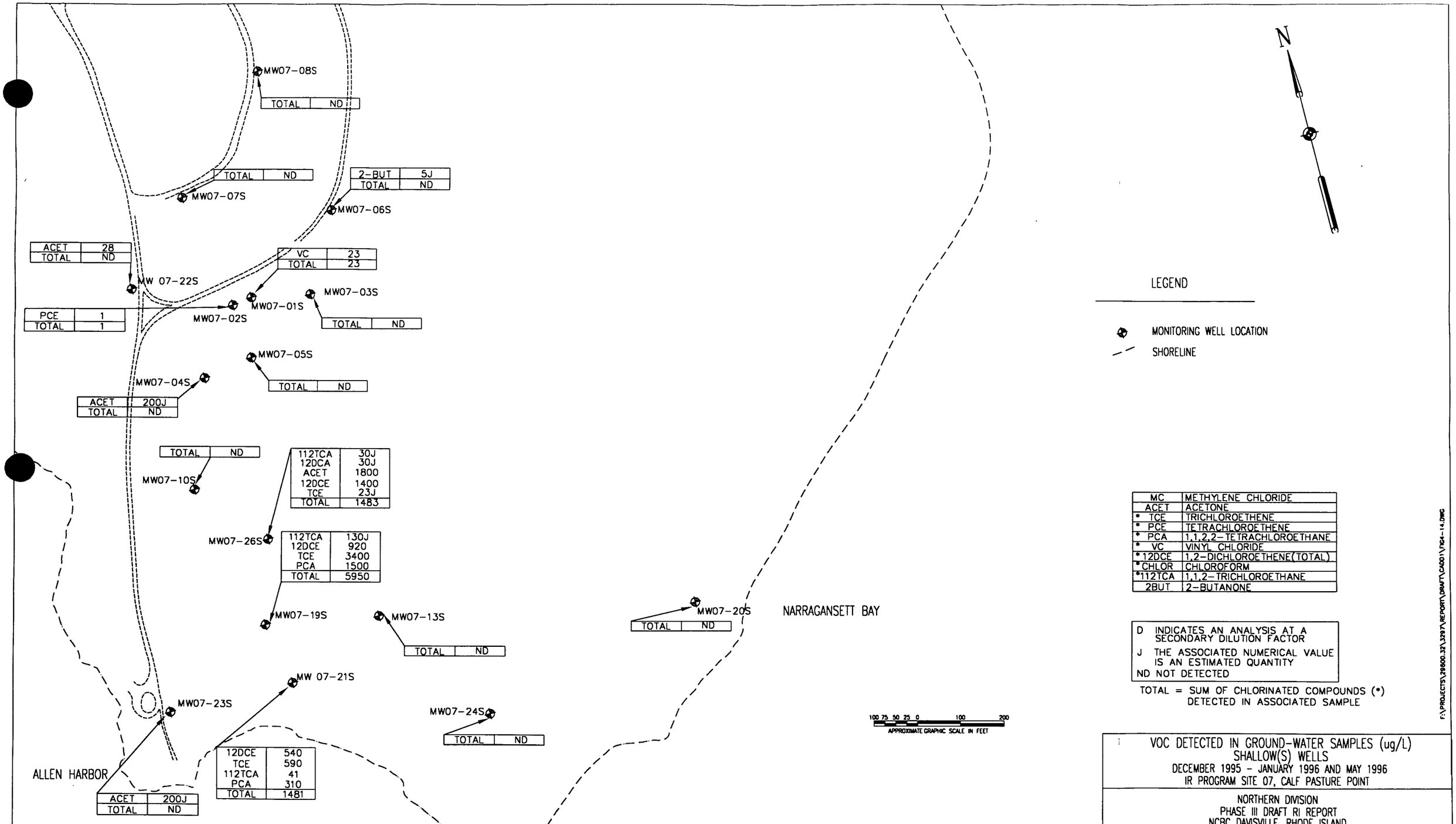
PROJECT NUMBER 29600 32
SCALE AS SHOWN
FILE NAME ERA-MAP
LAYER NAME CHLORIDE - ROCK
FIGURE NUMBER 4-13A




| | | | | | | |
|---|---|---|---|---|---|---|
| EA® EA ENGINEERING, SCIENCE, AND TECHNOLOGY | DESIGNED BY JAS | DRAWN BY RWC | DATE 7/7/98 | PROJECT NO. 29600.32 | FILE NAME FIG4-13F | NORTHERN DIVISION<br>CALF PASTURE POINT, IR PROGRAM SITE 07<br>NCBC DAVISVILLE, RHODE ISLAND |
| | CHECKED BY JAS | PROJECT MGR. JAS | SCALE AS SHOWN | DRAWING NO. – | FIGURE 4-13B | |

SALINITY DETECTED IN GROUND-WATER SAMPLES FROM BEDROCK MONITORING WELLS, ALLEN HARBOR AND NARRIGANSETT BAY

FIGURE 4-13B




| | |
|---|---|
| MC | METHYLENE CHLORIDE |
| ACET | ACETONE |
| * TCE | TRICHLOROETHENE |
| * PCE | TETRACHLOROETHENE |
| * PCA | 1,1,2,2-TETRACHLOROETHANE |
| * VC | VINYL CHLORIDE |
| *12DCE | 1,2-DICHLOROETHENE(TOTAL) |
| *CHLOR | CHLOROFORM |
| *112TCA | 1,1,2-TRICHLOROETHANE |
| 2BUT | 2-BUTANONE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED QUANTITY

ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS (*) DETECTED IN ASSOCIATED SAMPLE

NOTES:1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CAD01\FIG4-14.DWG

VOC DETECTED IN GROUND-WATER SAMPLES (ug/L)
SHALLOW(S) WELLS
DECEMBER 1995 - JANUARY 1996 AND MAY 1996
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

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| | |
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| DESIGNED BY | JFW |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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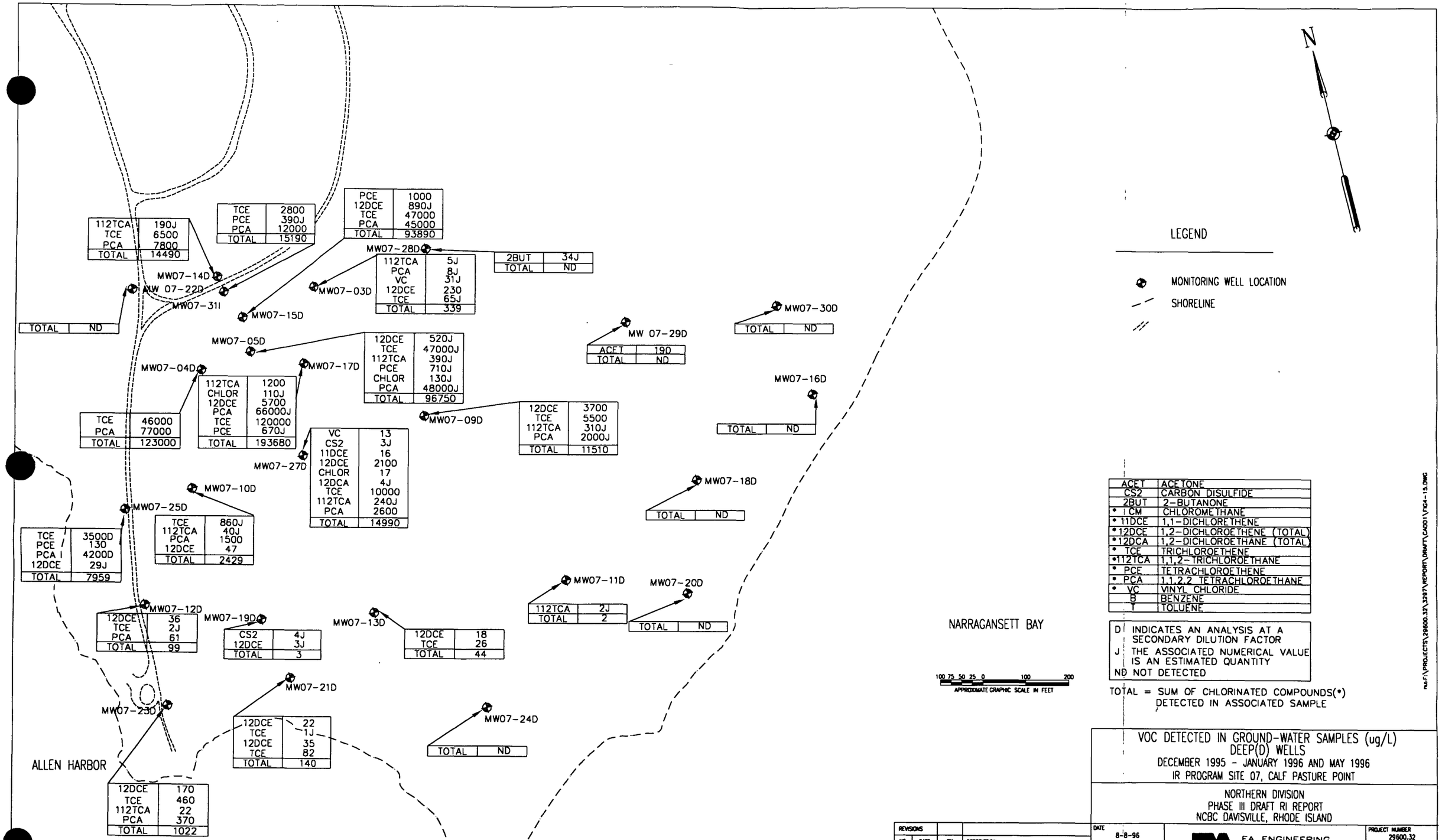
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG4-14 |
| DRAWING NUMBER | - |
| FIGURE NUMBER | 4-14 |




| | |
|---|---|
| ACET | ACETONE |
| CS2 | CARBON DISULFIDE |
| 2BUT | 2-BUTANONE |
| * CM | CHLOROMETHANE |
| * 11DCE | 1,1-DICHLORETHENE |
| *12DCE | 1,2-DICHLOROETHENE (TOTAL) |
| *12DCA | 1,2-DICHLOROETHANE (TOTAL) |
| * TCE | TRICHLOROETHENE |
| *112TCA | 1,1,2-TRICHLOROETHANE |
| * PCE | TETRACHLOROETHENE |
| * PCA | 1,1,2,2 TETRACHLOROETHANE |
| * VC | VINYL CHLORIDE |
| B | BENZENE |
| T | TOLUENE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR
J THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED QUANTITY
ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS(*) DETECTED IN ASSOCIATED SAMPLE

NOTES: 1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

# VOC DETECTED IN GROUND-WATER SAMPLES (ug/L) DEEP(D) WELLS

DECEMBER 1995 - JANUARY 1996 AND MAY 1996
IR PROGRAM SITE 07, CALF PASTURE POINT

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PROJECT MANAGER JAS

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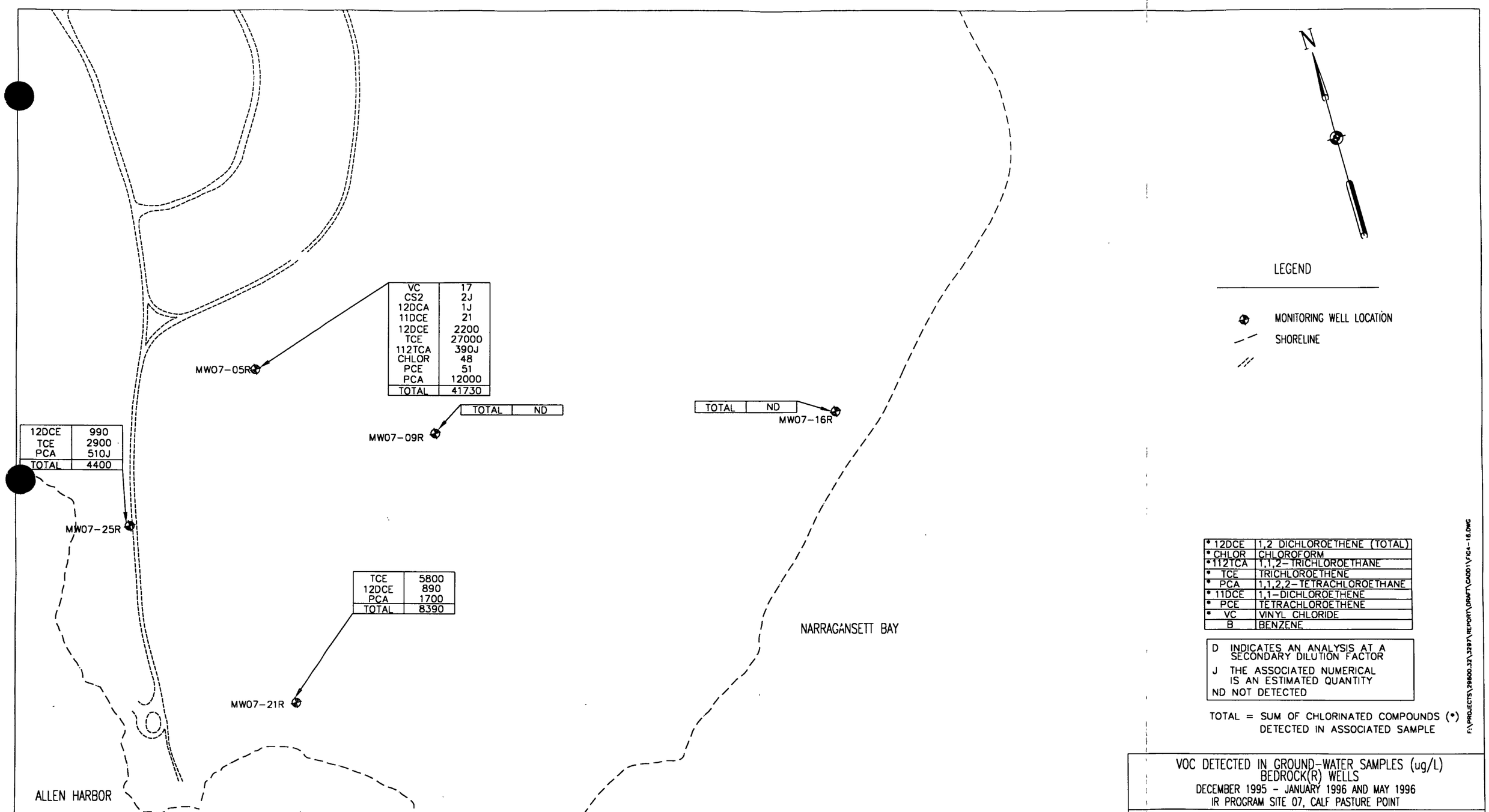
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG4-15
DRAWING NUMBER -
FIGURE NUMBER 4-15

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD11\FIG4-15.DWG




| | |
|---|---|
| * 12DCE | 1,2 DICHLOROETHENE (TOTAL) |
| * CHLOR | CHLOROFORM |
| * 112TCA | 1,1,2-TRICHLOROETHANE |
| * TCE | TRICHLOROETHENE |
| * PCA | 1,1,2,2-TETRACHLOROETHANE |
| * 11DCE | 1,1-DICHLOROETHENE |
| * PCE | TETRACHLOROETHENE |
| * VC | VINYL CHLORIDE |
| B | BENZENE |

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL IS AN ESTIMATED QUANTITY

ND NOT DETECTED

TOTAL = SUM OF CHLORINATED COMPOUNDS (*) DETECTED IN ASSOCIATED SAMPLE

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG4-16.DWG

NOTES: 1) ANALYTICAL RESULTS ARE SUMMARIZED IN TABLE 4-2, AND INCLUDED IN APPENDIX K
2) BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800) COMPILED BY EASTERN TOPOGRAPHICS DATED 6-22-95

VOC DETECTED IN GROUND-WATER SAMPLES (ug/L)
BEDROCK(R) WELLS
DECEMBER 1995 - JANUARY 1996 AND MAY 1996
IR PROGRAM SITE 07, CALF PASTURE POINT

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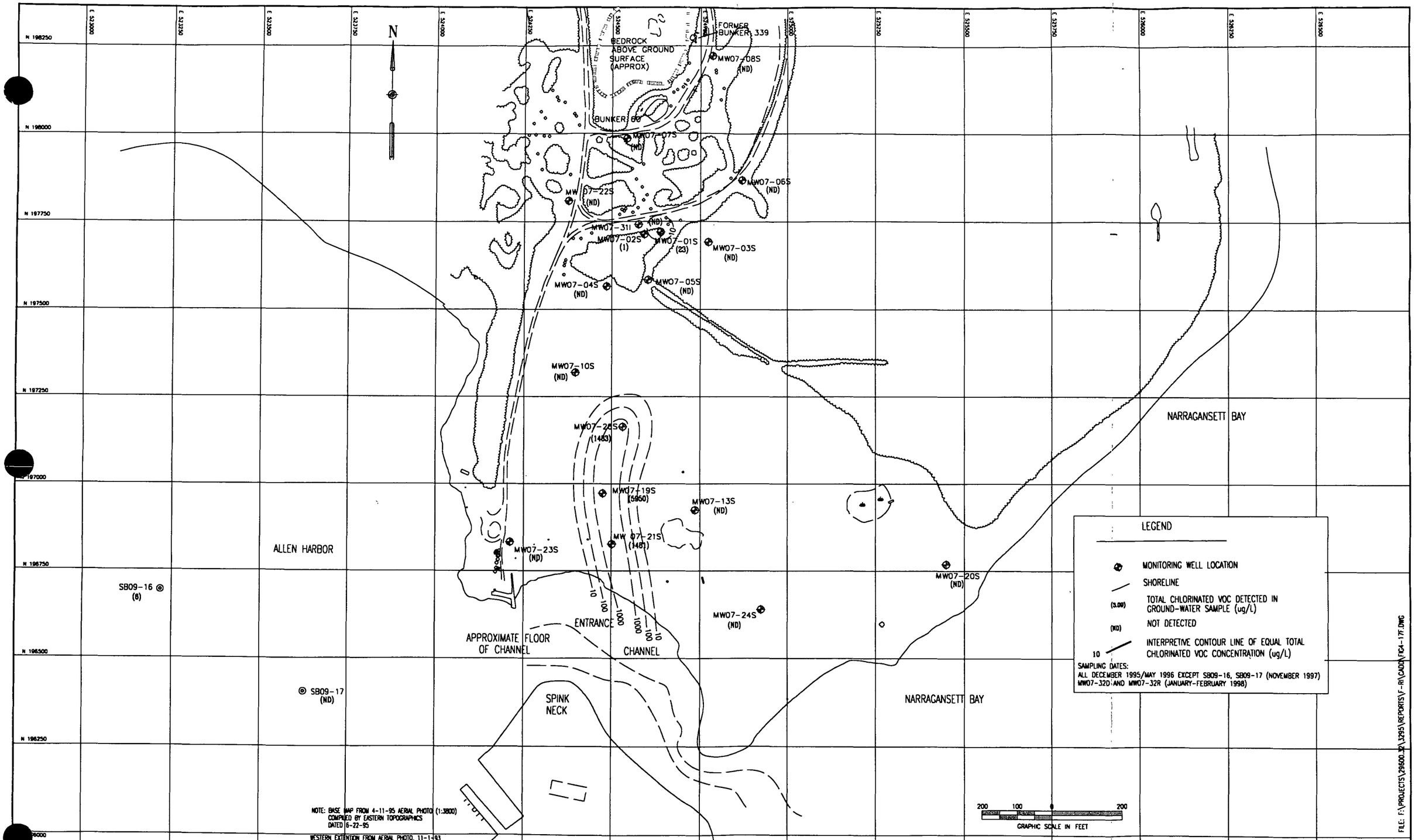
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG4-16
DRAWING NUMBER -
FIGURE NUMBER 4-16

