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Massachusetts Military Reservation

RECORD OF DECISION
AREA OF CONTAMINATION FS-17
and
AREA OF CONTAMINATION FS-19
FINAL

October 1999

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RECORD OF DECISION
AREA OF CONTAMINATION FS-17
AND
AREA OF CONTAMINATION FS-19

MASSACHUSETTS MILITARY RESERVATION
CAPE COD, MASSACHUSETTS

October 1999

CONTENTS

LIST OF FIGURES v

LIST OF TABLES v

ACRONYMS AND ABBREVIATIONS xiii

1. DECLARATION 1-1
   1.1 SITE NAMES AND LOCATIONS 1-1
   1.2 STATEMENT OF BASIS AND PURPOSE 1-1
   1.3 ASSESSMENT OF AOC FS-17 AND AOC FS-19 1-1
   1.4 DESCRIPTION OF THE SELECTED REMEDY FOR AOC FS-17 AND AOC FS-19 1-1
   1.5 STATUTORY DETERMINATIONS FOR AOC FS-17 AND AOC FS-19 1-2
   1.6 SIGNATURE AND SUPPORT AGENCY ACCEPTANCE 1-2

2. DECISION SUMMARY 2-1
   2.1 SITE NAME, LOCATION, AND DESCRIPTION 2-1
   2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES 2-3
      2.2.1 MMR and Site History 2-3
      2.2.2 AOC FS-17 Site History and Investigation History 2-3
         2.2.2.1 Site Investigation 2-3
         2.2.2.2 Sump Removal Action Program 2-4
         2.2.2.3 Remedial Investigation 2-4
         2.2.2.4 Fuel Systems Upgrade 2-4
         2.2.2.5 Drainage Structure Removal Program 2-4
      2.2.3 AOC FS-19 Site History and Investigation History 2-5
         2.2.3.1 Army Environmental Hygiene Agency Investigation 2-5
         2.2.3.2 Site Investigation 2-5
         2.2.3.3 Remedial Investigation 2-6
      2.2.4 History of Enforcement Activities 2-6
   2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION 2-7
   2.4 SCOPE AND ROLE OF RESPONSE ACTION 2-8
   2.5 SITE CHARACTERISTICS 2-8
      2.5.1 AOC FS-17 Potential Sources 2-8
      2.5.2 AOC FS-17 Surface Soil Contamination 2-9
      2.5.3 AOC FS-17 Subsurface Soil Contamination 2-10
      2.5.4 AOC FS-17 Groundwater 2-11
      2.5.5 AOC FS-17 Completed Removal Actions 2-13
      2.5.6 AOC FS-19 Potential Sources 2-14
      2.5.7 AOC FS-19 Surface Soil Contamination 2-14
      2.5.8 AOC FS-19 Subsurface Soil Contamination 2-14
      2.5.9 AOC FS-19 Groundwater 2-15

2.5.10 AOC FS-19 Completed Removal Actions 2-17
2.6 SUMMARY OF SITE RISKS FOR AOC FS-17 AND AOC FS-19 2-17
2.6.1 Human Health PRA for AOC FS-17 2-17
2.6.1.1 Contaminant Identification 2-18
2.6.1.2 Exposure Assessment 2-18
2.6.1.3 Toxicity Assessment 2-19
2.6.1.4 Human Health Risk Characterization 2-20
2.6.2 Ecological PRA for AOC FS-17 2-22
2.6.2.1 Contaminant Identification 2-22
2.6.2.2 Exposure Assessment 2-23
2.6.2.3 Risk Characterization 2-32
2.6.3 Conclusions for Human Health and Ecological Risk for AOC 17 2-41
2.6.4 Human Health PRA for AOC FS-19 2-41
2.6.4.1 Contaminant Identification 2-41
2.6.4.2 Exposure Assessment 2-42
2.6.4.3 Toxicity Assessment 2-43
2.6.4.4 Risk Characterization 2-43
2.6.5 Ecological PRA for AOC FS-19 2-45
2.6.5.1 Contaminant Identification 2-45
2.6.5.2 Exposure Assessment 2-45
2.6.5.3 Risk Characterization 2-53
2.6.6 Conclusions for Human Health and Ecological Risk for AOC FS-19 2-59
2.7 DESCRIPTION OF NO FURTHER ACTION ALTERNATIVE 2-59
2.8 DOCUMENTATION OF NO SIGNIFICANT CHANGES 2-59

3. RESPONSIVENESS SUMMARY 3-1
3.1 OVERVIEW 3-1
3.2 BACKGROUND AND COMMUNITY INVOLVEMENT 3-1
3.3 SUMMARY OF COMMENTS RECEIVED AND RESPONSE TO THOSE COMMENTS 3-2
3.4 NO FURTHER ACTION DECISION CONCERNS 3-2

4. STATE ROLE 4-1

5. REFERENCES 5-1

APPENDIX A: FIGURES
APPENDIX B: TABLES
APPENDIX C: RESPONSIVENESS SUMMARY
APPENDIX D: TRANSCRIPT OF PUBLIC HEARING
APPENDIX E: MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION LETTER OF CONCURRENCE
APPENDIX F: CLOSURE REPORTS
APPENDIX G: 1999 LABORATORY DATA SHEETS

LIST OF FIGURES
(Appendix A)

2.1 Location Map Massachusetts Military Reservation
2.2 AOC FS-17 Site and Nearby Land Use Characteristics
2.3 AOC FS-19 Site and Nearby Land Use Characteristics
2.4 AOC FS-17 Map of Site Features
2.5 AOC FS-19 Map of Site Features
2.6 Summary of Analytes Detected in Structures and Surface Soil AOC FS-17
2.7 CLP TCL and TAL Surface Soil Analyses Summary AOC FS-17
2.7a Field Exploration Locations
2.8 Summary of Analytes Detected in Subsurface Soil AOC FS-17
2.9 CLP TCL and TAL Subsurface Soil Analysis Summary AOC FS-17
2.10 Summary of Analytes Detected in Groundwater AOC FS-17
2.11 CLP TCL and TAL Groundwater Analysis Summary AOC FS-17
2.12 Summary of Analytes Detected in Soil AOC FS-19
2.13 Surface Soil Contamination Map AOC FS-19
2.14 8' – 12' Subsurface Soil Contamination Map AOC FS-19
2.15 15' – 17' Subsurface Soil Contamination Map AOC FS-19
2.16 24' – 27' Subsurface Soil Contamination Map AOC FS-19
2.17 Summary of Analytes Detected in Groundwater AOC Fs-19
2.18 Groundwater Contamination Map AOC FS-19

LIST OF TABLES
(Appendix B)

2-1 Summary Of Analytes Detected In Surface Soil Study Area FS-17
2-2 Summary Of Surface Soil Clip Results AOC FS-17
2-3 Summary Of Geoprobe Screening and Confirmation Analyses AOC FS-17
2-4 Summary Of Analytes Detected In Subsurface Soil Study Area FS-17
2-5 Phase I Sump Removal Action Program FS-27
2-6 Summary Of Surface Soil CLP Results AOC FS-17
2-7 Summary Of Analytes Detected In Groundwater Study Area FS-17
2-8 Analytical Results For Unfiltered Metals In Groundwater AOC FS-17; Analytical Results For Filtered Metals In Groundwater AOC FS-17
2-8a Groundwater Analytical Results Of 1999 For FS-17
2-9 Summary Of Analytes Detected In Surface Soil Study Area FS-19
2-10 Summary Of Surface Soil CLP Results AOC FS-19
2-11 Summary Of Analytes Detected In Subsurface Soil Study Area FS-19
2-12 CLP Results For Test Borings TB-5 And TB-6 AOC FS-19
2-13 Summary Of Analytes Detected In Groundwater Study Area FS-19

2-13a	Analytical Results For Unfiltered Metals In Groundwater AOC FS-19; Analytical Results For Filtered Metals In Groundwater AOC FS-19; Summary Of Groundwater CLP Results (Organics) AOC FS-19
2-13b	Groundwater Analytical Results Of 1999 For FS-19
2-14	Selection Of COCs For Surface Soils – Human Health AOC FS-17
2-15	Selection OF COCs FOR Subsurface Soils – Human Health AOC FS-17
2-16	Selection of COCs for Groundwater – Human Health Total and Dissolved Inorganics Concentrations AOC FS-17
2-17	Identification of COPCs for Surface Water – Human Health Based on Groundwater Concentrations AOC FS-17
2-18	Exposure Scenarios, Exposure Equations, and Exposure Assumptions Used to Estimate Human Health Risks AOC FS-17
2-19	Reference Doses (RfDs) and Cancer Slope Factors (CSFs) for Site Contaminants of Concern AOC FS-17
2-20	Equation of Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation, and Dermal Pathways Utility Workers, Current Use Maximum Soil Concentrations FS-17
2-21	Equation of Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Utility Workers, Future Use Maximum Soil Concentrations FS-17
2-22	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Utility Workers, Current Use Mean Soil Concentrations FS-17
2-23	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Utility Workers, Future Use Mean Soil Concentrations FS-17
2-24	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Child Trespasser, Current and Future Use Maximum Concentrations FS-17
2-25	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Child Trespasser, Current and Future Use Mean Concentrations FS-17
2-26	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Dermal and Inhalation Pathways Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone) Maximum Concentrations FS-17
2-27	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Dermal and Inhalation Pathways Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone) Mean Concentrations FS-17
2-28	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Residential (7 years-Adult), Future Use, Onsite (Outside Security Zone) Maximum Soil Concentrations FS-17
2-29	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Residential (7 years-Adult), Future Use, Onsite (Outside Security Zone) Mean Soil Concentrations FS-17

2-30 Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Maximum Groundwater Concentrations – Organics – Total Inorganics FS-17
2-31 Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Maximum Groundwater Concentrations – Organics – Dissolved Inorganics FS-17
2-32 Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Mean Groundwater Concentrations – Organics – Total Inorganics FS-17
2-33 Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Mean Groundwater Concentrations – Organics –Dissolved Inorganics FS-17
2-33a Summary of Risks and Hazard Quotients AOC FS-17
2-34 Selection of Contaminants of Ecological Concern for Surface Soils
2-35 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil White-footed Mouse AOC FS-17
2-36 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil White-footed Mouse AOC FS-17
2-37 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Meadow Vole AOC FS-17
2-38 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Meadow Vole AOC FS-17
2-39 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-17
2-40 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-17
2-41 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Red Fox AOC FS-17
2-42 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Red Fox AOC FS-17
2-43 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Upland Sandpiper AOC FS-17
2-44 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Upland Sandpiper AOC FS-17
2-45 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Grasshopper Sparrow AOC FS-17
2-46 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Grasshopper Sparrow AOC FS-17
2-47 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Harrier AOC FS-17