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|---|---|---|---|---|
| JAS | RWC | 4-10-98 | 29600.32 | FIG4-17F |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | – | 4-17 |

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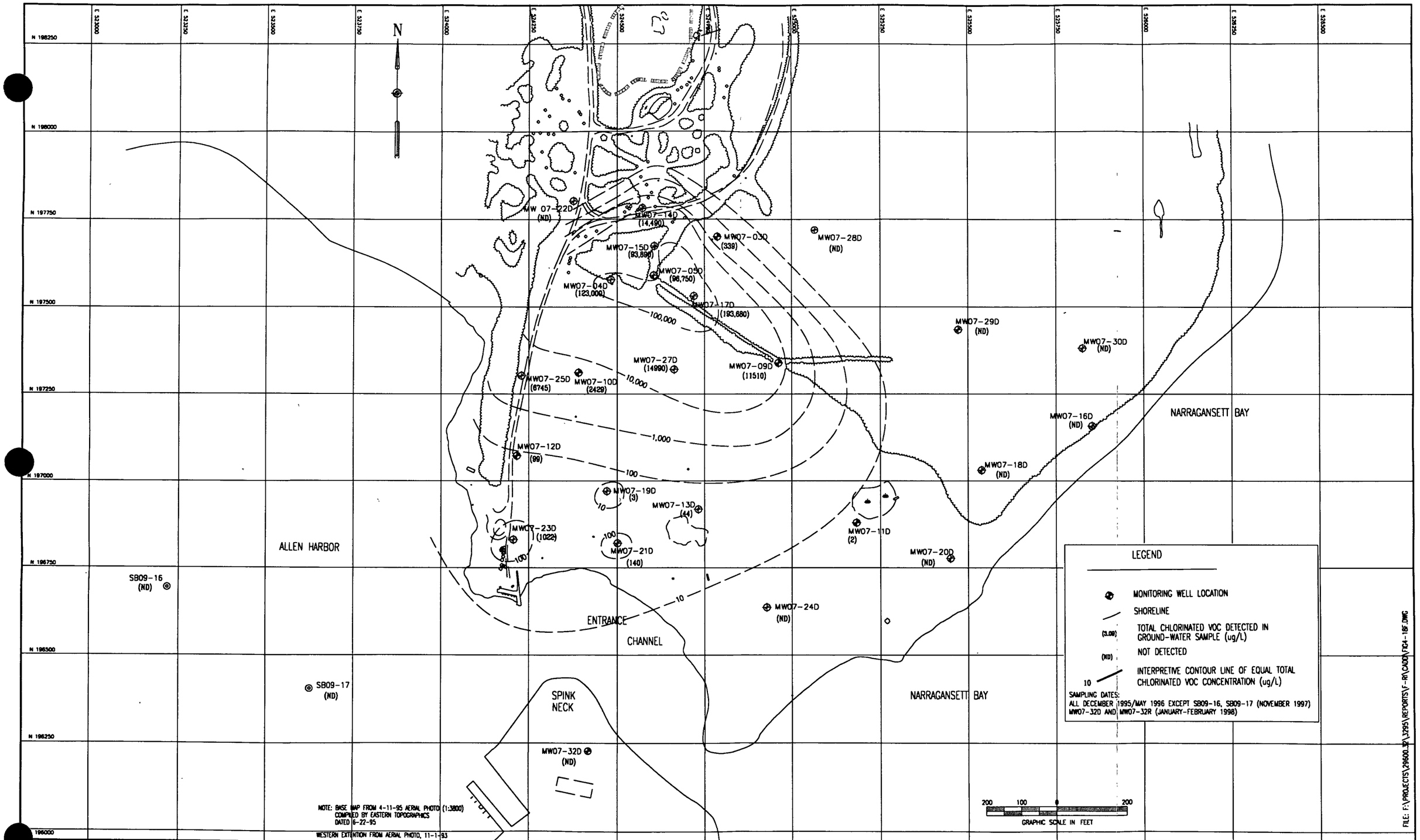
TOTAL CHLORINATED VOC DETECTED IN GROUNDWATER SAMPLES, SHALLOW WELLS
FIGURE 4-17

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| JAS | RWC | 4-10-98 | 29600.32 | FIG4-18F |
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| JAS | JAS | AS SHOWN | - | 4-18 |

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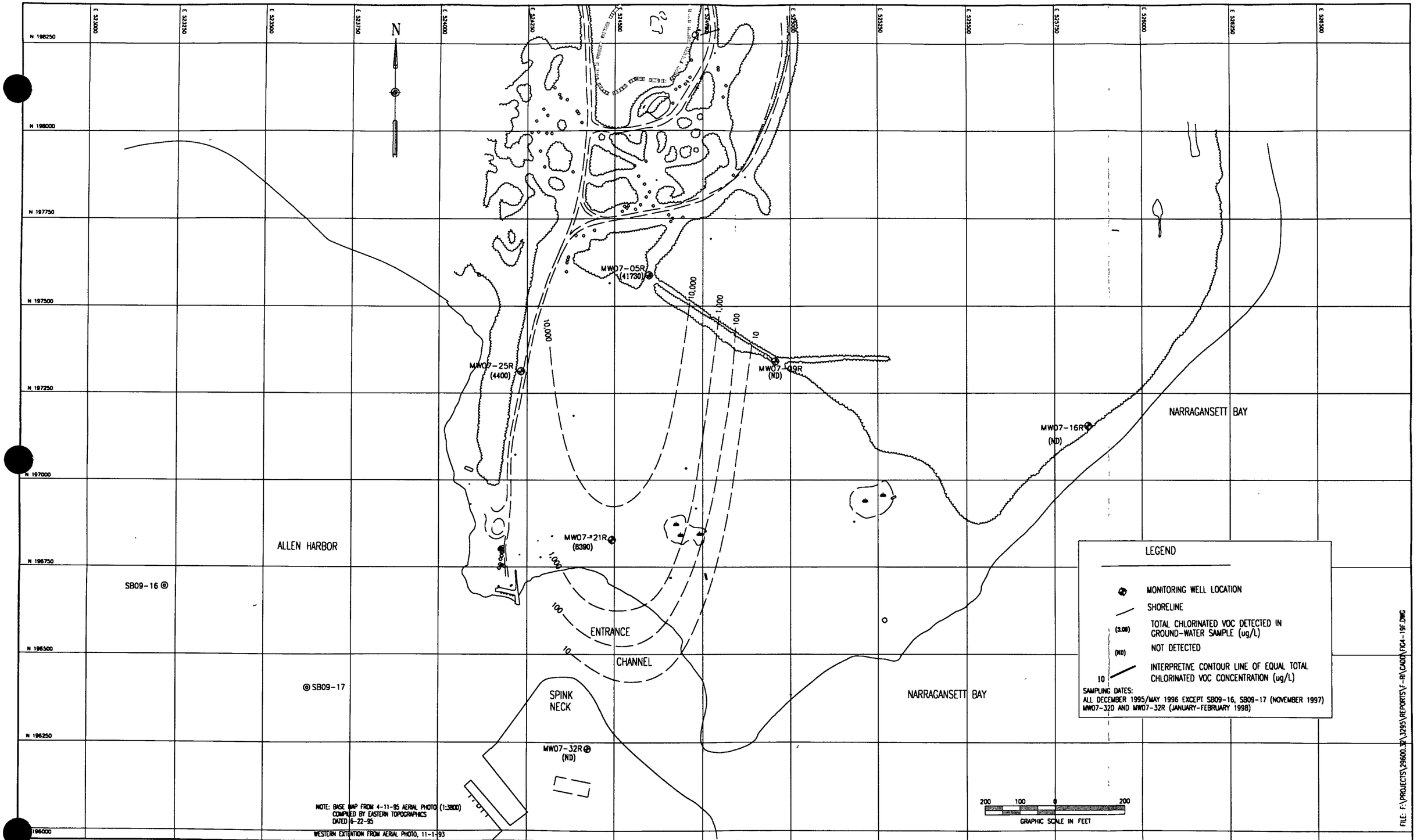
TOTAL CHLORINATED VOC DETECTED IN GROUND-WATER SAMPLES, DEEP WELLS
FIGURE 4-18

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|---|---|---|---|---|
| JAS | RWC | 4-10-98 | 29600.32 | FIG4-19F |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | - | 4-19 |

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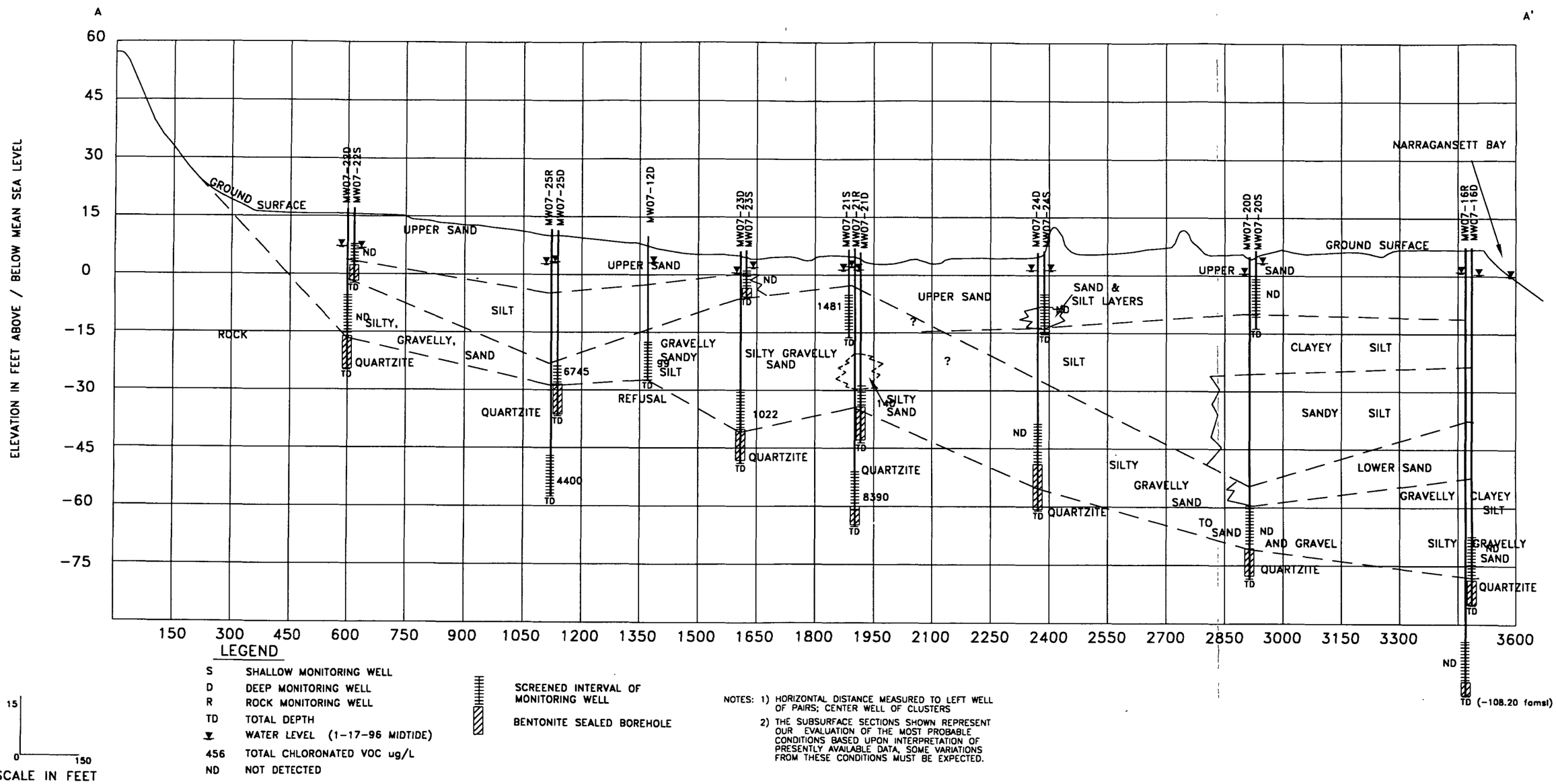
TOTAL CHLORINATED VOC DETECTED IN IN GROUND-WATER, BEDROCK WELLS

FIGURE 4-19




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| 456 | TOTAL CHLORONATED VOC ug/L |
| ND | NOT DETECTED |

SCREENED INTERVAL OF MONITORING WELL

BENTONITE SEALED BOREHOLE

15
0
150
SCALE IN FEET

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

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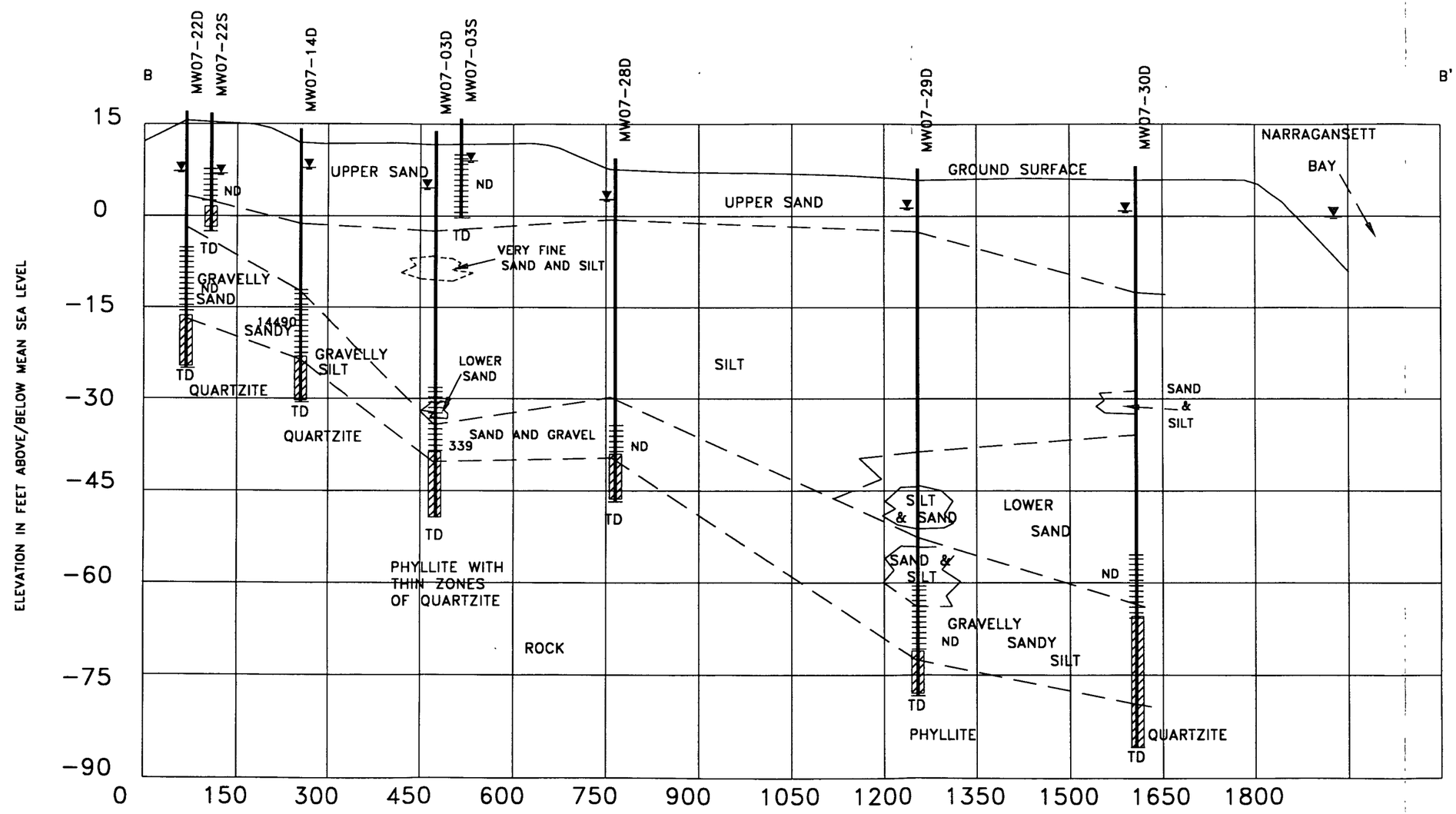
TOTAL CHLORINATED VOC DETECTED IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION A-A'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-20




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| 388 | TOTAL CHLORINATED VOC ug/L |
| ND | NOT DETECTED |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

15
0
150
SCALE IN FEET

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| PWH | NAL | AS SHOWN | SOILDATA |

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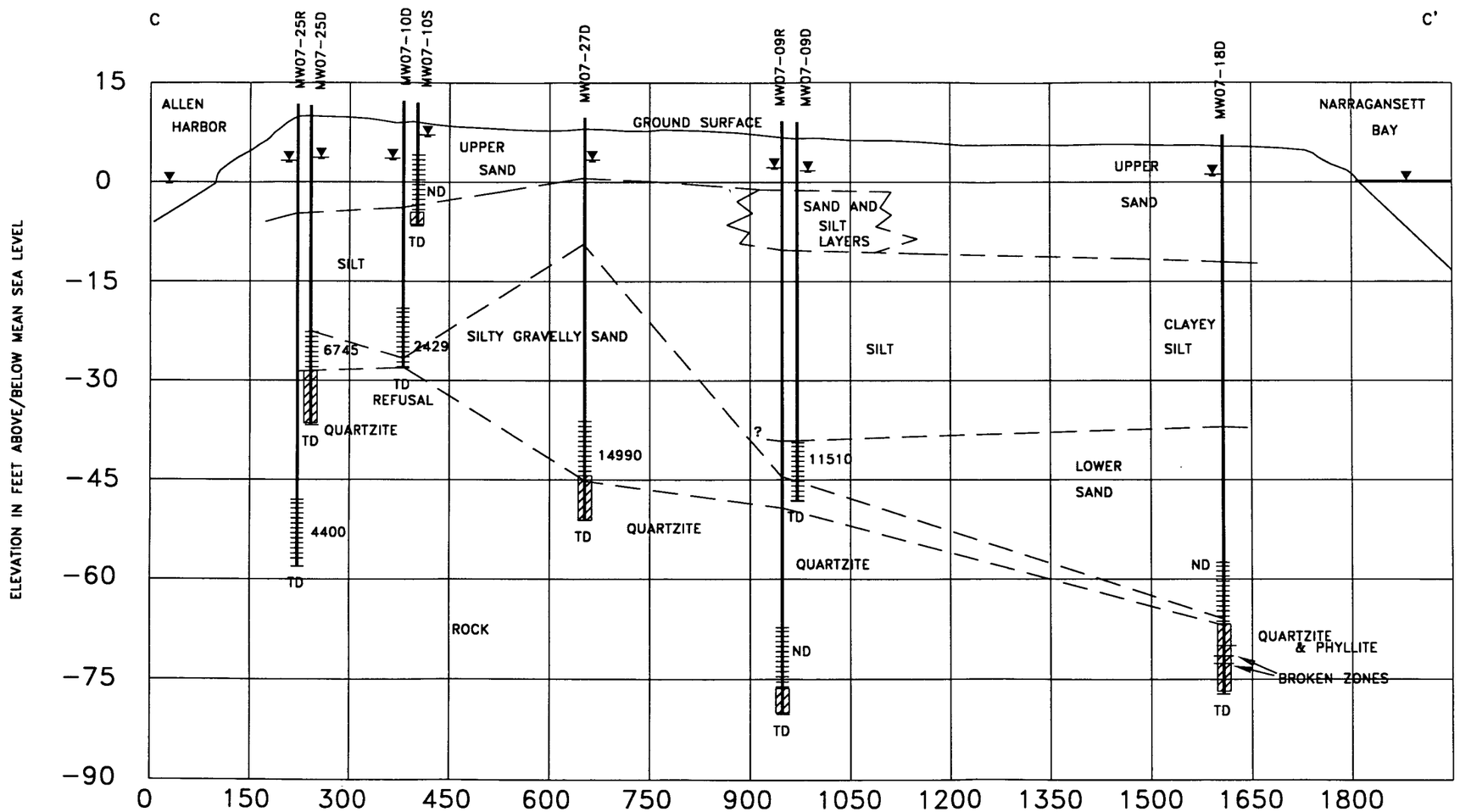
TOTAL CHLORINATED VOC DETECTED IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION B-B'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-21




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| 6106 | TOTAL CHLORINATED VOC (ug/L) |
| ND | NOT DETECTED |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA, SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

15
0
150
SCALE IN FEET

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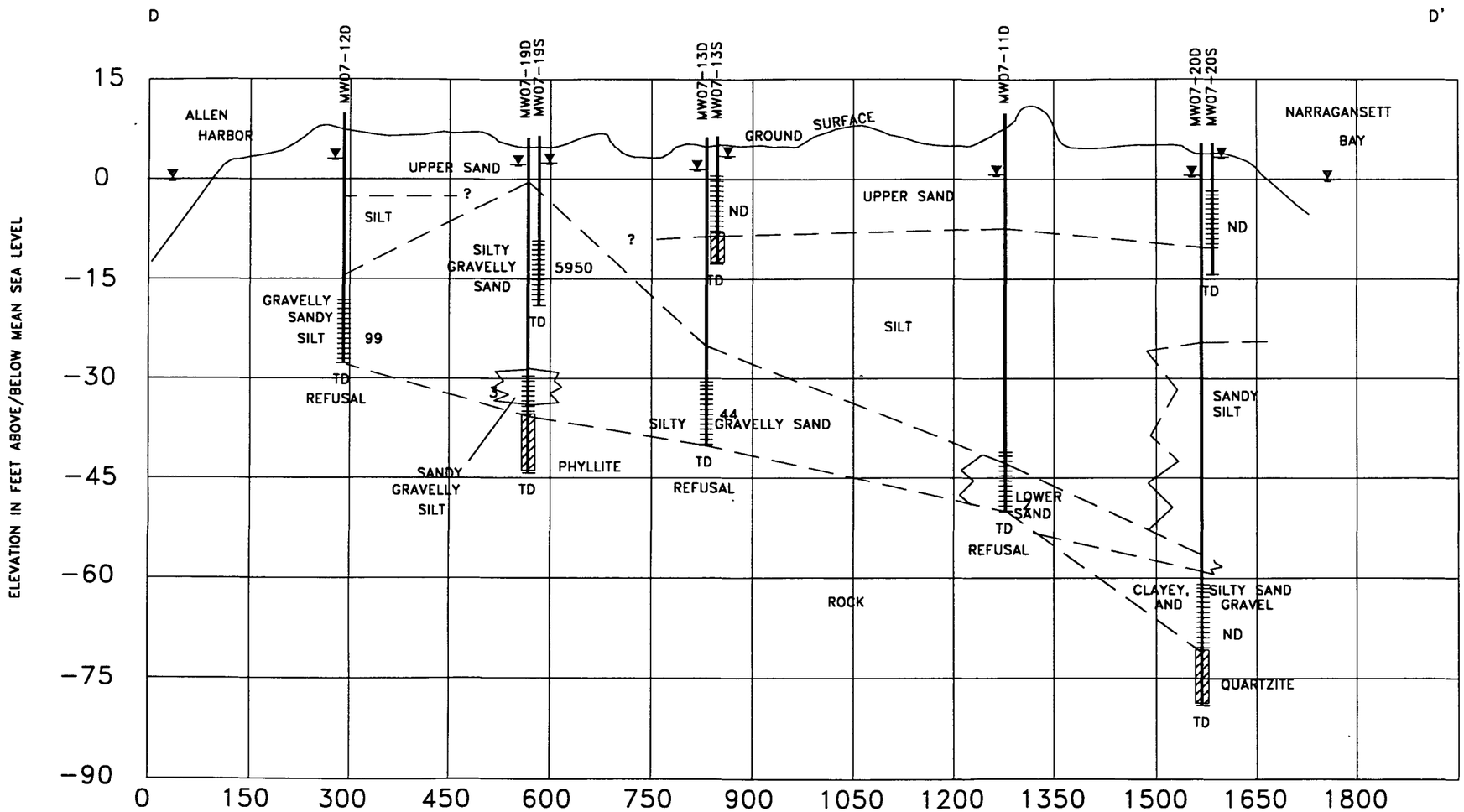
NCBC DAVISVILLE, RHODE ISLAND

TOTAL CHLORINATED VOC DETECTED IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION C-C'
IR PROGRAM SITE 07, CALF PASTURE POINT

FIGURE 4-22




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| ⊞ | SCREENED INTERVAL OF MONITORING WELL |
| ▨ | BENTONITE SEALED BOREHOLE |
| 121 | TOTAL CHLORINATED VOC (ug/L) |
| ND | NOT DETECTED |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

15

0 150

SCALE IN FEET

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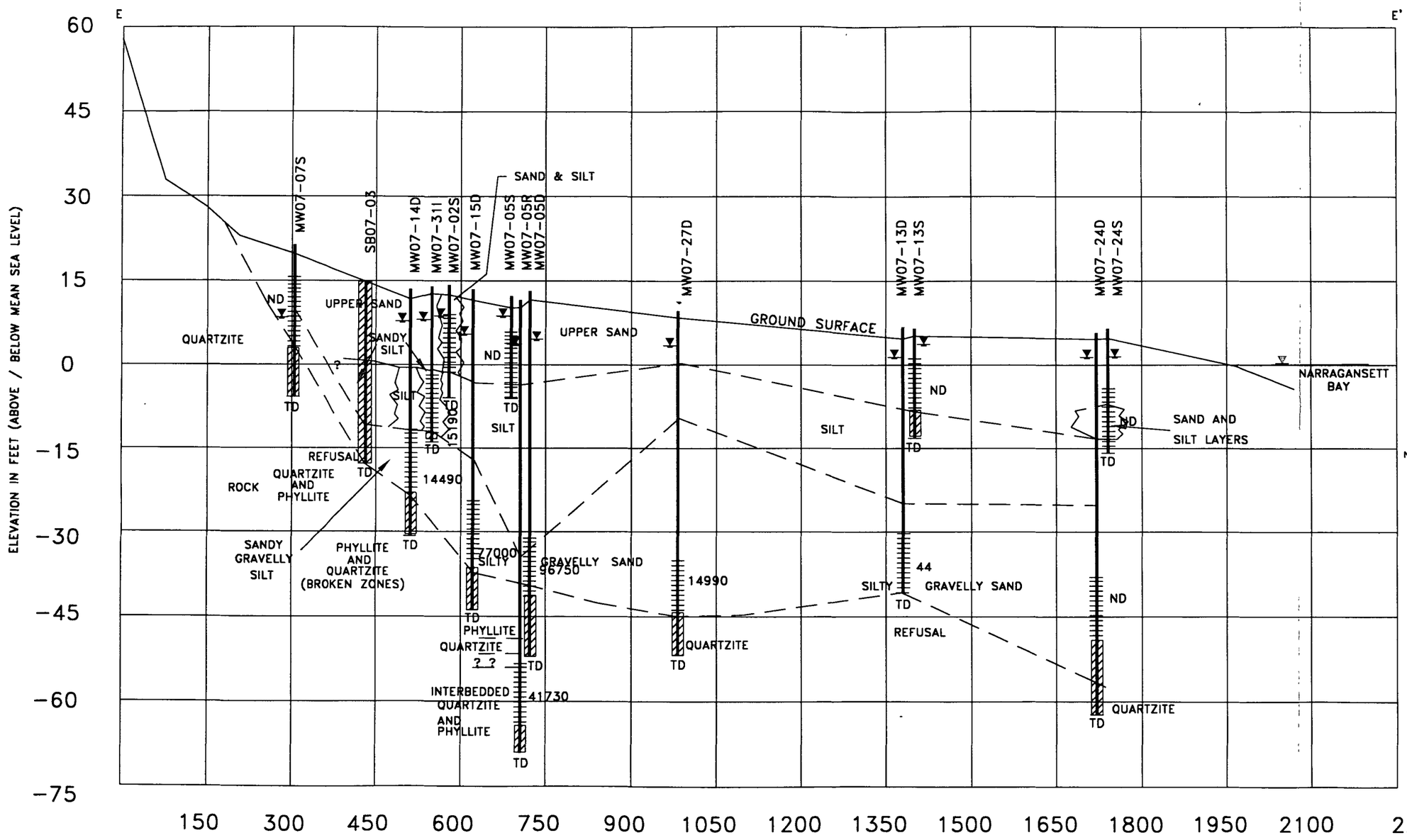
TOTAL CHLORINATED VOC DETECTED IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION D-D'
IR PROGRAM SITE 07, CALF PASTURE POINT

FIGURE 4-23




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MID) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| 44 | TOTAL CHLORINATED VOC (ug/L) |
| ND | NOT DETECTED |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.
51.5' BGS
4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE

15
0
150
SCALE IN FEET

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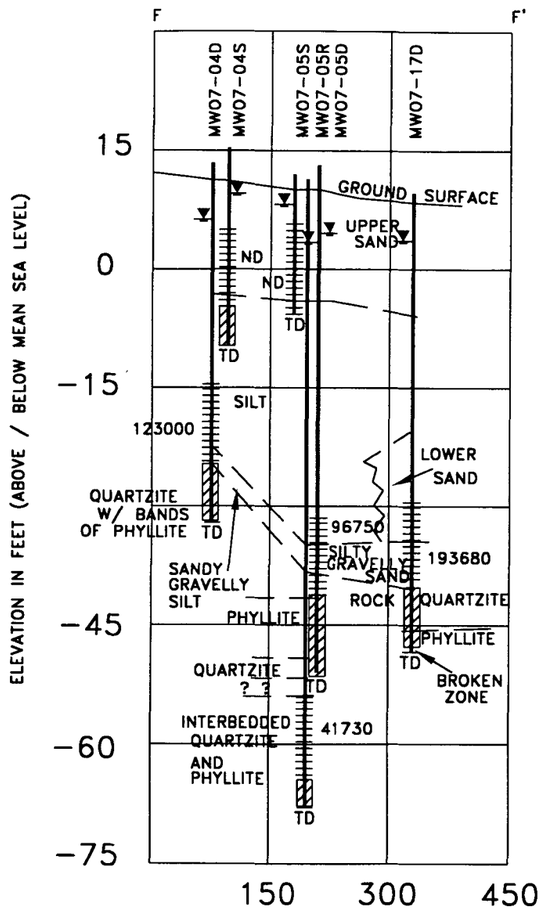
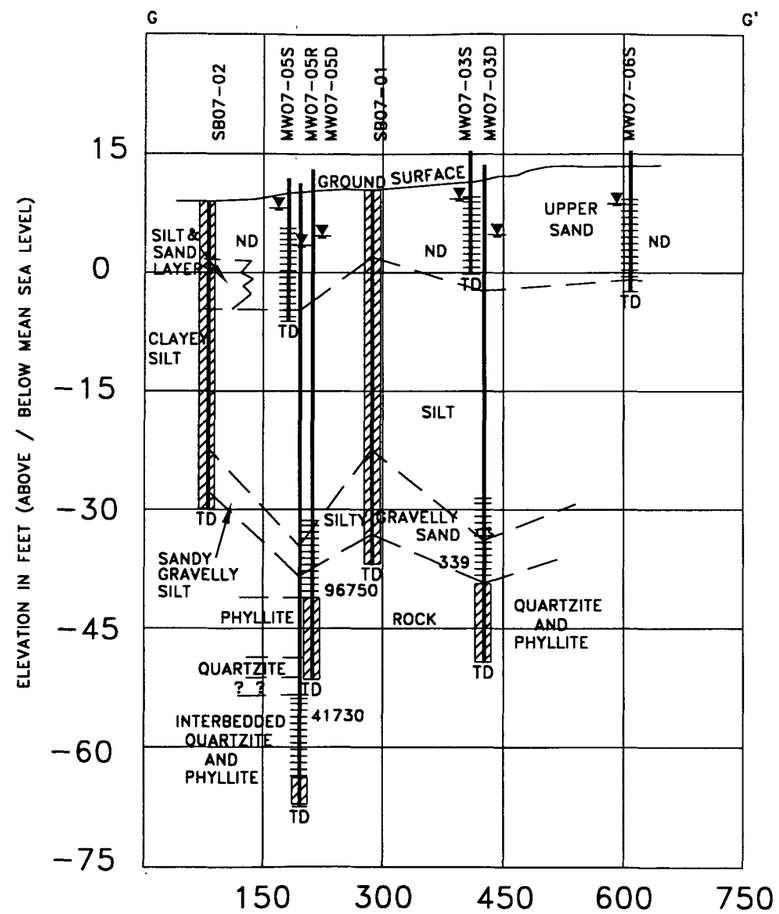
TOTAL CHLORINATED VOC IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION E-E'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-24

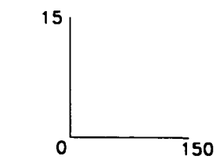



## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| 388 | TOTAL CHLORINATED VOC (ug/L) |
| ND | NOT DETECTED |

NOTES:
1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.
4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS
5) SOIL BORINGS AT SITE 07 WERE BACKFILLED WITH CEMENT/ BENTONITE GROUT FROM TOTAL DEPTH TO LAND SURFACE.

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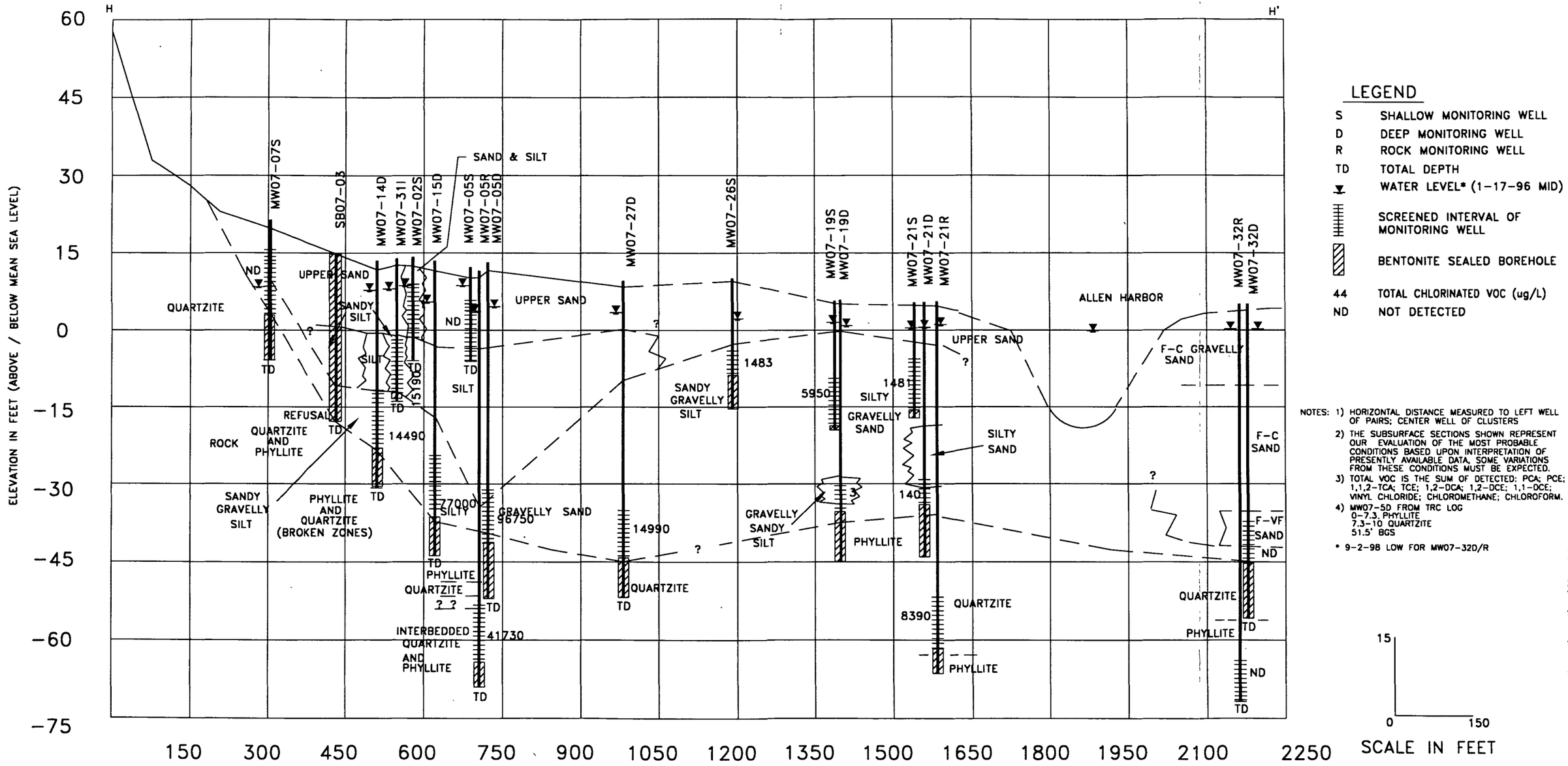
TOTAL CHLORINATED VOC IN GROUND WATER
(DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTIONS F-F' & G-G'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-25