2-48 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Harrier AOC FS-17
2-49 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Short-eared Owl AOC FS-17
2-50 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Short-eared Owl AOC FS-17
2-51 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Cardinal AOC FS-17
2-52 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Cardinal AOC FS-17
2-53 Terrestrial Vegetation Risk Characterization Maximum Surface Soil Concentrations AOC FS-17
2-54 Terrestrial Vegetation Risk Characterization Mean Surface Soil Concentrations AOC FS-17
2-55 Aquatic Risk Characterization – Maximum Concentrations AOC FS-17
2-56 Aquatic Risk Characterization – Mean Concentrations AOC FS-17
2-57 Adjusted Benchmarks Terrestrial Model Receptors Mammals AOC FS-17
2-58 Adjusted Benchmarks Terrestrial Model Receptors Birds AOC FS-17
2-59 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil White-footed Mouse AOC FS-17
2-60 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil White-footed Mouse AOC FS-17
2-61 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Meadow Vole AOC FS-17
2-62 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Meadow Vole AOC FS-17
2-63 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-17
2-64 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-17
2-65 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Red Fox AOC FS-17
2-66 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Red Fox AOC FS-17
2-67 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Upland Sandpiper AOC FS-17
2-68 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Upland Sandpiper AOC FS-17
2-69 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Grasshopper Sparrow AOC FS-17
2-70 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Grasshopper Sparrow AOC FS-17
2-71 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Harrier AOC FS-17

2-72 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Harrier AOC FS-17
2-73 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Short-eared Owl AOC FS-17
2-74 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Short-eared Owl AOC FS-17
2-75 Calculation of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Cardinal AOC FS-17
2-76 Calculation of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Cardinal AOC FS-17
2-77 Terrestrial Vegetation Risk Characterization MMR Maximum Background Soil Concentrations AOC FS-17
2-78 Aquatic Risk Characterization MMR Maximum Background Groundwater Concentrations AOC FS-17
2-79 Selection of COCs for Surface Soils – Human Health AOC FS-19
2-80 Selection of COCs for Test Boring Subsurface Soils Human Health AOC FS-19
2-81 Selection of COCs for Groundwater – Human Health AOC FS-19
2-82 Identification of COPCs for Surface Water – Human Health Base on Groundwater Concentrations Total Inorganics Concentrations AOC FS-19
2-83 Exposure Scenarios, Exposure Equations, and Exposure Assumptions Used to Estimate Human Health Risks AOC FS-19
2-84 Reference Doses (RfDs) and Cancer Slope Factors (CSFs) for Site Contaminants of Concern AOC FS-19
2-85 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Utility Workers, Current and Future Use Maximum Soil Concentrations FS-19
2-86 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Utility Workers, Current and Future Use Mean Soil Concentrations FS-19
2-87 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Child Trespasser, Current and Future Use Maximum Concentrations FS-19
2-88 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Child Trespasser, Current and Future Use Mean Concentrations FS-19
2-89 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Dermal and Inhalation Pathways Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone) Maximum Concentrations FS-19
2-90 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Dermal and Inhalation Pathways Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone) Mean Concentrations FS-19
2-91 Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Residential (7yrs. – Adult), Future Use, Onsite (Outside Security Zone) Maximum Soil Concentrations FS-19

2-92	Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Maximum Groundwater Concentrations – Total Inorganics FS-19
2-93	Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Maximum Groundwater Concentrations –Dissolved Inorganics FS-19
2-93a	Summary of Risks and Hazard Quotients, AOC FS-19 Study Area
2-94	Equation for Deriving Risk/Hazard Quotient for Soils for Human Health Ingestion, Inhalation and Dermal Pathways Resident (7yrs.-Adult), Future Use, Onsite (Outside Security Zone) Mean Soil Concentrations FS-19
2-95	Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Mean Groundwater Concentrations –Total Inorganics FS-19
2-96	Equation for Deriving Risk/Hazard Quotient for Groundwater for Human Health Ingestion, Inhalation and Dermal Pathways Adult Resident, Future Use, Onsite/Offsite Mean Groundwater Concentrations –Dissolved Inorganics FS-19
2-97	Terrestrial Vegetation Risk Characterization MMR Maximum Background Soil Concentrations AOC FS-19
2-98	Contaminants of Ecological Concern in Surface Soils for Food Chain Receptors AOC FS-19
2-99	Selection of Contaminants of Ecological Concern for Groundwater AOC FS-19
2-100	Summary of Data for Surface Soils
2-101	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Meadow Vole AOC FS-19
2-102	Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Meadow Vole AOC FS-19
2-103	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil White-footed Mouse AOC FS-19
2-104	Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil White-footed Mouse AOC FS-19
2-105	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-19
2-106	Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-19
2-107	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Upland Sandpiper AOC FS-19
2-108	Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Upland Sandpiper AOC FS-19
2-109	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Cardinal AOC FS-19
2-110	Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Cardinal AOC FS-19
2-111	Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Grasshopper Sparrow AOC FS-19

2-112 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Grasshopper Sparrow AOC FS-19
2-113 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Northern Harrier AOC FS-19
2-114 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Northern Harrier AOC FS-19
2-115 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Short-eared Owl AOC FS-19
2-116 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Short-eared Owl AOC FS-19
2-117 Ecological Exposure Dose for Food Chain Receptors Maximum Concentrations Surface Soil Red Fox AOC FS-19
2-118 Ecological Exposure Dose for Food Chain Receptors Mean Concentrations Surface Soil Red Fox AOC FS-19
2-119 Terrestrial Vegetation Risk Characterization Maximum Soil Concentrations FS-19
2-120 Terrestrial Vegetation Risk Characterization Mean Soil Concentrations FS-19
2-121 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Meadow Vole AOC FS-19
2-122 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Meadow Vole AOC FS-19
2-123 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil White-footed Mouse AOC FS-19
2-124 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil White-footed Mouse AOC FS-19
2-125 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-19
2-126 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Short-tailed Shrew AOC FS-19
2-127 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Upland Sandpiper AOC FS-19
2-128 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Upland Sandpiper AOC FS-19
2-129 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Cardinal AOC FS-19
2-130 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Cardinal AOC FS-19
2-131 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Grasshopper Sparrow AOC FS-19
2-132 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Grasshopper Sparrow AOC FS-19
2-133 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Northern Harrier AOC FS-19
2-134 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Northern Harrier AOC FS-19

2-135 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Short-eared Owl AOC FS-19
2-136 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Short-eared Owl AOC FS-19
2-137 Calculations of Hazard Index for Food Chain Receptors Maximum Concentrations Surface Soil Red Fox AOC FS-19
2-138 Calculations of Hazard Index for Food Chain Receptors Mean Concentrations Surface Soil Red Fox AOC FS-19
2-139 Aquatic Risk Characterization – Maximum Concentrations AOC FS-19
2-140 Aquatic Risk Characterization – Mean Concentrations AOC FS-19

ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
AEHA	Army Environmental Hygiene Agency
AFCEE	Air Force Center for Environmental Excellence
AOC	Area of Contamination
AWQC	Ambient Water Quality Criteria
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CPF	cancer potency factor
CPT	current product tank
CSF	Cancer Slope Factor
CRQL	Contract-Required Quantitation Limit
DDT	dichlorodiphenyltrichloroethane
dL	deciliter
DOD	Department of Defense
DPDO	Defense Property Disposal Office
DSRP	Drainage Structure Removal Program
EDB	ethylene dibromide
FFA	Federal Facility Agreement
FSUP	Fuel System Upgrade Program
GTE	General Telephone and Electronics
HAZWRAP	Hazardous Waste Remedial Actions Program
HEC	hazard equivalent concentration
HI	Hazard Index
HQ	Hazard Quotient
IEUBK	Integrated Exposure Uptake Biokinetic (model)
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LOAEL	lowest observed adverse effect level

MADEP	Massachusetts Department of Environmental Protection
MATC	maximum acceptable toxicant concentration
MMR	Massachusetts Military Reservation
μg/kg	microgram per kilogram
μg/L	microgram per liter
mg/kg	milligram per kilogram
MOGAS	motor gasoline
MW	monitoring well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGB	National Guard Bureau
NOAEL	no observed adverse effects level
NPL	National Priorities List
PAH	polycyclic aromatic hydrocarbons
PAT	Process Action Team
PCB	polychlorinated biphenyl
PRA	Preliminary Risk Assessment
PRE	Preliminary Risk Evaluation
RAH	Risk Assessment Handbook
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	site investigation
SRAP	Sump Removal Action Program
SVOC	semivolatile organic compound
TEAC	Technical Environmental Affairs Committee
TIC	tentatively identified compound
TPH	total petroleum hydrocarbons
USAF	U.S. Air Force
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
VPH/EPH	volatile petroleum hydrocarbon/extractable petroleum hydrocarbon
VOC	volatile organic compound

1. DECLARATION

1.1 SITE NAMES AND LOCATIONS

Areas of Contamination
Fuel Spill No. 17 (FS-17)
Fuel Spill No. 19 (FS-19)
Otis Air National Guard [U.S. Air Force (USAF)]
Falmouth, Massachusetts

1.2 STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedial actions at Area of Contamination (AOC) FS-17 and AOC FS-19 at the Massachusetts Military Reservation (MMR) in Barnstable County, Falmouth, Massachusetts, hereinafter referred to as AOC FS-17 and AOC FS-19. These remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 U.S. Code §§ 9601 et seq., and to the extent practicable the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as amended, 40 *Code of Federal Regulations* (CFR) Part 300. The Director, Air Force Center for Environmental Excellence (AFCEE), and the Director of the Office of Site Remediation and Restoration, U.S. Environmental Protection Agency (USEPA) New England have been delegated the authority to approve this ROD.

This ROD is based on the Administrative Record for AOC FS-17 and AOC FS-19 that has been developed in accordance with Section 113(k) of CERCLA. The Administrative Record is available for public review at the AFCEE Installation Restoration Program (IRP) Office at MMR and at the Falmouth Public Library, Falmouth, Massachusetts.