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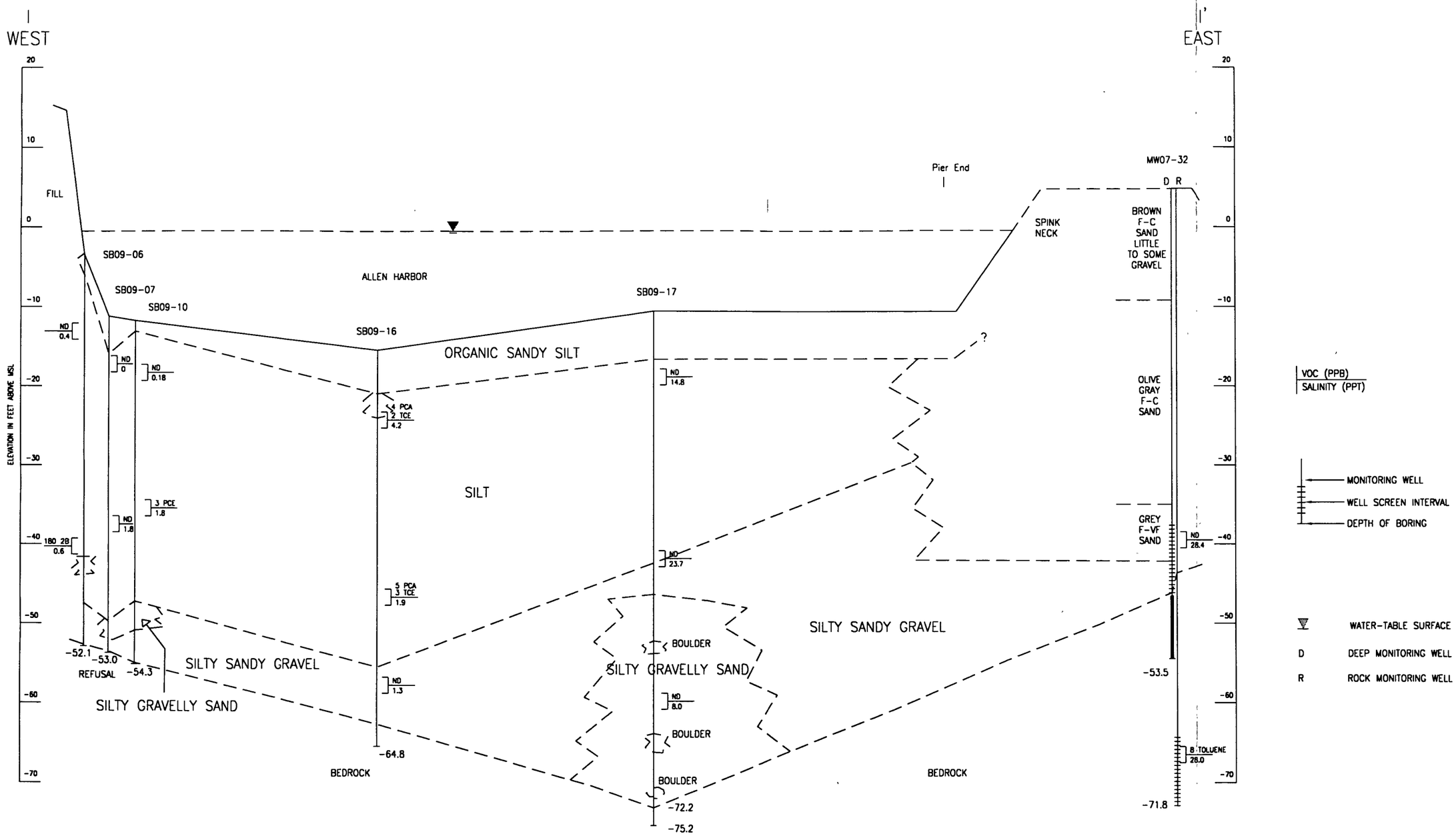
TOTAL CHLORINATED VOC IN GROUND WATER
(DECEMBER 1995-JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION H-H'
IR PROGRAM SITE 07, CALF PASTURE POINT
FIGURE 4-26

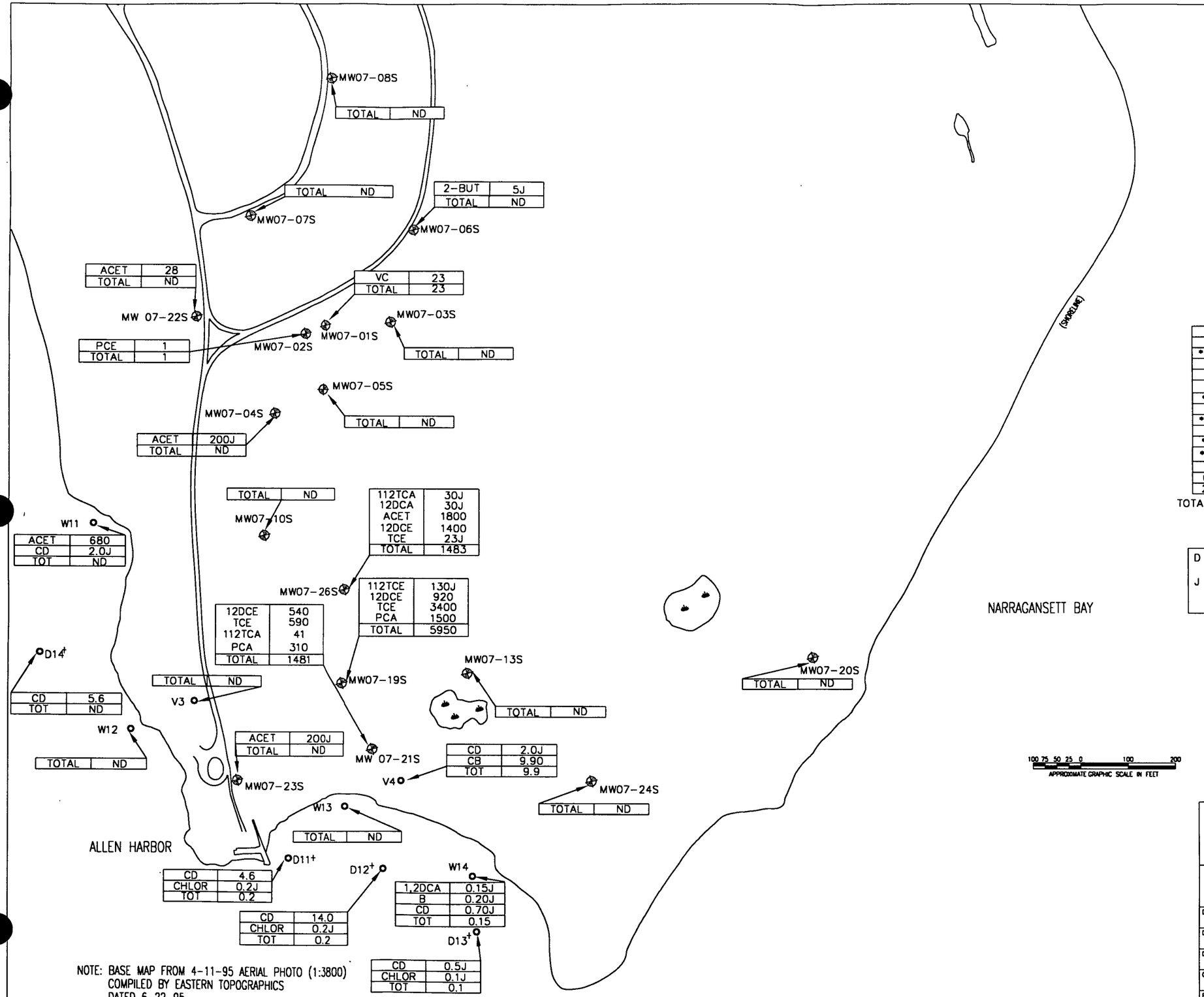



NOTE:
THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

HORIZONTAL SCALE: 1"=200'

FILE: F:\PROJECTS\29600.32\3295\REPORTS\F-RI\CADD\XS4-26A.DWG

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EA ENGINEERING, SCIENCE, AND TECHNOLOGY | NORTHERN DIVISION<br>PHASE III RI REPORT<br>IR PROGRAM SITE 07, CALF PASTURE POINT<br>NCBC DAVISVILLE, RHODE ISLAND | VOC AND SALINITY DETECTED IN GROUND-WATER SAMPLES (SEPT. - NOV. 97)<br>GEOLOGICAL CROSS SECTION I-I' | DESIGNED BY<br>JAS | DRAWN BY<br>MSM/FDV | DATE<br>3/25/98 | PROJECT NO.<br>29600.67 | FILE NAME<br>XS4-26A |
| | | | CHECKED BY<br>JAS | PROJECT MGR.<br>JAS | SCALE<br>AS SHOWN | DRAWING NO.<br>- | FIGURE<br>4-26A |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

LEGEND

- MONITORING WELL LOCATION
- DIRT ROAD OR PATH
- OBJECT
- MARSH
- SHORELINE
- ND UNDETECTED

| | |
|---|---|
| CD | CARBON DISULFIDE |
| CB | CHLOROBENZENE |
| *1,2DCA | 1,2 DICHLOROETHANE (TOTAL) |
| B | BENZENE |
| ACET | ACETONE |
| *PCE | TETRACHLOROETHENE |
| *12DCE | 1,2-DICHLOROETHENE |
| *TCE | TRICHLOROETHENE |
| *112TCA | 1,1,2-TRICHLOROETHANE |
| *PCA | 1,1,2,2-TETRACHLOROETHANE |
| *12DCA | 1,2-DICHLOROETHANE |
| *112TCE | 1,1,2-TRICHLOROETHENE |
| *VC | VINYL CHLORIDE |
| CHLOR | CHLOROFORM |
| 2-BUT | 2-BUTANONE |

TOTAL = SUM OF CHLORINATED COMPOUNDS (*) DETECTED IN ASSOCIATED SAMPLE

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL VALUE IS AN ESTIMATED QUANTITY

MARINE ERA SAMPLING LOCATIONS

- o W11-W14 WETLAND INTERTIDAL
- o V3-V4 VEGETATED WETLAND
- o D11-D14 SURFICIAL SEDIMENT (OFFSHORE)
- o DC11-DC14 DEEPER SEDIMENT

F:\PROJECTS\29600.32\3295\REPORT\F-RI\CADD\FIG4-27.DWG

TOTAL VOC DETECTED IN GROUND-WATER SAMPLES (ug/L) SHALLOW WELLS
DECEMBER 1995 AND MAY 1996
AND AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (ng/g) (3/95-4/95)
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| | |
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| DATE | 5/13/98 |
| DESIGNED BY | RMC |
| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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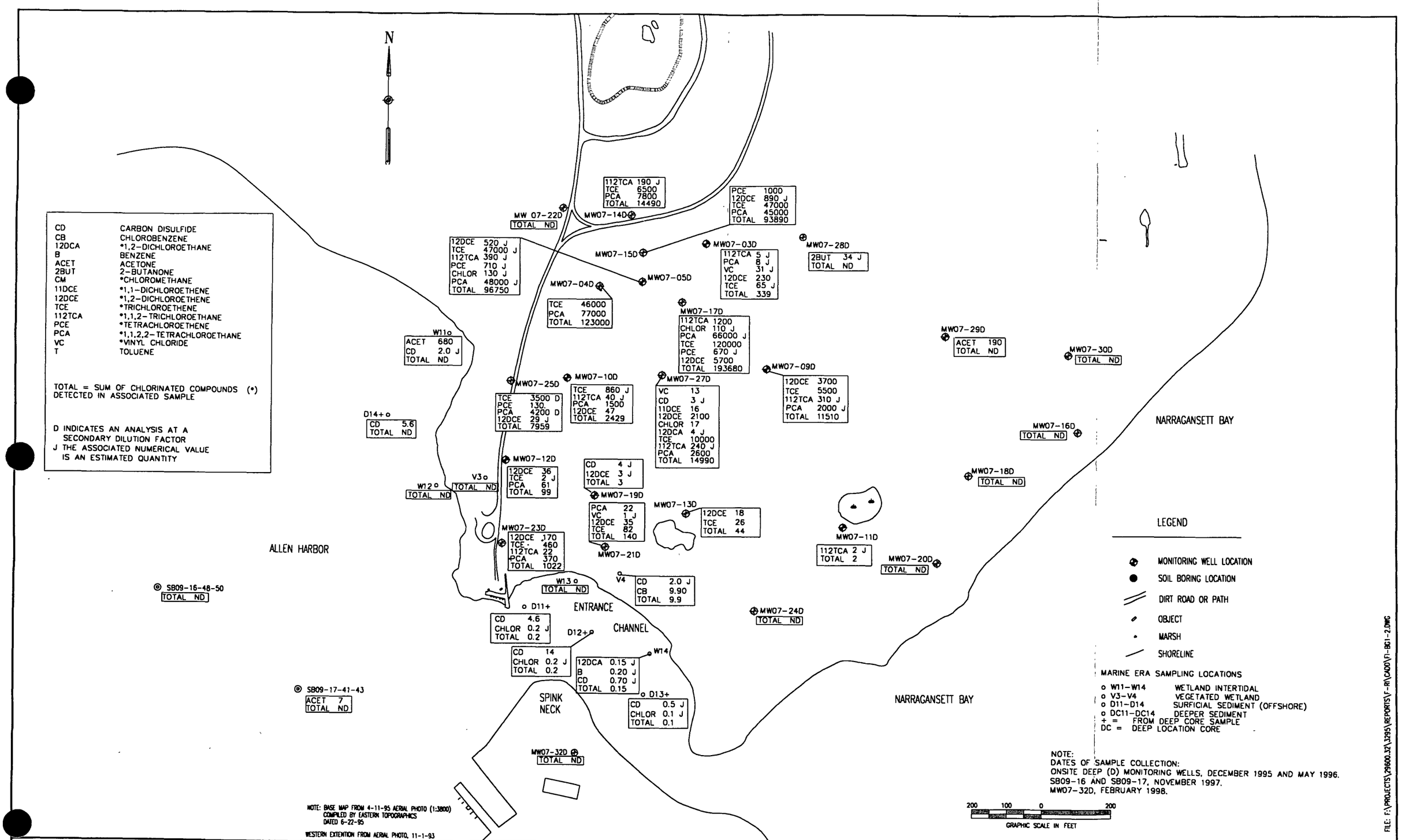
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG4-27 |
| LAYER NAME | VOCS SHALLOW WELLS |
| FIGURE NUMBER | 4-27 |

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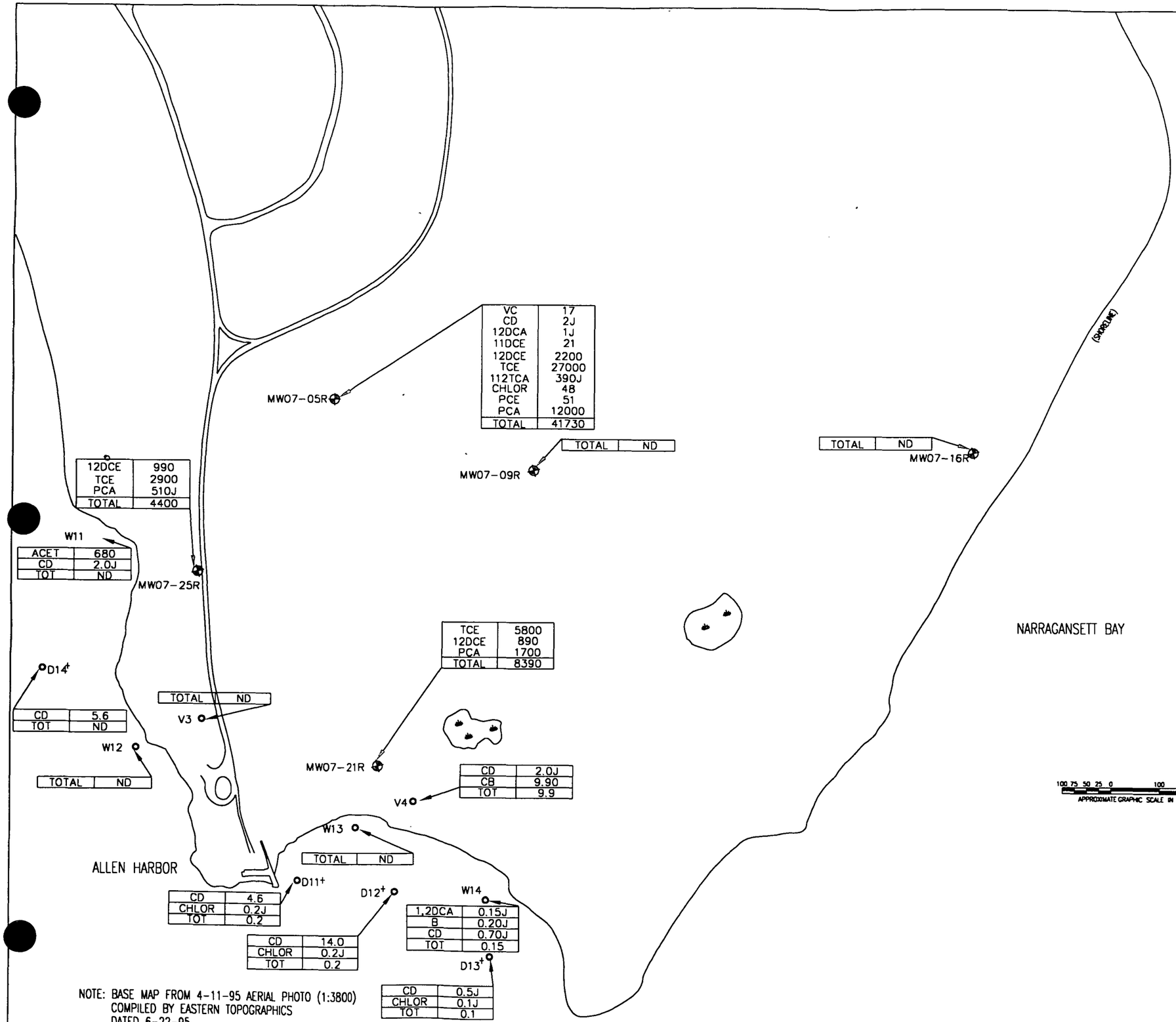
|---|---|---|---|---|
| JAS | RWC | 7/10/98 | 29600.32 | FI-BG1-2 |
| CHECKED BY | PROJECT MGR. | SCALE | DRAWING NO. | FIGURE |
| JAS | JAS | AS SHOWN | - | 4-28 |

NORTHERN DIVISION
CALF PASTURE POINT, IR PROGRAM SITE 07
NCBC DAVISVILLE, RHODE ISLAND

VOC DETECTED IN GROUND WATER (UG/L) FROM DEEP MONITORING WELLS, IN GROUND WATER (UG/L) COLLECTED FROM SOIL BORINGS (TILL UNIT) IN ALLEN HARBOR, AND AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (UG/G)
FIGURE 4-28




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

## LEGEND

- MONITORING WELL LOCATION
- DIRT ROAD OR PATH
- OBJECT
- MARSH
- SHORELINE
- ND UNDETECTED

| | |
|---|---|
| CD | CARBON DISULFIDE |
| CB | CHLOROBENZENE |
| 1,2DCA | 1,2 DICHLOROETHANE (TOTAL) |
| B | BENZENE |
| ACET | ACETONE |
| 12DCE | 1,2 DICHLOROETHENE (TOTAL) |
| * CHLOR | CHLOROFORM |
| *112TCA | 1,1,2-TRICHLOROETHANE |
| * TCE | TRICHLOROETHENE |
| * PCA | 1,1,2,2-TETRACHLOROETHANE |
| * 11DCE | 1,1-DICHLOROETHENE |
| * PCE | TETRACHLOROETHENE |
| * VC | VINYL CHLORIDE |

TOTAL = SUM OF CHLORINATED COMPOUNDS (*) DETECTED IN ASSOCIATED SAMPLE

D INDICATES AN ANALYSIS AT A SECONDARY DILUTION FACTOR

J THE ASSOCIATED NUMERICAL IS AN ESTIMATED QUANTITY

### MARINE ERA SAMPLING LOCATIONS

- o W11-W14 WETLAND INTERTIDAL
- o V3-V4 VEGETATED WETLAND
- o D11-D14 SURFICIAL SEDIMENT (OFFSHORE)
- o DC11-DC14 DEEPER SEDIMENT
- + = FROM DEEP CORE SAMPLE
- DC = DEEP LOCATION CORE

F:\PROJECTS\29600.32\3295\REPORT\F-RI\CADD\FIG4-29.DWG

VOC DETECTED IN GROUND-WATER (ug/L) BEDROCK WELLS
DECEMBER 1995 AND MAY 1996
AND AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (ng/g) (3/95-4/95)
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| | |
|---|---|
| DATE | 5/13/98 |
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| DRAWN BY | JFW |
| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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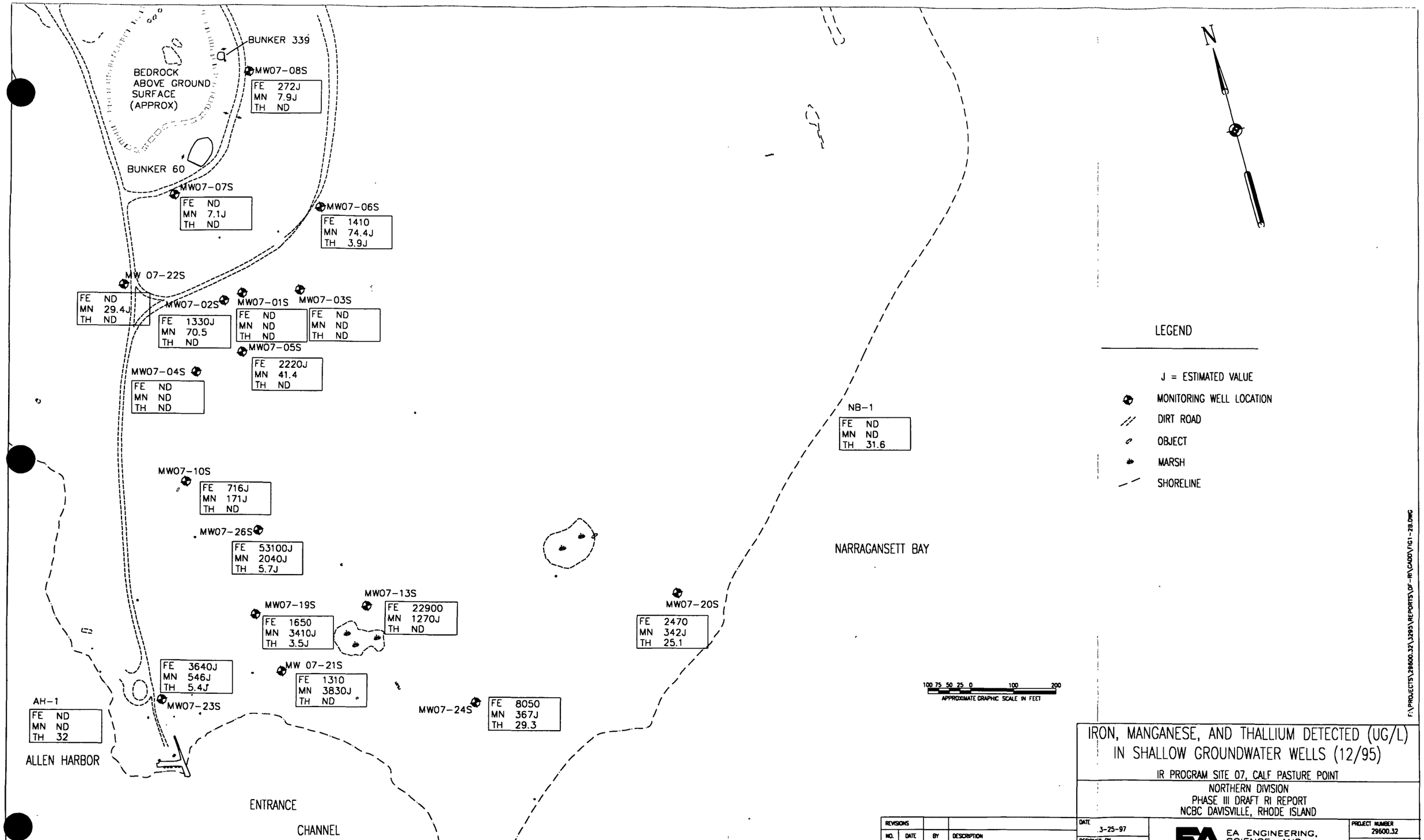
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG4-29 |
| LAYER NAME | VOCS ROCK WELLS |
| FIGURE NUMBER | 4-29 |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

# IRON, MANGANESE, AND THALLIUM DETECTED (UG/L) IN SHALLOW GROUNDWATER WELLS (12/95)

IR PROGRAM SITE 07, CALF PASTURE POINT

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NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RWC | MOVED MW07-31I TO DEEP FIGURE |
| 2 | 6/5/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 3-25-97
DESIGNED BY RWC
DRAWN BY RWC
CHECKED BY JAS
PROJECT MANAGER JAS

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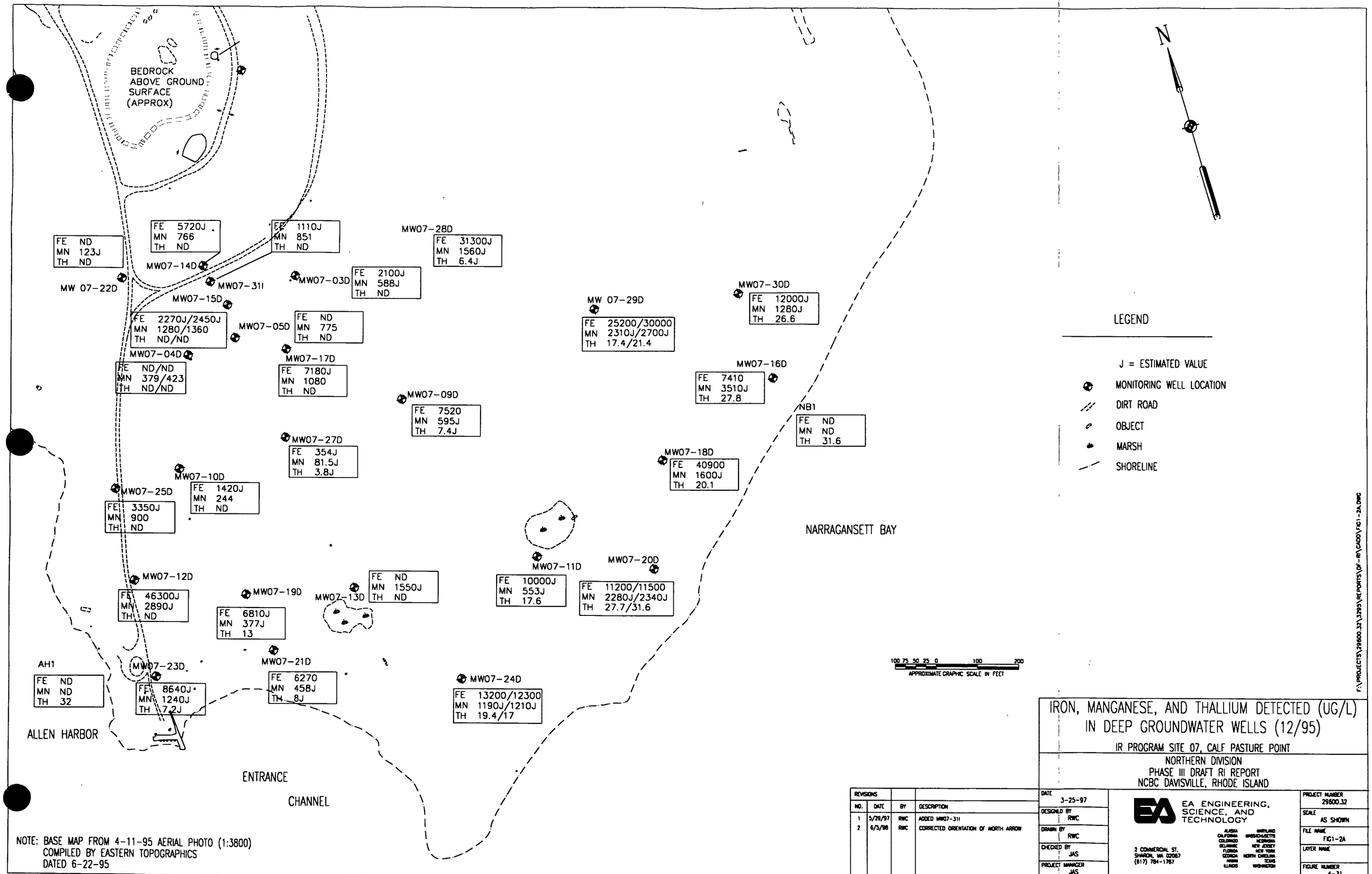
COLORADO NEBRASKA
COLUMBIA NEW JERSEY
FLORIDA NEW YORK
GEORGIA NORTH CAROLINA
HAWAII TEXAS
ILLINOIS WASHINGTON

PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG1-2
LAYER NAME
FIGURE NUMBER 4-30




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

# IRON, MANGANESE, AND THALLIUM DETECTED (UG/L) IN DEEP GROUNDWATER WELLS (12/95)

IR PROGRAM SITE 07, CALF PASTURE POINT

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NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 5/29/97 | RWC | ADDED MW07-31I |
| 2 | 6/5/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

DATE 3-25-97
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DRAWN BY RWC
CHECKED BY JAS
PROJECT MANAGER JAS

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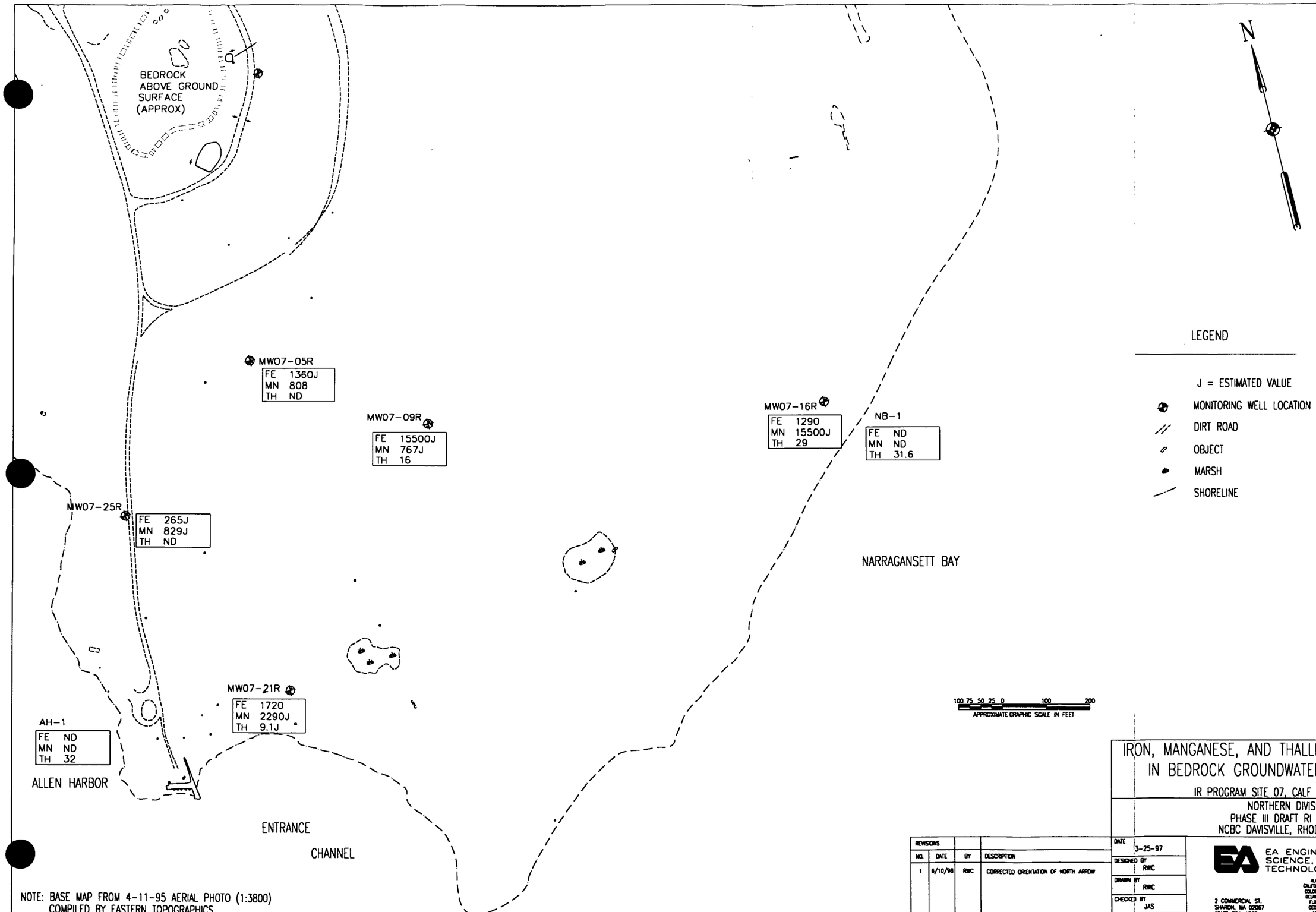
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME FIG1-2A
LAYER NAME
FIGURE NUMBER 4-31




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
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DATED 6-22-95

F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD1\FIG1-2C.DWG

# IRON, MANGANESE, AND THALLIUM DETECTED (UG/L) IN BEDROCK GROUNDWATER WELLS (12/95)

IR PROGRAM SITE 07, CALF PASTURE POINT

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|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 6/10/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
| DATE | 3-25-97 |
| DESIGNED BY | RWC |
| DRAWN BY | RWC |
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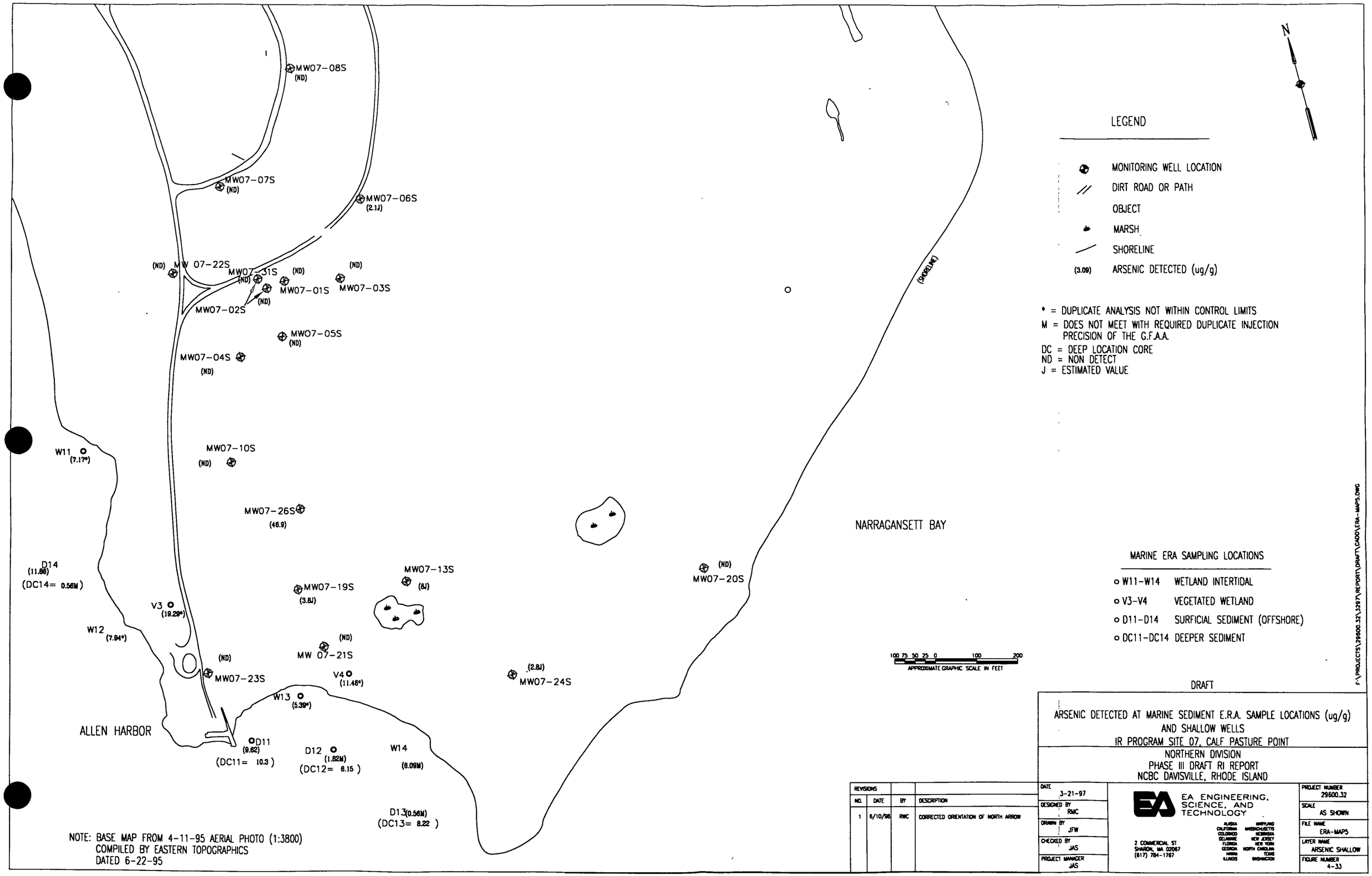
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | FIG1-2 |
| LAYER NAME | |
| FIGURE NUMBER | 4-32 |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

DRAFT

ARSENIC DETECTED AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (ug/g)
AND SHALLOW WELLS
IR PROGRAM SITE 07, CALF PASTURE POINT

NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND

| REVISIONS | | | |
|---|---|---|---|
| NO. | DATE | BY | DESCRIPTION |
| 1 | 6/10/98 | RWC | CORRECTED ORIENTATION OF NORTH ARROW |

| | |
|---|---|
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| CHECKED BY | JAS |
| PROJECT MANAGER | JAS |