The Commonwealth of Massachusetts concurs with the selected remedies for AOC FS-17 and AOC FS-19. Appendix E of this ROD contains a copy of the letter of concurrence.

1.3 ASSESSMENT OF AOC FS-17 AND AOC FS-19

Actual or threatened releases of hazardous substances from AOC FS-17 and AOC FS-19 do not present a current or potential threat to public health, welfare, or the environment.

1.4 DESCRIPTION OF THE SELECTED REMEDY FOR AOC FS-17 AND AOC FS-19

The selected remedy for AOC FS-17 and AOC FS-19 is No Further Action. No further action is necessary to ensure protection of human health and the environment. A 5-year review

of AOC FS-17 and AOC FS-19 is not necessary. Removal actions completed at the AOC source areas removed soils containing hazardous substances that may have posed risk. The removal actions did not include the implementation of engineering or institutional controls to prevent exposure from hazardous substances because all hazardous substances were removed from the AOCs.

1.5 STATUTORY DETERMINATIONS FOR AOC FS-17 AND AOC FS-19

The selected remedy is consistent with CERCLA and, to the extent practicable, the NCP; is protective of human health and the environment; and is cost effective. Because the selected remedy is No Further Action, there are no applicable or relevant and appropriate requirements with which to comply.

1.6 SIGNATURE AND SUPPORT AGENCY ACCEPTANCE

The foregoing represents the decision for No Further Action at AOC FS-17 and AOC FS-19 by AFCEE and the USEPA with the concurrence of the Massachusetts Department of Environmental Protection (MADEP).

Concur and recommend for immediate implementation:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE

Gary M. Erickson, P.E.
Director

29 NOV 1999
Date

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Patricia L. Meaney
Director, Office of Site Remediation and Restoration
U.S. Environmental Protection Agency, New England

12/10/99
Date

2. DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

This ROD addresses past releases of contaminants to surface soil, subsurface soil, and groundwater at the AOC FS-17 and AOC FS-19 sites at MMR.

MMR is a National Priorities List (NPL) site under CERCLA. MMR is located on western Cape Cod in Barnstable County, Massachusetts, approximately 60 miles south of Boston and immediately southeast of the Cape Cod Canal. It occupies approximately 22,000 acres within the towns of Bourne, Falmouth, Mashpee, and Sandwich (Figure 2-1, Appendix A). MMR is organized into four functional areas: Range Maneuver and Impact Area, Cantonment Area, Massachusetts National Cemetery, and Cape Cod Air Force Station. AOC FS-17 occupies approximately 1 acre and is west of Frank Perkins Road and north of Connery Avenue (Figure 2-2, Appendix A). AOC FS-19 occupies less than 1 acre and is located east of Weaver Road and north of Lee Road (Figure 2-3, Appendix A).

Currently, AOC FS-17 consists of one concrete slab, relic asphalt, and unvegetated soil. All other surface and subsurface structures have been removed. Before the removal actions and the Fuel System Upgrade Program (FSUP), the site included two underground storage tanks (USTs), a pump house with pumps, a vehicle maintenance area with two vehicle maintenance pits, a leaching well, a French drain, and a dry well. AOC FS-17 is located just west of Frank Perkins Road and the former main base landfill (AOC LF-1) in the south-central portion of MMR. The study area is a former World War II motor pool approximately 1 acre in size (Figure 2-2, Appendix A). A pitch pine and scrub oak forest that serves as a wildlife habitat borders the study area on three sides. At the time of the 1993/1994 remedial investigation (RI), prominent features of the paved and gravel-covered study area included an intact structure (Building 3693), a pump island for both gasoline and diesel fuel, and two building foundations (former Buildings 3692 and 3694). Two USTs were associated with the pump island as current product tanks [(CPT)-104 and -105]. Also at the time of the 1993/1994 RI, the concrete foundation of former Building 3694 contained two vehicle repair bays (structure codes 23CDXX4 and 23CDXX5) that were connected to a leaching well (structure code 23CDXX1) adjacent to the western edge of the building slab. A drainage structure referred to as a French drain (structure code 23CDXX2) also existed north of former Building 3694. A dry well (structure code 23CDXX3) located approximately 10 feet northeast of Building 3693 was identified during Phase I of the Sump Removal Action Program (SRAP) [renamed the Drainage Structure Removal Program (DSRP)]. Pertinent features identified during the AOC FS-17 RI are depicted in Figure 2-4 (Appendix A). Subsequent to the completion of the RI, the USTs and pump island, along with Building 3693, were removed as part of the MMR Fuel System Upgrade Program. Additional structures removed subsequent to the completion of the RI included the foundations of former Buildings 3692 and 3694 (along with the vehicle repair bays 23CDXX4 and 23CDXX5), the leaching well (23CDXX1), the dry well (23CDXX3), and the French drain (23CDXX2). These structures were removed as part of the MMR DSRP.

AOC FS-19 is presently an undeveloped area of grass-covered soil. All structures have been removed from the site. Before such removal, the site included six USTs, a pump house with pumps, and a small building.

AOC FS-19 is located in the south-central portion of MMR in the township of Sandwich at the intersection of Lee and Weaver Roads. The nearest major cross street is Turpentine Street. The AOC FS-19 site is approximately 60 feet long and 40 feet wide (0.05 acre) in the vicinity of the former USTs and 20 feet long and 40 feet wide (0.02 acre) in the vicinity of former Building 3493. The long axis of the site is parallel to Weaver Road and is oriented approximately northeast-southwest. It is bounded on the west by Weaver Road, on the north by an open undeveloped area, on the east by the General Telephone and Electronics (GTE) Complex and wooded areas, and on the south by Lee Road. At the time of the RI, the site was open and undeveloped and was covered by grass. No buildings are present on the site. A chain link fence separates the site from the GTE Complex. Access to AOC FS-19 is unrestricted.

The northern portion of the site is the location of former Building 3493 (Area I). Two asphalt driveways leading from Weaver Road to the GTE Complex are situated on either side of the site of former Building 3493. A small wooded area exists between the southernmost of the two driveways and the former Building 3493 location. Near the corner formed by Weaver Road and the northernmost of the two driveways is an area of disturbed earth that approximately matches the dimensions of the footprint of former Building 3493 given in reports (ABB-ES 1993). The area measures approximately 20 feet by 40 feet. The long axis of the area is oriented parallel to the driveway. The area appears to have been excavated. It is assumed that this was the location of former Building 3493 and that the excavation was performed to remove the concrete foundation slab.

The southern portion of the site is the location of the former vehicle fueling facility and UST excavation (Area II). No visible surface expression of any fueling station structures is present. The approximate location of the former UST excavation was obtained from a previous report (ABB-ES 1993) that stated the outline of the UST excavation was visible, that it measured approximately 60 feet by 40 feet, and that monitoring well MW-1 was placed in the center of the UST excavation area. During CDM Federal Program's RI activities, a concrete slab measuring approximately 60 feet long and 15 feet wide was encountered at approximately 1 foot below ground surface (bgs) adjacent to the UST excavation. The concrete foundation was oriented parallel to Weaver Road and is believed to be a remnant of the former control building that was located east of the USTs. In addition, several chunks of asphalt were encountered at approximately 6 inches to 1 foot bgs over an area of approximately 1,200 square feet immediately west and southwest of the southern end of the concrete slab. No other evidence of artificial structures was encountered during RI activities.

A more complete description of MMR and AOC FS-17 and AOC FS-19 can be found in the Phase I Records Search prepared by E.C. Jordan in 1986 and in *Remedial Investigation Report, Area of Concern FS-17* (HAZWRAP 1998a) and *Remedial Investigation Report, Area of Concern FS-19* (HAZWRAP 1998b). These reports are available for review at the main libraries

in the towns of Bourne, Falmouth, Mashpee, and Sandwich and at the U.S. Coast Guard library at MMR.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

This section provides background information on the sites' history and enforcement actions taken to date. Factors addressed include a history of activities at the site, the history of site investigations, and the history of CERCLA enforcement activities.

2.2.1 MMR and Site History

Although military activity began at MMR as early as 1911, most operations occurred after 1935 and consisted of two general types: (1) mechanized Army training and maneuvers and (2) military aircraft operations, maintenance, and support. Intensive Army activity occurred with the onset of World War II and continued through demobilization following the war (1940–1946). Major aircraft operations were associated with surveillance and air defense aircraft and occurred from 1955 to 1970. Although aircraft operations continue today, the greatest potential for release of contaminants to the environment was between 1940 and 1970. Tenants at MMR include, or have included, the U.S. Coast Guard, Army National Guard (Camp Edwards), USAF, Air National Guard (Otis Air National Guard Base), Veterans Administration National Cemetery, U.S. Marine Corps, U.S. Department of Agriculture, and the Commonwealth of Massachusetts. The USAF managed MMR until 1973, when base management was transferred to the Air National Guard.

2.2.2 AOC FS-17 Site History and Investigation History

AOC FS-17 was used as a motor pool and vehicle maintenance facility during World War II until 1946 (E.C. Jordan 1986). At the time of the 1993/1994 RI field investigations, the main concerns at AOC FS-17 were the disposal of wastes associated with vehicle repairs that took place in former Building 3694 and possible leaks from the two USTs, which were installed in 1941 (E.C. Jordan 1986). CPT-104 contained motor gasoline (MOGAS) and CPT-105 contained diesel fuel at the time of the 1986 investigation; no other portions of the facility were active.

Multiple investigations have occurred at AOC FS-17. Those actions included a site investigation (SI), a part of the SRAP, and an RI. In addition, investigations were incorporated into the FSUP and undertaken as part of removal actions at AOC FS-17. The following subsections outline these activities. A summary of the results of these activities is contained in Section 2.5.

2.2.2.1 Site Investigation

An SI was performed in 1989 to assess the presence or absence of contamination resulting from fuel spills or leaks associated with the fuel pump island, USTs, and vehicle repair bays.

The SI consisted of a soil-gas survey, a limited soil investigation, sampling of the leaching well and French drain, and a limited groundwater investigation. Samples were submitted for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides and polychlorinated biphenyls (PCBs), metals, and total petroleum hydrocarbons (TPH). Refer to *Priority 2 and 3 Study Areas Site Investigation* (ABB-ES 1993) for detailed information (including figures and tables) regarding the SI results. Section 2.5 of this ROD provides a summary of SI findings.