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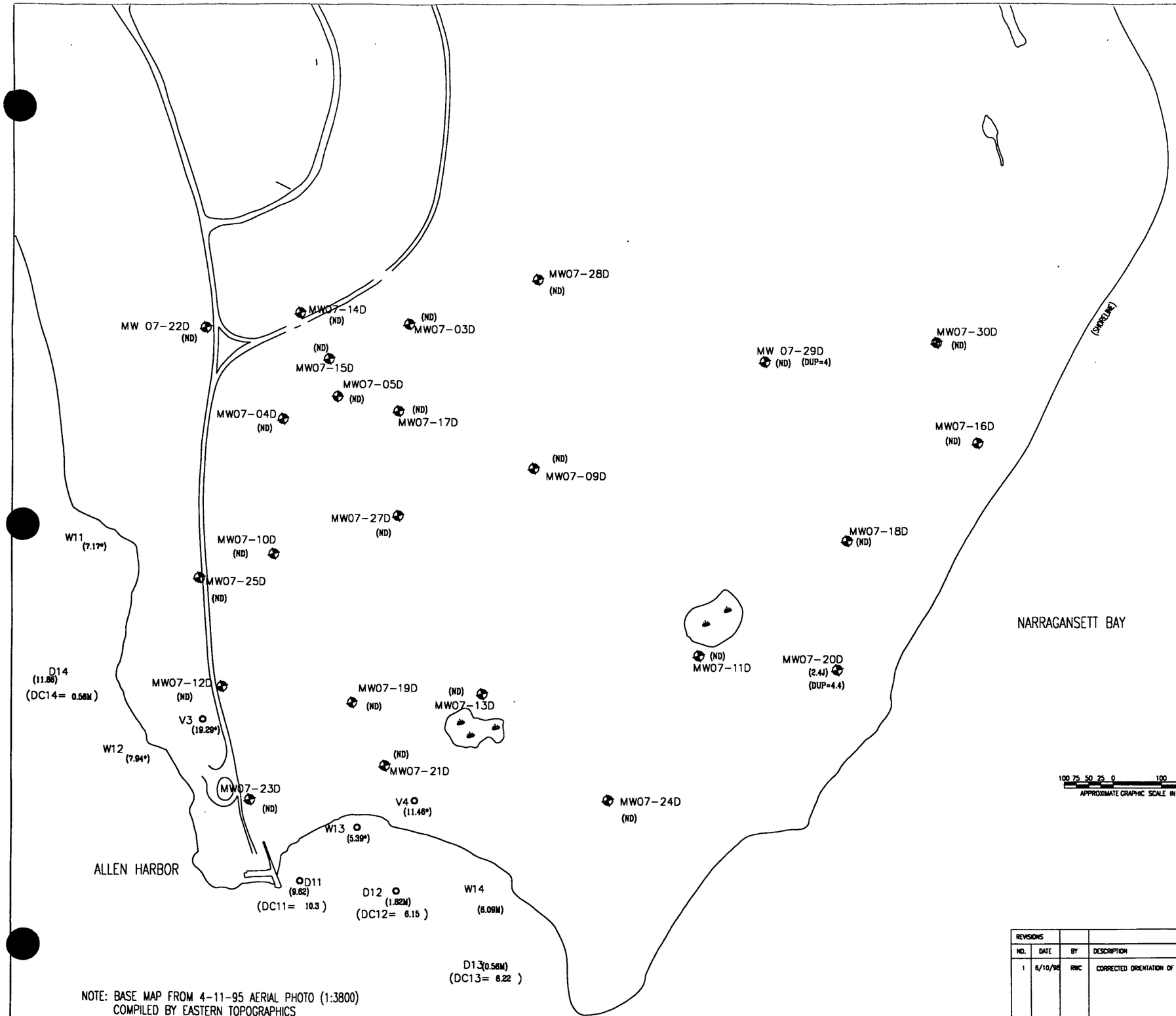
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | ERA-MAP5 |
| LAYER NAME | ARSENIC SHALLOW |
| FIGURE NUMBER | 4-33 |




NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
COMPILED BY EASTERN TOPOGRAPHICS
DATED 6-22-95

DRAFT

ARSENIC DETECTED AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (ug/g)
AND DEEP WELLS
IR PROGRAM SITE 07, CALF PASTURE POINT

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| | |
|---|---|
| DATE | 3-21-97 |
| DESIGNED BY | RMC |
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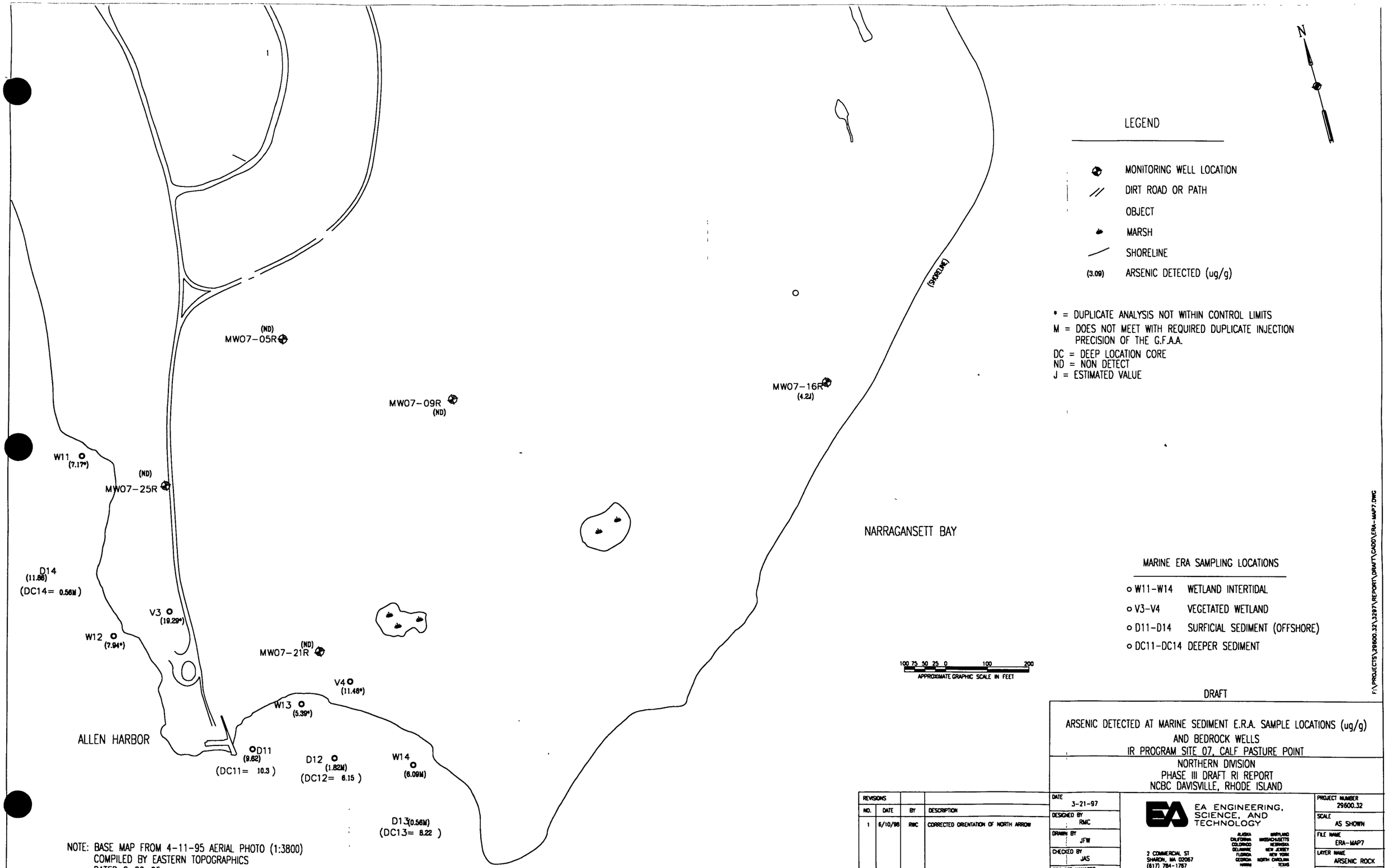
| | |
|---|---|
| PROJECT NUMBER | 29600.32 |
| SCALE | AS SHOWN |
| FILE NAME | ERA-MAP6 |
| LAYER NAME | ARSENIC DEEP |
| FIGURE NUMBER | 4-34 |


N
LEGEND
MONITORING WELL LOCATION
DIRT ROAD OR PATH
OBJECT
MARSH
SHORELINE
(3.09) ARSENIC DETECTED (ug/g)
* = DUPLICATE ANALYSIS NOT WITHIN CONTROL LIMITS
M = DOES NOT MEET WITH REQUIRED DUPLICATE INJECTION PRECISION OF THE G.F.A.A.
DC = DEEP LOCATION CORE
ND = NON DETECT
J = ESTIMATED VALUE
(SHORELINE)
(ND)
MW07-05R
MW07-09R
(ND)
MW07-16R
(4.2J)
W11
(7.17*)
(ND)
MW07-25R
NARRAGANSETT BAY
D14
(11.86)
(DC14= 0.56M)
V3
(19.29*)
W12
(7.94*)
(ND)
MW07-21R
V4
(11.46*)
W13
(5.39*)
ALLEN HARBOR
D11
(9.62)
(DC11= 10.3)
D12
(1.82M)
(DC12= 6.15)
W14
(6.09M)
D13
(0.56M)
(DC13= 8.22)
MARINE ERA SAMPLING LOCATIONS
W11-W14 WETLAND INTERTIDAL
V3-V4 VEGETATED WETLAND
D11-D14 SURFICIAL SEDIMENT (OFFSHORE)
DC11-DC14 DEEPER SEDIMENT
100 75 50 25 0 100 200
APPROXIMATE GRAPHIC SCALE IN FEET
F:\PROJECTS\29600.32\3297\REPORT\DRAFT\CADD\ERA-MAP7.DWG
NOTE: BASE MAP FROM 4-11-95 AERIAL PHOTO (1:3800)
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DATED 6-22-95
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ARSENIC DETECTED AT MARINE SEDIMENT E.R.A. SAMPLE LOCATIONS (ug/g)
AND BEDROCK WELLS
IR PROGRAM SITE 07, CALF PASTURE POINT
NORTHERN DIVISION
PHASE III DRAFT RI REPORT
NCBC DAVISVILLE, RHODE ISLAND
REVISIONS
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1 6/10/98 RMC CORRECTED ORIENTATION OF NORTH ARROW
DATE 3-21-97
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CHECKED BY JAS
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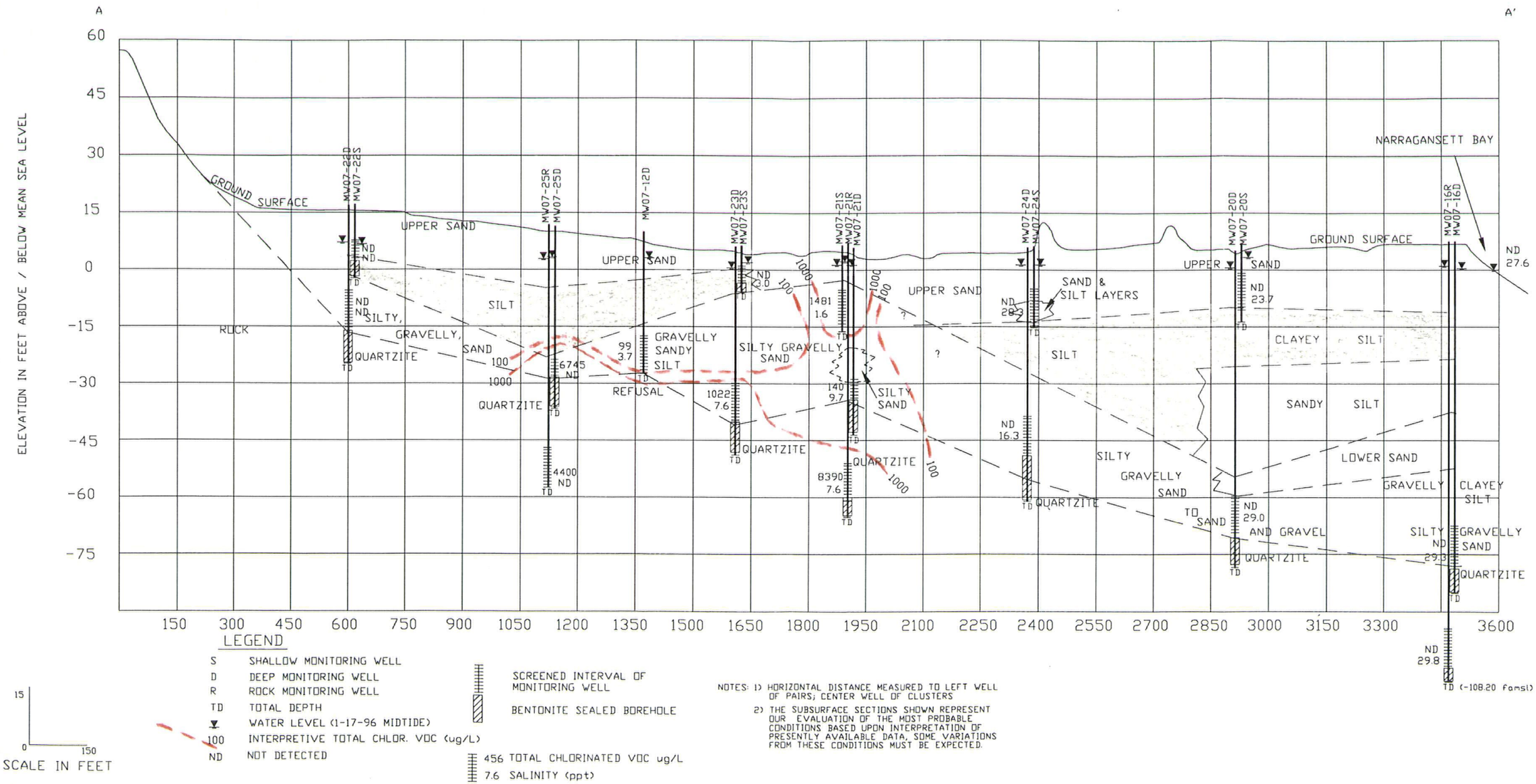
PROJECT NUMBER 29600.32
SCALE AS SHOWN
FILE NAME ERA-MAP7
LAYER NAME ARSENIC ROCK
FIGURE NUMBER 4-35




LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| 100 | INTERPRETIVE TOTAL CHLOR. VOC (ug/L) |
| ND | NOT DETECTED |

SCREENED INTERVAL OF MONITORING WELL

BENTONITE SEALED BOREHOLE

456 TOTAL CHLORINATED VOC ug/L

7.6 SALINITY (ppt)

15 / 0 / 150

SCALE IN FEET

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

F:\PROJECTS\29600.32\3297\REPORTS\DRAFT\CAD01\FIG4-20.DWG

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| JLS | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | FILE NAME |
| JAS | JAS | AS SHOWN | CROSS7A.DWG |

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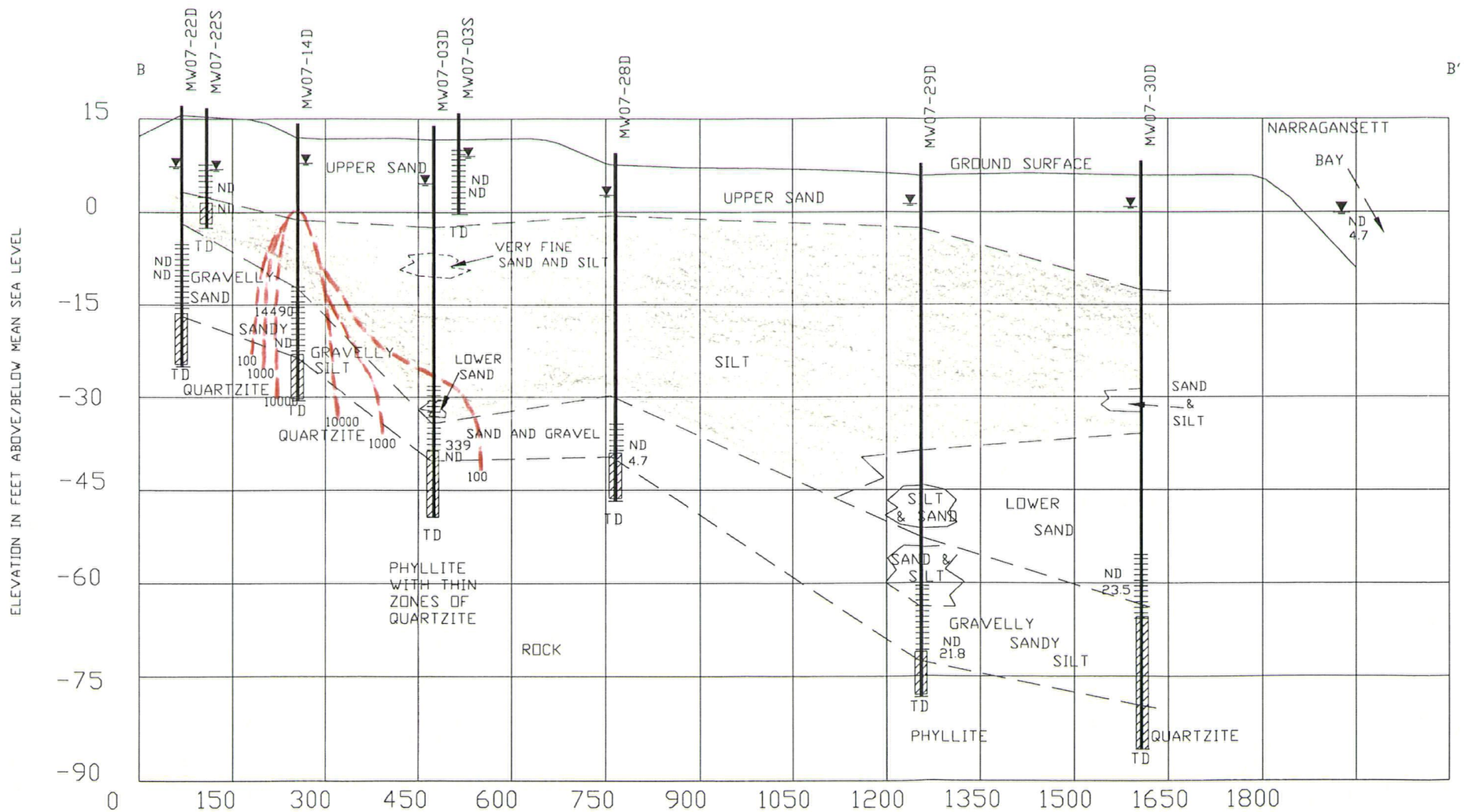
INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUND WATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION A-A'

FIGURE 4-36




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ND | NOT DETECTED |
| 388 | TOTAL CHLORINATED VOC ug/L |
| 4.7 | SALINITY (PPT) |
| 100 | INTERPRETIVE CONTOUR CHLORINATED VOC (UG/L) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS
2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.
3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

15
0
150
SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORTS\DRAFT\CADD\VFIG4-21.DWG