2.2.2.2 Sump Removal Action Program

As part of the SRAP, ABB Environmental Services, Inc. (ABB-ES) investigated the leaching well and the French drain during 1989. TerraProbes were advanced beneath the leaching well and French drain. Samples were submitted to a mobile laboratory for VOCs, SVOCs, pesticides/PCBs, TPH, and five metals (lead, copper, zinc, arsenic, and chromium). Refer to *Sump Removal Action Program, Phase I Sump Investigation Program, Work Completion Report* (ABB-ES 1992) for detailed information (including figures and tables) regarding the SRAP results. Section 2.5 of this ROD provides a summary of SRAP findings.

2.2.2.3 Remedial Investigation

An RI was performed at AOC FS-17 in several phases extending from 1993 through 1998. The phases included the initial RI, a supplemental RI, and volatile petroleum hydrocarbon/extractable petroleum hydrocarbon (VPH/EPH) sampling. Samples were submitted for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Refer to *Remedial Investigation Report Area of Contamination FS-17* (HAZWRAP 1998a) for detailed information (including figures and tables) regarding the RI results. A summary of the findings of the RI is included in Section 2.5 of this ROD. Analytical results from the RI are included in Appendix B, and figures depicting RI findings are included in Appendix A.

2.2.2.4 Fuel Systems Upgrade

The USTs CPT-104 and CPT-105 present at AOC FS-17 were removed from the site in 1994, along with Building 3693 and the fuel pump island, as part of the MMR FSUP. Soils were screened for VOCs. A summary of the findings is included in Section 2.5 of this ROD.

2.2.2.5 Drainage Structure Removal Program

The French drain (23CDXX2), leaching well (23CDXX1), dry well (23CDXX3), vehicle maintenance bays (23CDXX4 and 23CDXX5), and foundations of former Buildings 3692 and 3694 were removed as part of the MMR DSRP. Removals occurred in 1996. Samples were submitted to mobile and fixed-base laboratories for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Refer to the drainage structure closure reports (Jacobs 1996) for detailed information (including figures and tables) regarding the closure results. A summary of the findings of the DSRP is included in Section 2.5 of this ROD.

2.2.3 AOC FS-19 Site History and Investigation History

AOC FS-19 was operated as a World War II leaded motor gas (MOGAS) fuel storage and transfer point. In 1941, six 10,000-gallon USTs (AT-24 through AT-29) were installed at AOC FS-19 and were used to store MOGAS until 1958. Between 1958 and 1965, the six USTs were used for the storage of hazardous waste. AOC FS-19 was referred to as hazardous waste storage area HWSS-2 during that period. The quantity of fuel and the type and quantity of waste that may have leaked from the USTs or spilled is unknown (E.C. Jordan 1986).

In 1965, subsequent to the establishment of the Defense Property Disposal Office (DPDO), the six USTs were reportedly emptied and the fill pipes capped. In May 1985, it was determined that the tanks still contained approximately 7,000 gallons of a waste fuel/solvent mixture. The DPDO issued a contract for the removal of the waste mixture and tanks, and in October 1989 the USTs were removed.

Base personnel reported that Building 3493, located northeast of the UST location, was used for the storage of hazardous waste.

Multiple investigations have occurred at AOC FS-19. Those actions included an Army Environmental Hygiene Agency (AEHA) investigation, SI, a part of the SRAP (renamed the DSRP in 1993), and an RI. The following sections outline these activities. A summary of the results of these activities is contained in Section 2.5.

Two removal actions have been completed at FS-19. In both instances, structures were removed and soils excavated. In both instances, soil samples collected from the excavations document that soils at the limits of the excavation did not contain contaminants of concern in concentrations posing an unacceptable risk to human health or the environment.

2.2.3.1 Army Environmental Hygiene Agency Investigation

The U.S. Army's AEHA installed a single monitoring well downgradient of the tank pit area to determine the presence or absence of groundwater contamination in 1985. A water sample was submitted for VOC analysis. Additional samples collected in 1986 were submitted for VOC and metals analyses. A summary of the results of the AEHA investigation is contained in Section 2.5.

2.2.3.2 Site Investigation

An SI was performed in 1989 and 1990 in two phases to assess the presence or absence of contamination resulting from fuel spills or leaks associated with the USTs. The SI included the installation of monitoring wells, groundwater sampling, advancement of soil borings, and soil sampling. Samples were submitted for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Refer to *Priority 2 and 3 Study Areas Site Investigation* (ABB-ES 1993) for detailed information

(including figures and tables) regarding the SI results. Section 2.5 of this ROD provides a summary of SI findings.

2.2.3.3 Remedial Investigation

An RI was performed at AOC FS-19 in two phases extending from 1993 through 1998. The phases included the initial RI and VPH/EPH sampling. The RI included the installation of monitoring wells, soil borings, and surface soil sampling. Samples were submitted for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Refer to *Remedial Investigation Report Area of Concern FS-19* (HAZWRAP 1998b) for detailed information (including figures and tables) regarding the RI results. A summary of the findings of the RI is included in Section 2.5 of this ROD. Analytical results from the RI are included in Appendix B, and the figures depicting RI findings are included in Appendix A.

2.2.4 History of Enforcement Activities

On November 21, 1989, USEPA placed MMR on the NPL under CERCLA, as amended by SARA, to evaluate and implement response actions to clean up past releases of hazardous substances, pollutants, and contaminants. A Federal Facility Agreement (FFA) between the National Guard Bureau (NGB) [representing all Department of Defense (DOD) agencies owning or controlling property at MMR], the U.S. Coast Guard, and USEPA was signed in 1991 and amended in 1996 and 1997. The FFA established a procedural framework for ensuring that appropriate response actions are implemented and required the NGB to take the lead in cleanup activities at MMR, including AOC FS-17 and AOC FS-19, which are considered subsites to the entire installation. AFCEE currently provides on-site management and direction for the execution of cleanup activities at MMR in accordance with the FFA.

In response to environmental contamination at MMR, DOD implemented its multiphase IRP at MMR to identify and evaluate problems associated with past releases of hazardous substances. The IRP parallels the USEPA CERCLA investigation and cleanup process. The NGB, and subsequently AFCEE, followed USEPA guidelines for most IRP investigations performed between 1986 and 1989 and for all investigations performed since 1989.

In 1986, an extensive records search and review of available soil and groundwater data identified 73 areas at MMR as having potential for contamination (E.C. Jordan Co. 1986). Six additional areas were later identified through anonymous sources and unrelated base construction projects, thus bringing the total to 79.

The Proposed Plan (MMR 1998) for remedial action for the contaminant source areas at AOC FS-17 and AOC FS-19 was issued in December 1998 for public comment. Technical comments presented during the public comment period are included in the Administrative Record and are provided in a transcript of the Public Hearing (Appendix D). The Responsiveness Summary contains a summary of these comments and AFCEE's responses and

describes how these comments affected the remedial action decision for each AOC (Appendix C).

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The NGB and AFCEE have held regular informational meetings, issued fact sheets, and held public meetings and public hearings to keep the community and other interested parties informed of the activities at AOC FS-17 and AOC FS-19.

Throughout MMR's history, community concern and involvement have been high. The NGB, AFCEE, USEPA, and MADEP have kept the community and other interested parties apprised of site activities through informational meetings, fact sheets, news releases, public hearings, and Technical Environmental Affairs Committee (TEAC) meetings. TEAC was organized in 1986 by the NGB to provide a forum for public input on the MMR response activities. Membership in TEAC comprised USEPA, MADEP, and representatives from local, regional, and state groups. Beginning with the October 7, 1992 TEAC meeting, members of the public could attend these bimonthly meetings. TEAC ceased meeting in 1996 and is no longer in existence.

During May 1991, an MMR Community Relations Plan was released that outlined a program to address community concerns and keep citizens informed and involved in the remediation process at MMR. In July 1994, and again in December 1996, an updated draft Community Relations Plan (AFCEE 1996) was issued to incorporate concerns and feedback provided by the community and to document changes in AFCEE policy such as the public attendance at TEAC meetings.

In October 1993, a senior management board was created to advise AFCEE on IRP activities. A person from each of the four towns surrounding MMR is among the Board members, along with the regulatory agencies and the Adjutant General's Office of the Commonwealth of Massachusetts. Process Action Teams (PATs) were also created to address specific issues at MMR; these issues including plume containment, long-range water supplies, innovative technologies, and public information. PATs have representation from the community, local business, regulatory agencies, and AFCEE.

Advertisements announcing the public meeting and Public Hearing were published in the *Falmouth and Mashpee Enterprises* on November 27, 1998; the *Cape Cod Times* on November 27, 1998; and the *Bourne and Sandwich Enterprises* on November 27, 1998. Before the start of the comment period, AFCEE made the RI reports, the Feasibility Study, and Proposed Plan available for public review at the U.S. Coast Guard library at MMR and at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts. The Proposed Plan has also been made part the Administrative Record available for public review at the AFCEE IRP office at MMR and at the Falmouth Public Library.

From December 9, 1998, to January 8, 1999, AFCEE held a 30-day public comment period to accept public comments on the No Further Action decision presented for AOC FS-17 and

AOC FS-19 in the Proposed Plan. On December 8, 1998, AFCEE held a public meeting at the Otis Theater, Building 5219, Turpentine Road, MMR, to present and discuss the Proposed Plan. On January 5, 1999, AFCEE held a Public Hearing at Building 330, MMR, to accept verbal comments on the Proposed Plan. No representatives of the general public attended the Public Meeting for AOC FS-17 and AOC FS-19. No representatives of the general public attended the Public Hearing for AOC FS-17 and AOC FS-19. Because no public attended the Public Hearing, no comments were received from the public at the hearing. No formal comments were submitted by the public through any venue during the public comment period extending from December 9, 1998, through January 8, 1999. A transcript of the January 5, 1999, public hearing is included in Appendix D. AFCEE's responses to the comments received at the hearing and during the public comment period are included in Appendix C.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The selected action for AOC FS-17 and AOC FS-19 is No Further Action. No further action is necessary to ensure protection of human health and the environment. Risks from all pathways at AOC FS-17 and AOC FS-19 are not sufficient to warrant remedial action. A 5-year review of AOC FS-17 and AOC FS-19 is not necessary. Removal actions completed at the AOC source areas removed soils containing hazardous substances that may have posed risk. The removal actions did not include the implementation of engineering or institutional controls to prevent exposure from hazardous substances because all potential hazardous substances were removed from the AOCs.

2.5 SITE CHARACTERISTICS

The sites, AOC FS-17 and AOC FS-19, do not include any known continuing sources of contamination. Potential sources at AOC FS-17 and AOC FS-19 have been demolished and/or removed. No activities continue on AOC FS-17 and AOC FS-19 that generate contamination. Potentially contaminated media (soils) associated with the potential sources of contamination have been removed. Several contaminants were detected in groundwater during sampling episodes in 1990 and 1991; however, the concentrations detected pose no unacceptable risk to human health. Data presented in the investigative reports for AOC FS-17 and AOC FS-19 substantiate the statements regarding the absence of contamination at levels that might negatively impact human health or the environment.

2.5.1 AOC FS-17 Potential Sources

Investigations at AOC FS-17 were based on site conceptual models that considered potential sources of contamination and the media impacted by those potential sources. As identified in the RIs for FS-17, potential sources included USTs (CPT-104 and CPT-105), the pump system associated with the USTs, leaching well 23CDXX1, French drain 23CDXX2, dry well 23CDXX3, vehicle maintenance pits 23CDXX4 and 23CDXX5, and disposal of hazardous

substances to the ground surface during maintenance activities. Identified potential sources are depicted on Figure 2-4 (Appendix A).

All potential sources of contamination have been removed. Drainage structures 23CDXX1 through 23CDXX5 were removed during the DSRP. Soils associated with the structures were also removed. Clean closure was accomplished at all five drainage structures. Closure reports are contained in Appendix F. The foundation of Building 3694 was also demolished during the DSRP. The USTs CPT-104 and CPT-105 were removed during the FSUP. The removal was a clean closure. The tank removal report is also included in Appendix F. Maintenance activities no longer occur at AOC FS-17. Consequently, there is no continuing potential source of contamination from maintenance activities.

2.5.2 AOC FS-17 Surface Soil Contamination

Investigative activities at AOC FS-17 that addressed surface soils were the SI and the RI. Figure 2-6 (Appendix A) presents SI surface soil results. Figure 2-7 (Appendix A) presents RI surface soil results. Tables 2-1 and 2-2 (Appendix B) contain analytical results from the SI and RI, respectively.

Three surface soil samples were collected during the SI and the locations are shown on Figure 2-6. Analytical results of surface soils from the SI did not quantify VOCs above Contract-Required Quantitation Limits (CRQLs). Low levels of a single SVOC bis(2-ethylhexyl)phthalate (BEHP) were detected in surface soils. The maximum detected concentration of the BEHP was 0.12J milligrams per kilogram (mg/kg). No pesticides/PCBs compounds were detected. Several inorganic compounds were quantified at levels above the MMR background. Refer to Figure 2-5 (Appendix A) for those elements. Xylene was detected in sediments from leaching well 23CDXX1 at a concentration of 51 mg/kg. SVOCs were detected within the sediments contained in 23CDXX1. The maximum quantified detection of an SVOC in 23CDXX1 was 220 mg/kg of 2-methylnapthalene. Note that structure 23CDXX1 was removed. Several inorganic compounds were detected at levels above the MMR background. Refer to Figure 2-5 (Appendix A) for these elements.

An additional 18 surface soil samples were collected and analyzed during the RI. Samples were collected during the initial RI and the supplemental VPH/EPH sampling activity and their locations are shown on Figure 2-7A. Thirteen surface soil samples were collected at Geoprobe boring locations GP-1 through GP-13 and submitted for on-site analyses. Analyses included selected VOCs, ethylene dibromide (EDB), and TPH. Table 2-3 (Appendix B) presents Geoprobe results. No VOCs or EDB were quantified. TPH values up to 7070 mg/kg were detected.

Five surface soil samples were collected and analyzed with CLP methods at an off-site laboratory. Figure 2-7 (Appendix A) depicts these surface soil sampling locations. Samples were submitted for VOC, SVOC, pesticides/PCBs, metals, and TPH analyses. VOCs, SVOCs, pesticides/PCBs, and metals were quantified at low levels at locations SS-1 through SS-4.

Elevated levels of organic compounds were quantified at SS-5. The xylene concentration at SS-5 was 25,000 micrograms per liter (μg/L). Multiple SVOCs were quantified from sample SS-5. The maximum concentration of an SVOC at SS-5 was napthalene at 48,000 μg/L. TPH values at SS-5 were 37,000 mg/kg by method 418.1 and 19,000 mg/kg for the diesel fraction of TPH.

The elevated levels of TPH, VOCs, and SVOCs at SS-5 suggested possible surface spills of fuels. However, the extent of contamination in the area of SS-5 was minimal. Additionally, after the RI, removal activities were performed at AOC FS-17 in the areas at which the elevated levels of fuel compounds were identified. Because there had been a removal in the area of SS-5, there was a question as to whether contamination associated with SS-5 still existed at FS-17. A TPH sampling event using MADEP VPH/EPH analytical methods was performed in the area of SS-5 to document the presence or absence of TPH. Additional areas at FS-17 were also resampled for TPH using the VPH/EPH methodology. Samples collected from SS-5, as well as from other areas, did not contain elevated levels of TPH, VOCs, or SVOCs. Total TPH, composed of VPH/EPH fractions, was below Massachusetts SI/GW soil cleanup action limits. VOCs and SVOCs were all below action limits and generally below detection limits.

Data collected during the various investigative and removal activities at AOC FS-17 indicate that minimal or no contamination is present in surface soil at AOC FS-17.

2.5.3 AOC FS-17 Subsurface Soil Contamination

Investigative activities at AOC FS-17 that addressed subsurface soils were the SI, the SRAP, the DSRP, the FSUP, and the RI. Figure 2-8 (Appendix A) presents SI subsurface soil results. Figure 2-9 (Appendix A) presents RI subsurface soil results. Table 2-4 contains results from the SI, Table 2-5 results from the SRAP, and Table 2-6 from the RI (Appendix B). DSRP and SRAP results are contained in Appendix F. During both actions, all soils with detected levels of contamination were removed.

Eight subsurface soil samples were collected and analyzed during SI activities. Primary areas in which samples were collected included the USTs, French drain 23CDXX2, and Building 3693. Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Low levels of VOCs and SVOCs were detected. No pesticides/PCBs were quantified. Multiple levels of metals were quantified at levels above background. Maximum detected VOCs of interest in subsurface soil included tetrachloroethene at 0.055J micrograms per kilogram (μg/kg) and acetone at 0.099J μg/L. The maximum level of SVOCs of interest was 2-methylnapthalene at 46 μg/kg. Details of the metals are shown on Figure 2-8 (Appendix A). Most elevated metals were associated with French drain 23CDXX2. Note that French drain 23CDXX 2 was removed during the DSRP. The closure achieved clean closure.

The SRAP included the collection of 28 subsurface soil samples in the areas of leaching well 23CDXX1 and French drain 23CDXX2. Geoprobes were advanced along the sides of the structure and also angled beneath the structures. Samples were analyzed in a field laboratory for selected VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Low levels of VOCs, SVOCs, a

pesticide, and metals were quantified. The maximum detections of a VOC, SVOC, and pesticides were, respectively, benzene at 15 μg/kg, BEHP at 2 mg/kg, and chlordane at 610 μg/kg. Maximum concentrations of TPH were 660 mg/kg.

RI subsurface soil sampling included 28 Geoprobe samples collected at locations shown on Figure 2-7a and 13 samples collected with split spoons at locations shown on Figure 2-9.

Geoprobe samples were analyzed for selected VOCs, EDB, and TPH. Samples collected with split spoons were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Low levels of VOCs and SVOCs were quantified in subsurface soils. No pesticides or PCBs were detected in subsurface soils. Moderate levels of TPH and metals were detected. Maximum levels of VOCs included trichloroethene at 1.8 μg/kg, xylene at 2.0 μg/kg, and acetone at 170 μg/kg. Maximum TPH in subsurface soils was 1,250 mg/kg at MW-6.1 Four metals exceeded background levels.

Soils in sidewalls and the bottoms of excavations from removal actions conducted during the DSRP were tested for selected VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Samples from the excavations of 23CDXX1, 23CDXX2, 23CDXX3, 23CDXX4, and 23CDXX5 were below action levels for all tested compounds. All excavations achieved clean closure as a result of the clean samples from the excavation.

The elevated levels of TPH at MW-6 suggested possible fuel contamination. Based on elevated TPH values, a VPH/EPH sampling event was conducted at AOC FS-17 in 1998. Subsurface soil samples collected from MW-6, as well as from other areas, did not contain elevated levels of TPH, VOCs, or SVOCs. Total TPH, composed of EPH and VPH fractions, was below Massachusetts action levels and, in most locations, below quantifiable concentrations. VOCs and SVOCs were all below action limits and generally below detection limits.

Data collected during the various investigative and removal activities at AOC FS-17 indicate that minimal contamination or no contamination is present in subsurface soil at AOC FS-17.

2.5.4 AOC FS-17 Groundwater

Investigative activities at AOC FS-17 that addressed groundwater were the SI, RI, and a supplemental well sampling effort in 1999. Figure 2-10 (Appendix A) presents SI groundwater results. Figure 2-11 (Appendix A) presents RI groundwater results. Table 2-7 (Appendix B) contains results from the SI, and Table 2-8 (Appendix B) contains results from the RI. Table 2-8a contains results of the 1999 sampling event. Negligible groundwater contamination was quantified at AOC FS-17. Laboratory data sheets for the 1999 sampling event are included in Appendix G.

Two wells were installed at AOC FS-17 during the SI. The wells were sampled for VOCs, SVOCs, pesticides/PCBs, and metals. A single low detection of a VOC was quantified. No site-related SVOCs were identified. No pesticides/PCBs were quantified. All metals were below

MMR background levels. Tetrachloroethane (1.0 μg/L) in groundwater from MW-1 was the only detected VOC. A single detection of BEHP (13 μg/L) was found in MW-2. During a second round of sampling, neither compound was present in groundwater samples.