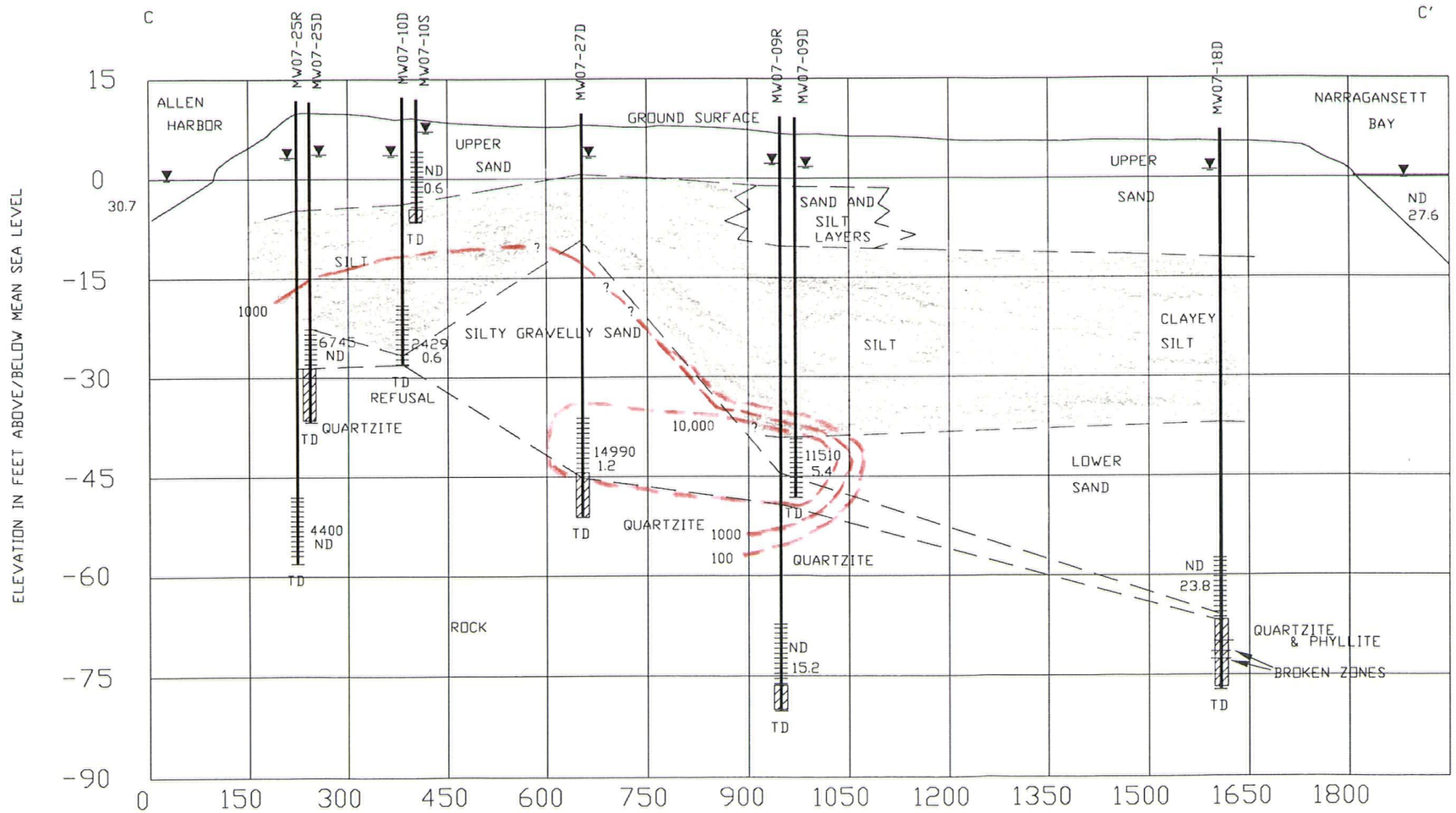
EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

| DESIGNED BY | DRAWN BY | DATE | PROJECT NO. |
|---|---|---|---|
| JBM | JFW | 8-8-96 | 29600.32 |
| CHECKED BY | PROJECT MGR. | SCALE | LAYER NAME |
| PWH | NAL | AS SHOWN | SOILDATA |

NORTHERN DIVISION
PHASE III RI REPORT
NCBC DAVISVILLE, RHODE ISLAND
IR PROGRAM SITE 07, CALF PASTURE POINT

INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUND WATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996) GEOLOGIC CROSS SECTION B-B'

FIGURE 4-37




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ND | NOT DETECTED |
| 100 | INTERPRETIVE TOTAL CHLOR. VOC (ug/L) |
| 6106 | TOTAL CHLORINATED VOC (ug/L) |
| 7.6 | SALINITY (ppt) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

15
0
150
SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORTS\DRAFT\CADD\FIG4-22.DWG

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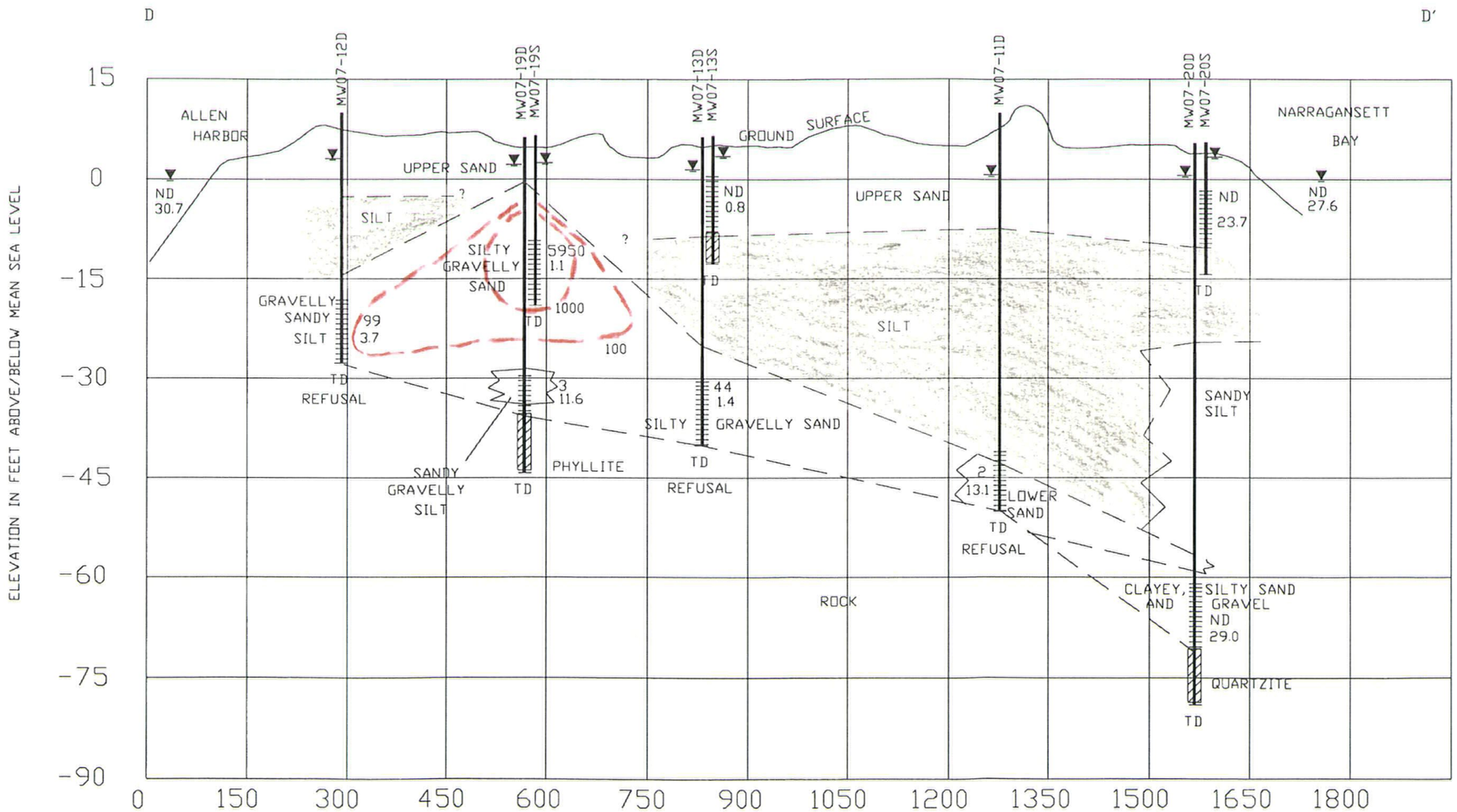
INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUNDWATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION C-C'
FIGURE 4-38



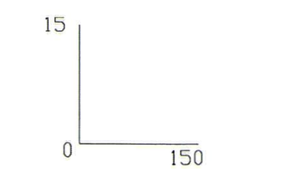

## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL (1-17-96 MIDTIDE) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ND | NOT DETECTED |
| 1000 | INTERPRETIVE CHLORINATED VOC (UG/L) |
| 121 | TOTAL CHLORINATED VOC (ug/L) |
| 27.6 | SALINITY (PPT) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.




SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORTS\DRAFT\CADD\VFIG4-23.DWG

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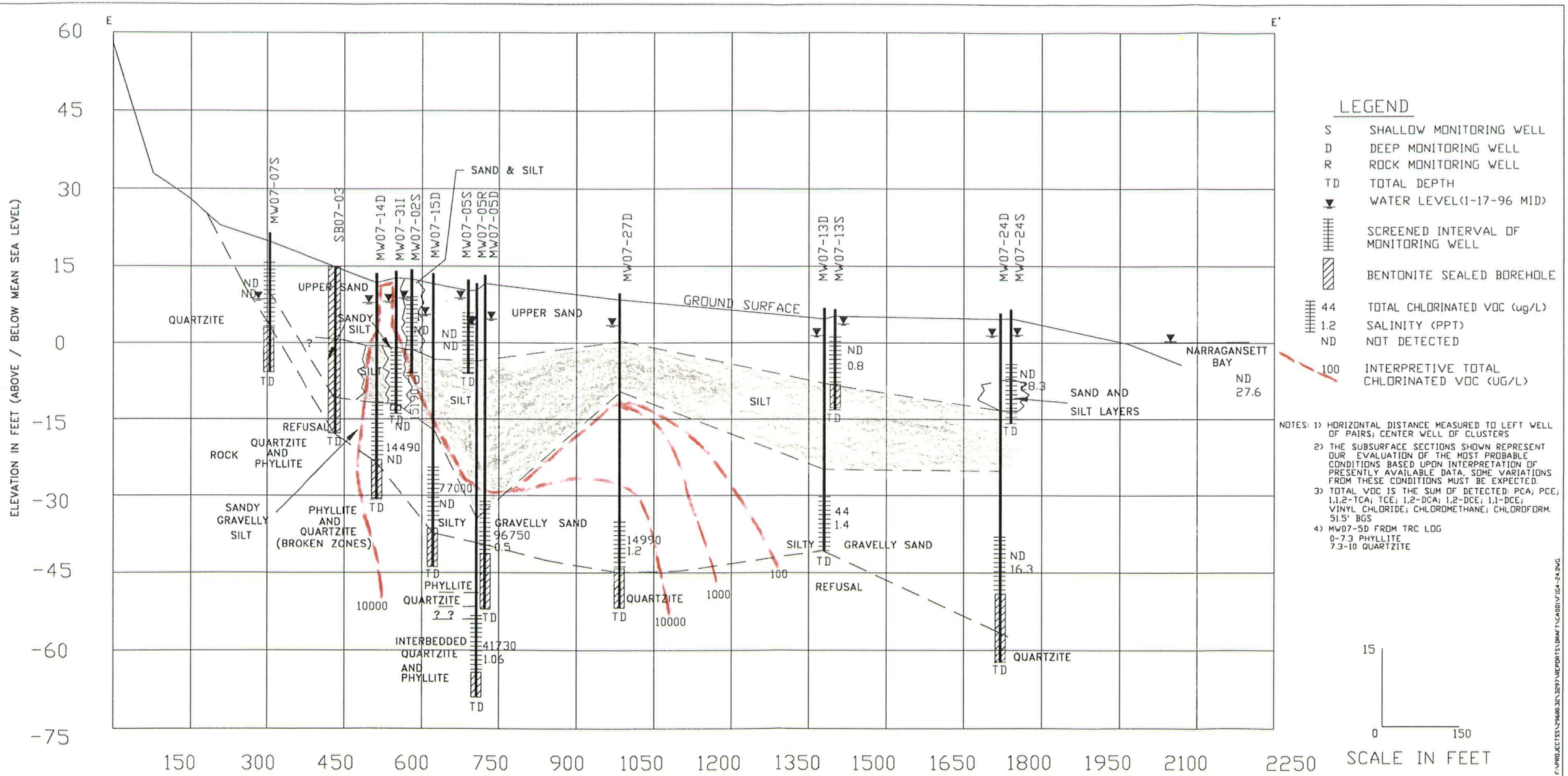
INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUND WATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996) GEOLOGIC CROSS SECTION D-D'

FIGURE 4-39




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL(1-17-96 MID) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| 44 | TOTAL CHLORINATED VOC (ug/L) |
| 1.2 | SALINITY (PPT) |
| ND | NOT DETECTED |
| 100 | INTERPRETIVE TOTAL CHLORINATED VOC (UG/L) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

51.5' BGS

4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE

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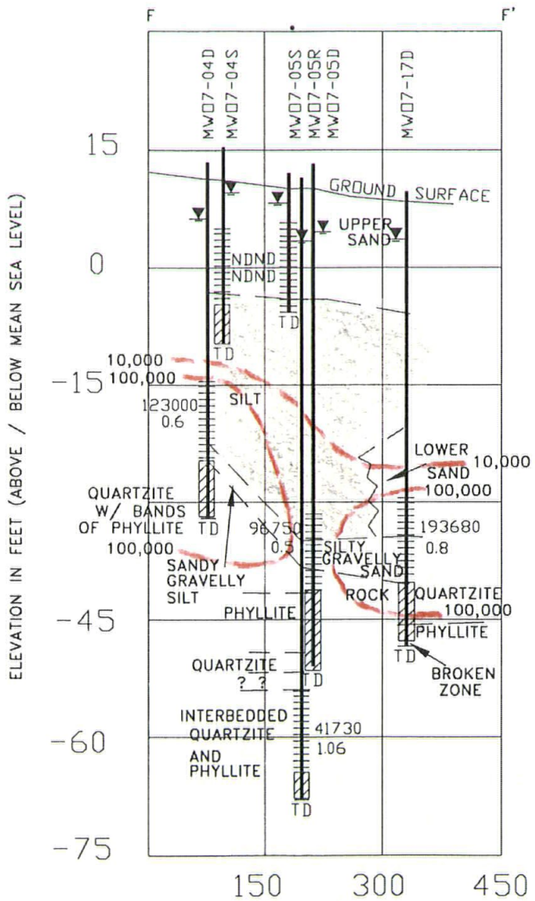
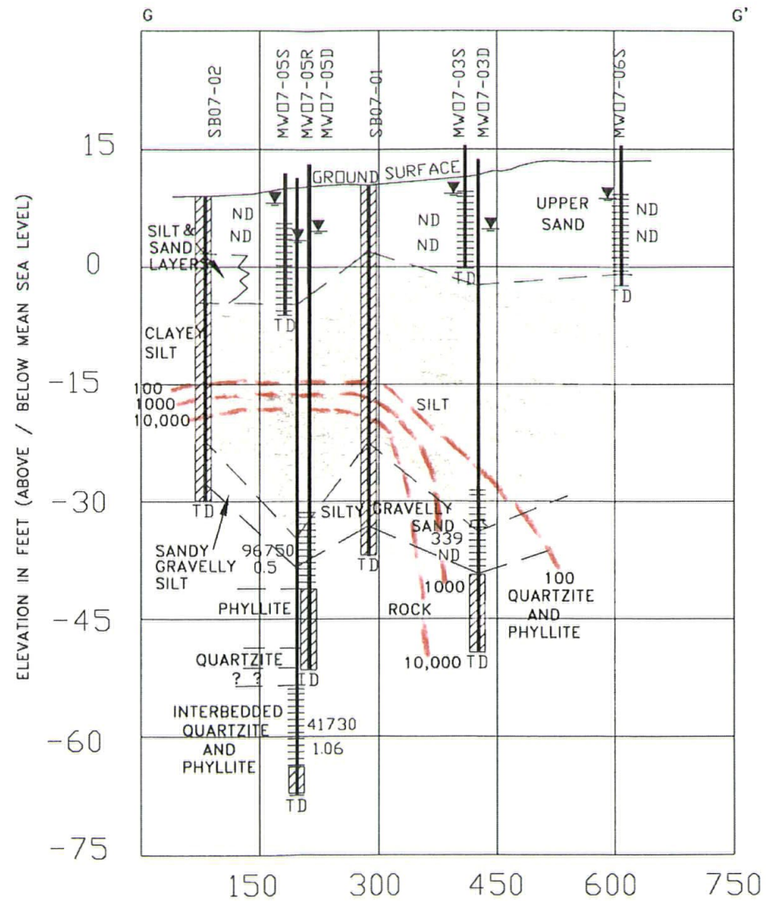
INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUND WATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTION E-E'
FIGURE 4-40




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ND | NOT DETECTED |
| 100 | INTERPRETIVE TOTAL CHLOR. VOC (ug/L) |
| 388 | TOTAL CHLORINATED VOC (ug/L) |
| 7.6 | SALINITY (ppt) |

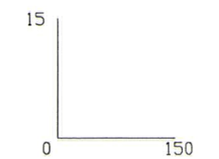
NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA. SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS

5) SOIL BORINGS AT SITE 07 WERE BACKFILLED WITH CEMENT/ BENTONITE GROUT FROM TOTAL DEPTH TO LAND SURFACE.