Six wells were installed during the RI activities of 1993/1994. Groundwater samples from the newly installed wells and existing wells were analyzed for VOCs, SVOCs, pesticides/PCBs, EDB, metals, and TPH. No VOCs were detected above state or federal MCLs. Five compounds were detected at low levels, including benzene (MW-4 at 0.2 μg/L) and tetrachloroethylene (5 locations, maximum from MW-1 at 0.5 μg/L). With the exception of the SVOC BEHP at 1J μg/L, no SVOCs were detected in groundwater. No pesticide compound was detected except for one detection in MW-2 at 0.02J μg/L. No PCB compounds were detected in groundwater samples. Eight metals were detected in the unfiltered analysis at concentrations that exceeded MMR background. Only lead, detected at 40 μg/L in MW-2, exceeded Massachusetts MCLs and the federal action limit of 15 μg/L. With respect to dissolved metals analysis, three metals exceeded MMR background; however, only antimony exceeded state or federal MCLs.

Uncertainties about well placements being placed downgradient of all possible sources instigated installation of four additional wells during 1997. The wells were sampled for VOCs, SVOCs, pesticides/PCBs, metals, and VPH/EPH. No VOCs, SVOCs, pesticides/PCBs, or VPH/EPH were detected. All metals were below state and federal MCLs.

The sampling performed during the 1997 event was with a submersible pump. The sampling in years prior to the 1997 sampling event had been with an inertial pump (Wattera). The difference in the metals results from the two events suggested that the detection of metals in the 1993 event was the result of mobilization of colloidal particles and not the presence of metals in groundwater. As a result, existing wells were resampled for metals in 1999. Two metals were detected above background levels in groundwater collected during 1999.

Four wells (MW-1, MW-2, MW-3, and AEHA-9) were resampled in January 1999. Sample collection conformed to low flow sampling methodologies. There were three detections of metals that exceeded MMR background levels, federal MCLs, and state MMCLs. Arsenic was quantified in the duplicate sample from MW-3 at 3.4J μg/L. Thallium was quantified in MW-3 at 7.0J μg/L and in the duplicate sample from MW-3 at 7.9 μg/L. No other samples contained metals above MMR background, MCLs, or MMCLs. Due to the concentration of Thallium detected in MW-3, groundwater from this monitoring well was re-sampled in July 1999, and re-analyzed for Thallium. The Thallium concentration was below laboratory detection limits (2 μg/L). Monitoring Well MW-3 had been sampled in January 1994 as part of the Remedial Investigation, using non-low flow purge and sample techniques. Thallium was not detected above laboratory detection limits (ND<2). The Thallium concentration in nine other groundwater monitoring wells upgradient of MW-3 at FS-17 had not been detected above laboratory detection limits (0.63 - 2.5 μg/L) using the low flow purge and sample method (1997-1999). This pulse of Thallium detected is not indicative a larger, surrounding plume of Thallium contamination.

There are no known sources of Thallium at FS-17. Thallium is a naturally occurring element in soils, which generally sorbs to manganese or iron oxy-hydroxides. Sporadic hits of thallium in groundwater are likely generated by the reductive dissolution of iron and manganese hydroxides that have accumulated trace amounts of natural thallium (AFCEE, 1998). It is likely an intermittent condition that generally subsides with the biodegradation of surrounding organic material in the subsurface. As the aquifer becomes more oxidizing, Thallium should readsorb onto the soil matrix.

The detection of Thallium in groundwater collected from MW-3 in January, 1999, was likely due to a temporary reducing condition which has since stabilized to more oxidizing conditions, as indicated by the lack of Thallium in groundwater detected in MW-3 in July, 1999. Further elevated concentrations of Thallium in groundwater from MW-3 are not anticipated - due in part to the lack of Thallium detected in groundwater collected from wells upgradient of MW-3 (MW-1, MW-2, MW-5, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11).

Data collected during the various investigative activities at AOC FS-17 indicate that minimal or no contamination is present in groundwater at AOC FS-17.

2.5.5 AOC FS-17 Completed Removal Actions

Two removal actions have been completed at FS-17. In both instances, structures were removed and soils excavated. In both instances, soil samples collected from the excavations document that soils at the limits of the excavation did not contain contaminants of concern in concentrations posing an unacceptable risk to human health or the environment.

The first removal action was the removal of USTs CPT-104 and CPT-105. The tanks, the associated dispensing system, and Building 3693 were removed as part of the FSUP conducted on August 8 and 9, 1994. The removal was conducted in accordance with applicable MADEP regulations. No evidence of soil contamination was identified during the removal. Clean closure was documented. Tank pull reports are included in Appendix F.

The French drain (23CDXX2), leaching well (23CDXX1), dry well (23CDXX3), vehicle maintenance bays (23CDXX4 and 23CDXX5), and foundations of former Buildings 3692 and 3694 were removed as part of the DSRP. Samples were submitted to mobile and fixed-base laboratories for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. All soil contamination associated with the drainage structures was removed. Samples collected from the limits of the excavations were clean. DSRP structure-specific reports are contained in Appendix F.

2.5.6 AOC FS-19 Potential Sources

Investigations at AOC FS-19 were based on a site conceptual model that considered potential sources of contamination and the media impacted by those potential sources. As identified in the RI report, potential sources included the tank pit remaining after the removal of six USTs (AT-24 through AT-29) and potential spills at Building 3493. Identified potential sources are depicted on Figure 2-5 (Appendix A).

All potential sources of contamination have been removed. USTs AT-24 through AT-29 were removed in 1989. The only remaining indication of Building 3493 is the foundation. Consequently, there is no continuing potential source of contamination at AOC FS-19.

2.5.7 AOC FS-19 Surface Soil Contamination

Investigative activities at AOC FS-19 that addressed surface soils were the AEHA investigation, SI, and RI. Figure 2-12 (Appendix A) presents SI surface soil results. Figure 2-13 (Appendix A) presents RI surface soil results. Tables 2-9 and 2-10 (Appendix B) contain analytical results from the SI and RI, respectively.

Two surface soil samples were collected at locations shown on Figure 2-12. Analytical results of surface soils from the SI did not quantify VOCs, SVOCs, or pesticides/PCBs above CRQLs. Metals were below the MMR background. TPH was quantified at 64 mg/kg.

Four surface soil samples were collected at locations shown on Figure 2-13. Low concentrations of VOCs, SVOCs, pesticides/PCBs, and TPH were identified in the vicinity of Building 3493. Twelve metals exceeded MMR background. Detections included a single VOC (acetone at 5J μg/kg), low concentrations of SVOCs (total PAHs at 3.8 mg/kg), pesticides (1.16 mg/kg), PCBs (Aroclor-1260 at 0.26 mg/kg), and TPH at 93J mg/kg. Surface soil samples in the tank pit area also contained low levels of VOCs, SVOCs, pesticides/PCBs, and TPH. Maximum detected levels in the tank pit area included VOCs (xylene at 3J μg/kg), SVOCs (total SVOCs 1.1 mg/kg), pesticides (0.43J mg/kg), PCBs (Aroclor-1260 at 0.52J mg/kg), and TPH at 50J mg/kg. Six metals were above MMR maximum background levels.

Data collected during the various investigative activities at AOC FS-19 indicates that minimal or no contamination is present in surface soil at AOC FS-19.

2.5.8 AOC FS-19 Subsurface Soil Contamination

Investigative activities at AOC FS-19 that addressed subsurface soils were the SI and the RI. Figure 2-12 (Appendix A) presents SI subsurface soil results. Figures 2-14 through 2-16 (Appendix A) present RI subsurface soil results. Table 2-11 contains results from the SI and Table 2-12 contains results from the RI (Appendix B). Results from the DSRP are included in Appendix F. During this action, all detected levels of contamination were removed.

Three subsurface soil samples were collected at locations shown on Figure 2-12. All samples were collected in the tank pit area. Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. No VOCs, SVOCs, pesticides/PCBs, or TPH were detected above contract-required quantitation limits. No metals were quantified at levels above background.

RI sampling included 51 Geoprobe subsurface soil samples and 7 samples collected with split spoons. Geoprobe samples were analyzed for selected VOCs, EDB, and TPH. Samples collected with split spoons were analyzed for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. Low levels of VOCs and SVOCs were quantified in subsurface soils. No pesticides or PCBs were detected in subsurface soils. Moderate levels of TPH and metals were detected. Maximum levels of VOCs included trichloroethene at 1.3 μg/kg, xylene at 6.6 μg/kg, toluene at 3.5 μg/kg, and acetone at 170 μg/kg. Maximum TPH in subsurface soils was 2,100 mg/kg at GP-11. Two metals exceeded background levels.

The presence of the elevated levels of TPH suggested possible fuel contamination. Based on elevated TPH values, a VPH/EPH sampling event was conducted at AOC FS-19 in 1998. Subsurface soil samples collected from MW-6, as well as other areas, did not contain elevated levels of TPH, VOCs, or SVOCs. Total TPH, composed of EPH and VPH fractions, was below MADEP S-1/GW-1 action levels and in most instances below quantifiable concentrations. VOCs and SVOCs were all below MADEP S-1/GW-1 action levels and generally below detection limits.

Data collected during the investigative activities at AOC FS-19 indicate that minimal or no contamination is present in subsurface soil at AOC FS-19.

2.5.9 AOC FS-19 Groundwater

Investigative activities at AOC FS-19 that addressed groundwater were the AEHA investigation, the SI, RI, and a supplemental well sampling effort in 1999. The validated analytical results and validation worksheets are included in Appendix F. Figure 2-17 (Appendix A) presents SI groundwater results. Figure 2-18 (Appendix A) presents RI groundwater results. Table 2-13 and Table 2-13a (Appendix B) contain groundwater results from the SI and RI. Table 2-13b contains results from the 1999 sampling event. Appendix G contains laboratory data sheets for the 1999 sampling event. Negligible groundwater contamination was quantified at AOC FS-19.

Initial groundwater investigations began with the AEHA installation of one well in 1985. The well was sampled for VOCs and metals. The well was sampled in 1985 and twice in 1986. Low levels of VOCs and metals were quantified in 1986. Maximum detected VOCs included trichloroethene at 2.9 μg/L and cyclohexane at 3.0 μg/L. Lead was quantified at 5 μg/L.

Two wells were installed at AOC FS-19 during the SI. All site wells were sampled for VOCs, SVOCs, pesticides/PCBs, and metals. Moderate levels of VOCs were quantified. No site-related SVOCs were identified. No pesticides/PCBs were quantified. All but two metals

were below MMR background levels. Maximum VOC detections included trichloroethane at 15J μg/L, trichloroethene at 3.0J μg/L, and dichloroethane at 4.0J μ/L

Two wells were installed during the RI activities of 1993/1994. Groundwater samples from the newly installed wells and existing wells were analyzed for VOCs, SVOCs, pesticides/PCBs, EDB, metals, and TPH. The RI reports duplicate sample from MW-1 as a sample from well MW-1A. No VOCs were detected above state or federal MCLs. Nine compounds were detected at low levels, including benzene (MW-1A at 1.6 μg/L) and xylenes (two locations, maximum total xylenes from MW-1 at 0.5 μg/L), toluene (maximum from MW-1A at 7.6 μg/L), and trimethylbenzenes (maximum total trimethylbenzenes from MW-1A at 5.0 μg/L). With the exception of the SVOC BEHP at 13 μg/L, no SVOCs were detected in groundwater. No pesticide compound was detected except for one detection in MW-2 at 0.02J μg/L. No PCB compounds were detected in groundwater samples. Thirteen metals were detected in the unfiltered analysis that exceeded MMR background. Only lead, detected at 18.5 μg/L in MW-1A, exceeded Massachusetts MCL and federal action limits of 15 μg/L. With respect to dissolved metals analysis, three metals exceeded MMR background; however, only barium exceeded state or federal MCLs.

The sampling performed during the 1993/1994 RI used an inertial pump (Wattera). There was concern that the metals detections were the result of mobilization of colloidal particles and not the presence of metals in groundwater. As a result, existing wells were resampled for metals in 1999.

Five wells (MW-1, MW-2, MW-3, MW-4, and AEHA-9) were re-sampled in January 1999 using the low flow sampling methodologies. One well contained one metal at levels exceeding MCLs; groundwater collected from MW-3 had a Thallium concentration of 13.3 μg/L. Due to the concentration of Thallium detected in MW-3, groundwater from this monitoring well was re-sampled in July 1999, and re-analyzed for Thallium. The Thallium concentration was below laboratory detection limits (2 μg/L).

There are no known sources of Thallium at FS-19. Groundwater collected from monitoring wells immediately downgradient of MW-3 (i.e., MW-1, and AEHA-9) did not have Thallium concentration detected above laboratory detection limits using the low flow purge and sample methodology. As detailed in section 2.5.4 (AOC FS-17 Groundwater), the detection of Thallium was likely due to an intermittent reducing condition. As shown by the lack of Thallium downgradient of MW-3, the sporadic hit of Thallium detected likely re-adsorbed to the soil matrix as oxidizing conditions in the aquifer increased.

Data collected during the various investigative activities at AOC FS-19 indicate that minimal or no contamination is present in groundwater at AOC FS-19.

2.5.10 AOC FS-19 Completed Removal Actions

Two removal actions have been completed at FS-19. In both instances, structures were removed and soils excavated. In both instances, soil samples collected from the excavations document that soils at the limits of the excavation did not contain contaminants of concern in concentrations posing an unacceptable risk to human health or the environment.

The first removal action was the removal of six USTs, AT-24 through AT-29. The tanks were removed under the action performed by the DPDO in 1989. Details of the removal are not available. However, samples collected during the RI document that there are no remaining contaminants in sufficient quantity to negatively impact human health or the environment.

The drainage structure 08CDXX1 was removed as part of the MMR DSRP. Samples were submitted to mobile and fixed-base laboratories for VOCs, SVOCs, pesticides/PCBs, metals, and TPH. All soil contamination associated with the drainage structures was removed. Samples collected from the limits of the excavations were clean. DSRP structure-specific reports are contained in Appendix F.

2.6 SUMMARY OF SITE RISKS FOR AOC FS-17 AND AOC FS-19

The risk assessment process for AOC FS-17 and AOC FS-19 consisted of Preliminary Risk Assessments (PRAs), which were conducted for their respective RI reports. The PRAs fulfill the CERCLA requirement that a baseline risk assessment be performed to establish whether remediation is necessary to protect human health and the environment.

The goal of the PRAs was to provide an estimate of the baseline risks (i.e., risks in the absence of remediation of contamination posing an unacceptable risk at AOC FS-17 and AOC FS-19). Baseline risks are estimated to determine whether a current or potential threat to human health or the environment exists that warrants remedial action (USEPA 1990).

The PRAs were conducted in accordance with federal CERCLA human health and ecological risk assessment guidance, requirements set forth by the state of Massachusetts, and site-specific guidance provided in *Risk Assessment Handbook, Volumes I and II* [Risk Assessment Handbook (RAH)] (Automated Sciences Group, Inc., 1994).

2.6.1 Human Health PRA for AOC FS-17

The objectives of the PRA at AOC FS-17 were to characterize the potential current and future risks to human health from exposure to contaminants at AOC FS-17. For risk assessment purposes, the AOC was defined by the contaminated soil and groundwater that may serve as exposure media for human receptors. Because portions of AOC FS-17 are accessible to workers and trespassers, one of the objectives of the risk assessment was to evaluate human health risks to these groups from existing contamination. The evaluation includes current risks as well as

future potential risks, assuming the area becomes residential. To fully characterize human health risks at AOC FS-17, a Tier III analysis was performed. The steps of the Tier III analysis include contaminant identification, exposure assessment, toxicity assessment, and risk characterization. These components of the PRA are summarized below.

2.6.1.1 Contaminant Identification

Fixed-base laboratory analytical results from the final RI report (HAZWRAP 1998a) for surface soil, subsurface soil test borings, and groundwater were evaluated in the PRA. An evaluation of duplicate sample results, blank results, detection limits, detection frequency, and tentatively identified compounds (TICs) was performed, and a comparison against inorganic background concentrations was made to establish the usability of these data for the PRA.

Because a preliminary risk evaluation (PRE) was not previously conducted for AOC FS-17, contaminants of concern (COCs) were not previously identified. COCs were selected in the PRA by comparing maximum detected chemical concentrations to risk equivalent concentrations (RECs) and hazard equivalent concentrations (HECs) provided for contaminant screening in Appendix F of the RAH. Maximum detected chemical concentrations exceeding RECs/HECs were considered COCs. Essential macronutrients (calcium, magnesium, potassium, and sodium) were not considered COCs. Chemical constituents with a detection frequency of less than 5% for data sets greater than 20 samples were not considered COCs. A comparison of chemical concentrations to MMR background was also conducted, but no COCs were eliminated based on this comparison.

Based on the COC selection process, environmental media of concern at AOC FS-17 are surface soil, subsurface soil, groundwater, and surface waters receiving groundwater discharge from the AOC. The human health COCs selected for further evaluation are summarized in Tables 2-14 through 2-17. Potential COCs for human health receptors for surface water were identified based on a conservative comparison of groundwater concentrations detected at AOC FS-17 to risk-based concentrations for surface water presented in the RAH. These potential COCs are not quantitatively evaluated in the PRA because the actual concentrations that may discharge from groundwater into Long or Red Brook Ponds have not been predicted.

2.6.1.2 Exposure Assessment

Potentially exposed populations and potential exposure pathways were identified based on current and future land use. For current land use, construction workers and trespassers (children and adults) were identified. For future land use, construction workers, trespassers (children and adults), and residents (children and adults) were identified.

Potential exposure pathways identified for construction workers under current and future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,

- ingestion of surface soil, and
- dermal contact with surface soil.

Trespassers at AOC FS-17 may include children and adolescents who play on the site and adults who walk across the site. Potential exposure pathways identified for trespassers (children and adults) under current and future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,
- ingestion of surface soil, and
- dermal contact with surface soil.

Potential exposure pathways identified for residents (children and adults) under future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,
- ingestion of surface soil,
- dermal contact with surface soil,
- ingestion of groundwater,
- dermal contact with groundwater,
- ingestion of surface waters receiving groundwater discharge from AOC FS-17, and
- dermal contact with surface waters receiving groundwater discharge from AOC FS-17.

Potential exposures were quantified using standardized dose equations based on USEPA risk assessment guidance and integrated into the equations used to estimate risk for AOC FS-17. The risk estimates are based on both maximum and mean detected COC concentrations. Table 2-18 summarizes the equations and parameters used to estimate site risks.

2.6.1.3 Toxicity Assessment

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. USEPA has performed the toxicity assessment for numerous chemicals and has made available the resulting toxicity information and toxicity values, which have undergone extensive peer review. The toxicity values consist of cancer potency factors (CPFs), and noncarcinogenic reference doses (RfDs). These toxicity values are evaluated and selected for use in the PRA based on their applicability to the specific COCs and types of exposures identified at AOC FS-17.

CPFs have been developed by USEPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CPFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen in mg/kg-day to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the

conservative estimate of the risks calculated from the CPF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. CPFs are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied.

RfDs have been developed by USEPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

Table 2-19 provides a summary of the CPFs and RfDs used to estimate risk for the AOC FS-17 PRA.

2.6.1.4 Human Health Risk Characterization

In the risk characterization, excess lifetime cancer risk and noncarcinogenic hazard potential are estimated based on the chemical dose received by a receptor and the toxicity per unit intake of the contaminant.

Excess lifetime cancer risks are determined by multiplying the intake level with the CPF. These risks are probabilities that are generally expressed in scientific notation (e.g., 1×10^{-6} or 1E-6). An excess lifetime cancer risk of 1×10^{-6} indicates that as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the Hazard Quotient (HQ) (or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's RfD). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the Hazard Index (HI) can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Tables 2-20 through 2-33 provide the risk/HQ/HI estimates (based on current and future land use) for the exposure scenarios evaluated in the PRA. For each exposure scenario, chemical-specific carcinogenic risks and noncarcinogenic HQs were estimated for the exposure pathways associated with each contaminated medium. Total pathway carcinogenic risks and noncarcinogenic HIs (e.g., risks from all COCs for dermal contact) were also calculated. Total

carcinogenic risks and noncarcinogenic HIs (e.g., risks from all COCs and all exposure pathways combined) were also calculated.

Cancer and noncancer risks are summarized for AOC FS-17 in Table 2-33a. For the current exposure scenario for utility workers and child trespassers, cancer risk estimates for soil are 8.5E-08 and 2.6E-07, respectively, for arithmetic mean concentrations and 1.1E-07 and 3.4E-07, respectively, for maximum concentrations. These risk levels are below USEPA's target risk range of 1E-04 to 1E-06. As measured by HIs, noncancer effects are not likely, as HIs are less than 1.0.