SCALE IN FEET

F:\PROJECTS\29600.32\3297\REPORTS\DRAFT\CADD\FIG4-25.DWG

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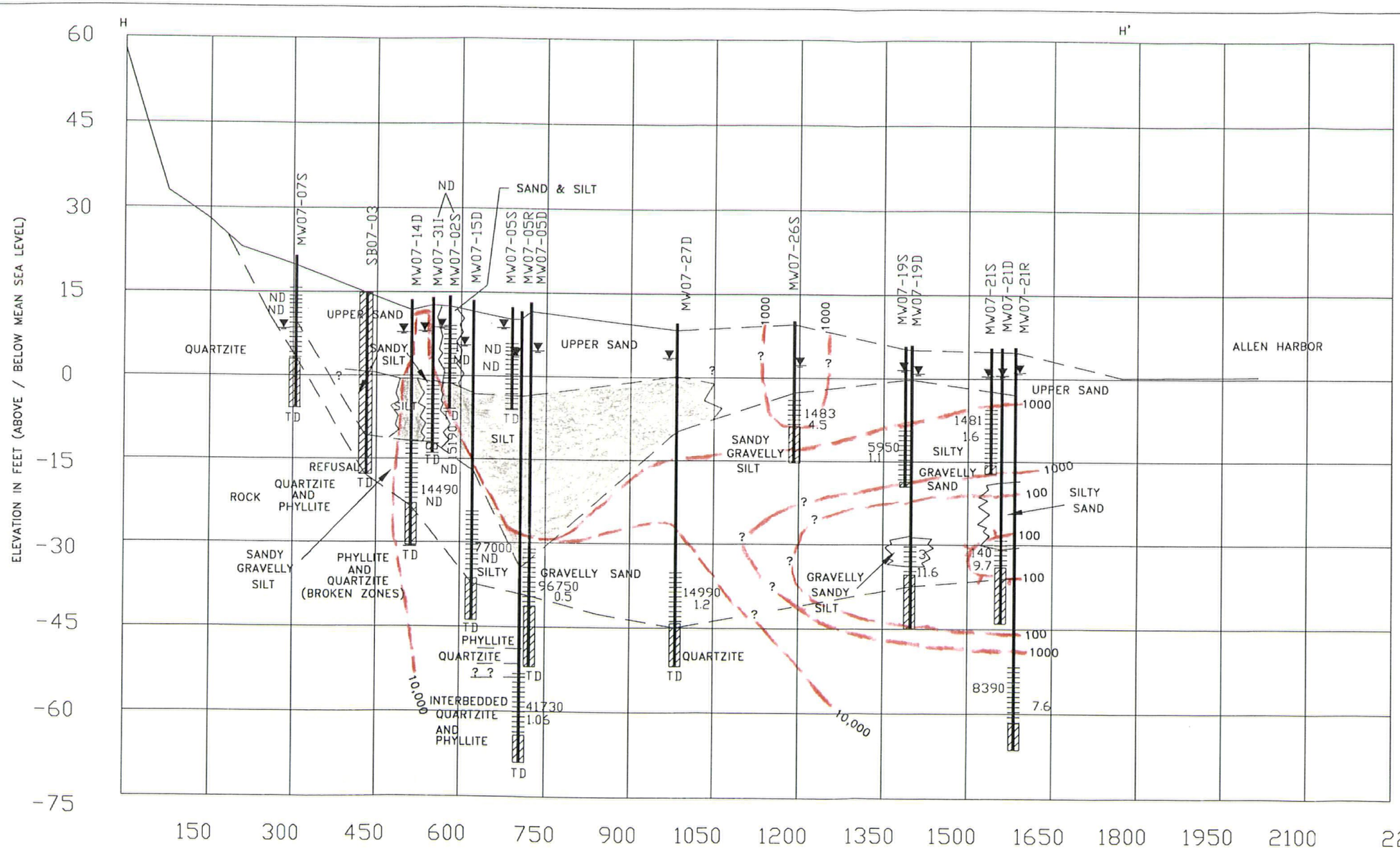
INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINITY DETECTED IN GROUND WATER (DECEMBER 1995 - JANUARY 1996 AND MAY 1996)
GEOLOGIC CROSS SECTIONS F-F' & G-G'
FIGURE 4-41




## LEGEND

| | |
|---|---|
| S | SHALLOW MONITORING WELL |
| D | DEEP MONITORING WELL |
| R | ROCK MONITORING WELL |
| TD | TOTAL DEPTH |
| ▼ | WATER LEVEL(1-17-96 MID) |
| | SCREENED INTERVAL OF MONITORING WELL |
| | BENTONITE SEALED BOREHOLE |
| ND | NOT DETECTED |
| 10,000 | INTERPRETIVE TOTAL CHLOR. VOC (ug/L) |
| 44 | TOTAL CHLORINATED VOC (ug/L) |
| 1.2 | SALINITY (ppt) |

NOTES: 1) HORIZONTAL DISTANCE MEASURED TO LEFT WELL OF PAIRS; CENTER WELL OF CLUSTERS

2) THE SUBSURFACE SECTIONS SHOWN REPRESENT OUR EVALUATION OF THE MOST PROBABLE CONDITIONS BASED UPON INTERPRETATION OF PRESENTLY AVAILABLE DATA, SOME VARIATIONS FROM THESE CONDITIONS MUST BE EXPECTED.

3) TOTAL VOC IS THE SUM OF DETECTED: PCA; PCE; 1,1,2-TCA; TCE; 1,2-DCA; 1,2-DCE; 1,1-DCE; VINYL CHLORIDE; CHLOROMETHANE; CHLOROFORM.

4) MW07-5D FROM TRC LOG
0-7.3 PHYLLITE
7.3-10 QUARTZITE
51.5' BGS

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INTERPRETIVE TOTAL CHLORINATED VOC PLUME WITH SALINTIY DETECTED IN GROUND WATER (DECEMBER 1995-JANUARY 1996 AND MAY 1996)) GEOLOGIC CROSS SECTION H-H'

FIGURE 4-42

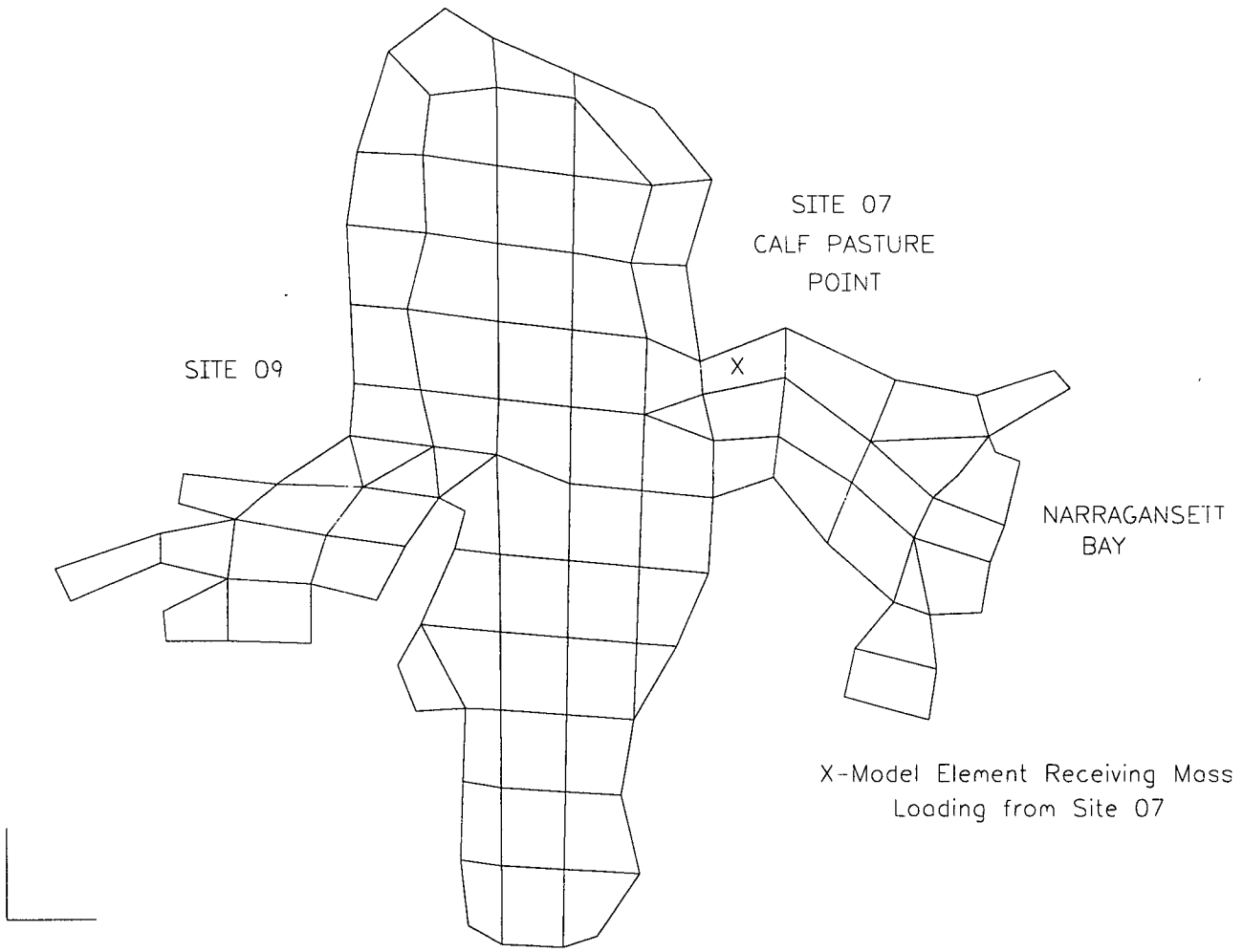


FIGURE 5-1 FINITE ELEMENT GRID USED FOR THE RMA-2 SURFACE WATER MODEL OF ALLEN HARBOR, SCALE: 1 IN = 200 M

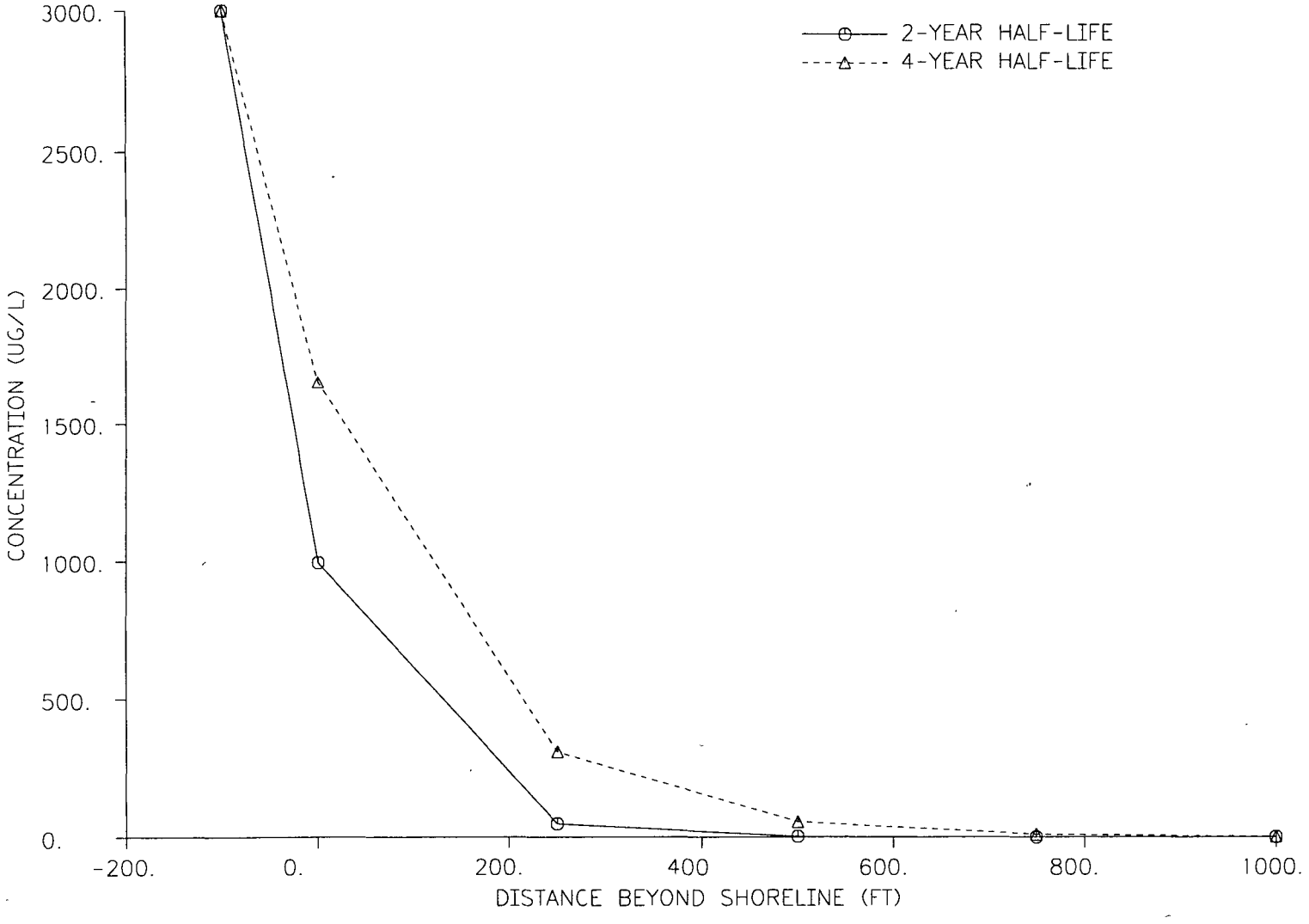


FIGURE 5-2 PREDICTED TCE GROUND-WATER CONCENTRATION BEYOND THE ENTRANCE CHANNEL SHORELINE, DEEP WELLS (TILL UNIT)

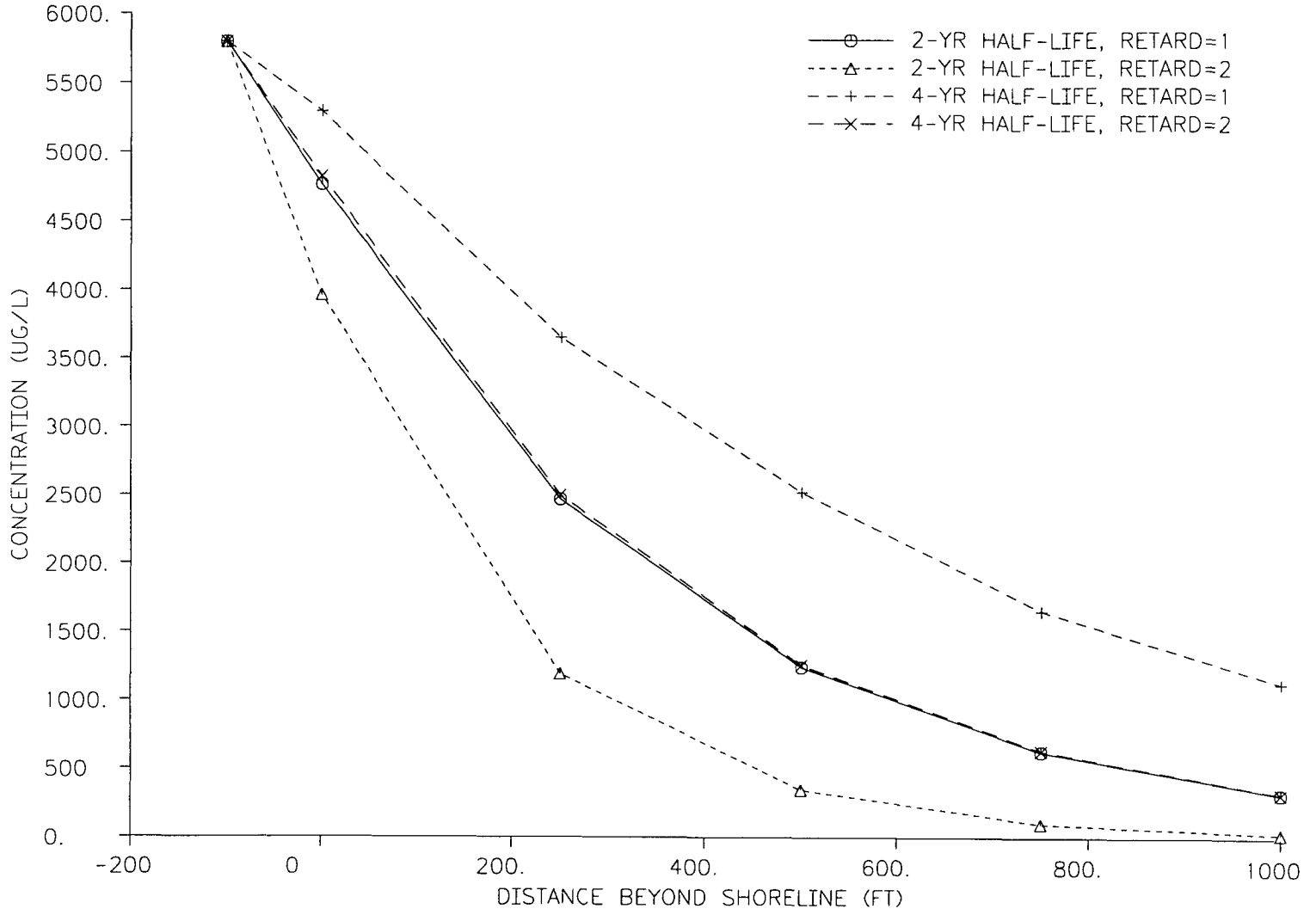


FIGURE 5-3 PREDICTED TCE GROUND-WATER CONCENTRATION BEYOND THE ENTRANCE CHANNEL SHORELINE, ROCK WELLS (BEDROCK UNIT)
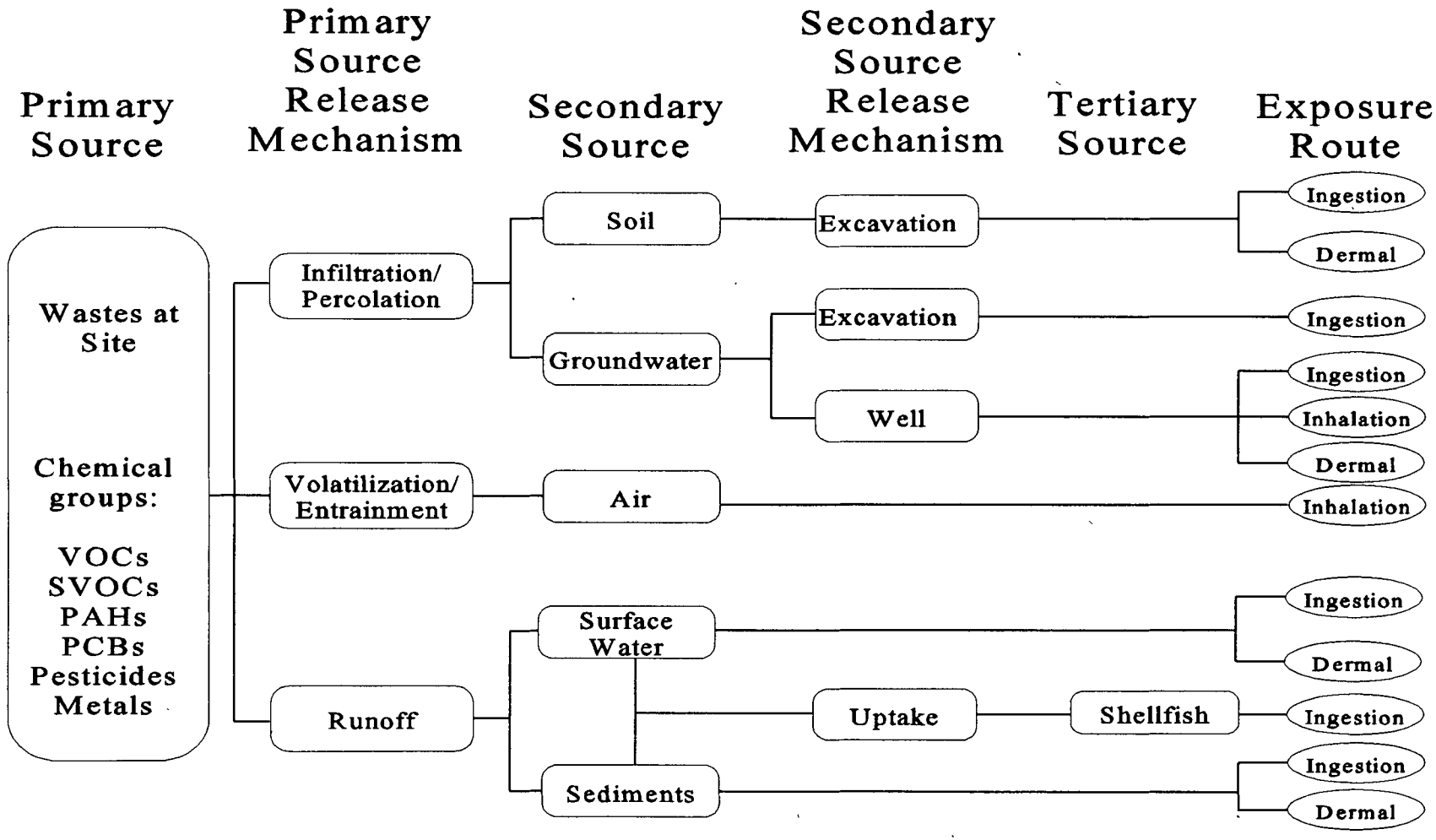
**Figure 6-1. Conceptual Site Model for NCBC Davisville Site 07**