For the future exposure scenario for utility workers and child trespasser, cancer risk estimates are below USEPA's target risk range, and HIs are less than the target level of 1.

For the future child and adult resident exposure scenario, cancer risk estimates for soils and groundwater are between 3.2E-06 and 3.1E-05 for arithmetic mean concentrations and between 4.7E-06 and 5.7E-05 for the maximum concentrations. The total lifetime cancer risks (child and adult) are 4.2E-05 (organics and total inorganics) and 1.9E-05 (organics and dissolved inorganics) for arithmetic mean concentrations, and 7.2E-05 (organics and total inorganics) and 2.6E-05 (organic and dissolved inorganics) for maximum concentrations. The risks are within USEPA's target risk range of 1E-04 to 1E-06.

As measured by HIs (all less than 1.0), future potential noncancer effects are not likely based on maximum and mean concentrations using organics and dissolved inorganics concentrations and mean concentrations using organics and total inorganics concentrations for groundwater (HIs less than 1.0). However, the HI for maximum concentrations based on organics and total inorganics concentrations in groundwater were greater than 1.0 (2.2). This exceedance is attributed to metals (including manganese, arsenic, and antimony) in groundwater. The maximum concentrations of manganese and arsenic exceeded the MMR maximum background concentration.

Neither a Cancer Slope Factor (CSF) nor an RfD is available for lead. Instead, blood lead concentrations have been accepted as the best measure of exposure. USEPA has developed the Integrated Exposure Uptake (IEUBK) model to assess chronic, noncancer exposures of children to lead. Version 0.99d of the model was used to evaluate exposures of child residents (in the future) to lead (USEPA 1994).

The maximum and arithmetic average of lead concentrations in surface soil and groundwater were used as the input for the model. Default values for lead in air and dietary ingestion were used. No contribution from paint ingestion was included. A blood lead level of 10 μg of lead/deciliters of blood (dL) is the benchmark to evaluate lead exposure. Based on the above assumptions and the maximum soil concentration (769 mg/kg) and maximum groundwater concentration (40 μg/L), projected blood lead levels of 65.98% of the exposed child population (0 to 84 months of age) would be expected to be below 10 μg/dL and 34.02% would be expected to be above 10 μg/dL. Based on the average soil concentration (229 mg/kg) and average

groundwater concentration (9.1 μg/L), projected blood lead levels of 96.95% of the exposed child population (0 to 84 months of age) would be expected to be below 10 μg/dL and 3.05% would be expected to be above 10 μg/dL.

The major uncertainties associated with the risk assessment are listed below.

- Toxicity values were available for most detected compounds. However, toxicity values were not available for several detected compounds, including 2-methylnaphthalene, endrin ketone, iron, copper, and cobalt. Therefore, these compounds were not evaluated in the risk assessment because of lack of toxicity information. The exclusion of these compounds adds uncertainty to the risk evaluation and may result in an underestimation of risks, but it is not likely to affect the validity of recommendations significantly.

- The toxicity values and exposure factors that are used in risk assessments result in very conservative estimates of risk, which may overemphasize the potential adverse effects associated with the site.

- A number of polycyclic aromatic hydrocarbons (PAHs) are present in the soil at AOC FS-17. The source of these compounds may be site related or may be attributed to other artificial and natural sources. However, they were evaluated as part of the risk assessment under the assumption that they are entirely site related. As their presence contributes to the human-health-predicted cancer risk, there is uncertainty related to the contribution of these compounds to actual site risks, and these risks may by overestimated. In addition, the toxicity values used for the carcinogenic PAH compounds are currently under review by various agencies. The toxicity value for the most potent carcinogenic, PAH [benzo(a)pyrene], and toxicity equivalency factors were used as a surrogate for other carcinogenic PAHs. This contributes to the uncertainty of the risks for carcinogenic PAHs, which may be overestimated.

2.6.2 Ecological PRA for AOC FS-17

To fully characterize ecological risks at AOC FS-17, a Tier III analysis was performed. The steps of the Tier III analysis include contaminant identification, exposure assessment, effects assessment, and risk characterization. These components of the PRA are summarized below.

2.6.2.1 Contaminant Identification

Fixed-base laboratory analytical results from the final RI report (HAZWRAP 1998a) for surface soil, subsurface soil test borings, and groundwater were evaluated in the PRA. An evaluation of duplicate sample results, blank results, detection limits, detection frequency, and TICs, and a comparison against inorganic background concentrations were performed to establish the usability of these data for the PRA.

Because a PRE was not conducted for AOC FS-17, COCs were not previously identified. COCs were selected in the PRA by comparing maximum detected chemical concentrations to ecological HECs provided for contaminant screening in Appendix F of the RAH. Maximum detected chemical concentrations exceeding HECs were considered COCs. Essential macronutrients (calcium, magnesium, potassium, and sodium) were not considered COCs. Chemical constituents with a detection frequency of less than 5% for data sets greater than 20 samples were not considered COCs. A comparison of chemical concentrations to MMR background was also conducted, but no COCs were eliminated based on this comparison. Based on the COC selection process, environmental media of concern at AOC FS-17 are surface soil, subsurface soil, groundwater, and surface waters receiving groundwater discharge from the AOC. The ecological COCs selected for further evaluation are summarized in Table 2-34.

2.6.2.2 Exposure Assessment

The purpose of the ecological exposure assessment was to identify and quantify site-specific exposure pathways for representative indicator species identified at AOC FS-17. For the coastal plain pond, pitch pine/scrub oak barren, and sandplain grassland/coastal heathland habitats identified in the PRA, site-specific receptor species were identified based on a survey of the site and surrounding environment conducted during November 1993, January 1994, and September 1995. AOC FS-17 is approximately 1 acre of disturbed open area primarily consisting of compacted soil, gravel, and pavement. Edge community habitats were associated with AOC FS-17 and consisted of the flat open field of AOC FS-17 and forested borders of the AOC consisting of pitch pine and scrub oak at its eastern, western, and northern limits. These areas may have the potential of supporting a greater abundance of wildlife or diversity of species than the open area of AOC FS-17. Based on these findings, there are potential ecological receptors at the limits of AOC FS-17 and they may have contact with on-site surface soil.

Identification of Receptor Species

Receptor species were selected to represent potentially affected organisms belonging to different taxa and trophic levels. The following nine indicator species presented in Appendix P of the RAH were considered representative receptor species that may inhabit AOC FS-17; they were selected for evaluation in the PRA:

- white-footed mouse (*Peromyscus leucopus*),
- meadow vole (*Microtus pennsylvanicus*),
- northern short-tailed shrew (*Blarina brevicauda*),
- red fox (*Vulpes vulpes*),
- upland sandpiper (*Bartramia longicauda*),
- grasshopper sparrow (*Ammodramus savannarum*),
- northern harrier (*Circus cyaneus*),
- short-eared owl (*Asio flammeus*), and
- northern cardinal (*Cardinalis cardinalis*).

Identification of Exposure Pathways

Exposure pathways are the means by which ecological receptors come into contact with contaminated environmental media. Exposure to the environmental COCs can occur through direct contact exposure with contaminated media or indirect exposure via the food chain. Groundwater from AOC FS-17 could potentially discharge to surface water located southwest of Route 28 at the cranberry bogs and Red Brook and Long Ponds. Given that groundwater in this area characteristically sinks as it flows toward discharge points, groundwater from the AOC FS-17 area would be expected to pass beneath water bodies located downgradient. Therefore, these surface water bodies were not evaluated as exposure media in the PRA. However, for purposes of qualitatively estimating risks to pelagic aquatic receptors in surface waters potentially receiving groundwater discharge from AOC FS-17, the groundwater analytical results from AOC FS-17 were evaluated directly.

An exposure pathway consists of an environmental medium (e.g., surface soil) and an ecological receptor (e.g., soil invertebrates, flora, and terrestrial receptors) that may have contact with the medium. Exposure pathways for secondary and tertiary consumers include direct contact with contaminated surface soil and/or indirect food chain transfer of soil contaminants. An exposure pathway is considered potentially complete if the ecological receptor can have contact with contaminants detected in a medium. Three major exposure routes for ecological receptors include ingestion of food and water, inhalation/respiration, and direct contact. Many of the COCs have the potential to bioconcentrate, bioaccumulate, and biomagnify within the food chain (see Appendix J of the RAH). Receptor species may ingest contaminated food items such as insects or vegetation. The ecological receptor's foraging behavior can significantly influence the consumption of contaminated food items. For example, the consumption of prey items such as the white-footed mouse or shrew by higher trophic-level organisms can present a significant indirect exposure pathway that might contribute greatly to the overall exposure of these receptors to site contaminants.

The white-footed mouse is a small, burrowing omnivore. According to dietary information provided in Appendix P of the RAH, its diet is assumed to consist of approximately 80% plant material and 17% invertebrates. Incidental soil ingestion accounts for the remaining 3% of its diet. Therefore, this animal would likely be chronically exposed to soil contaminants directly through incidental soil ingestion, inhalation, and dermal contact and indirectly through ingestion of potentially contaminated food items.

The meadow vole is an herbivore that consumes seeds, grasses, and sedges. This animal might also be exposed to contaminants directly through incidental soil ingestion, inhalation and dermal contact and indirectly through ingestion of potentially contaminated plant matter.

The northern short-tailed shrew is a representative of the insectivore trophic level. The shrew might similarly be directly exposed through dermal contact, incidental soil ingestion, and inhalation and indirectly via the food chain.

Based on its life history, the red fox might be exposed to contaminants primarily through the food chain. If the red fox were to have a den within AOC FS-17, this receptor may also be exposed to COCs through dermal contact and inhalation routes of exposure.

The state-listed endangered upland sandpiper is a ground-nesting bird; therefore, it may be exposed to soil contaminants by means of incidental soil ingestion, inhalation, and dermal exposure. Also, these birds are insectivorous and may further be exposed through their food source as a result of the potential uptake of chemicals by insects.

The grasshopper sparrow, a state species of special concern, is a ground-nesting insectivorous bird and therefore may be exposed to contaminants by means of incidental soil ingestion, inhalation, and dermal exposure, as well as uptake via the food chain of insects.

The northern harrier, a state threatened species, and the short-eared owl are also ground-nesting species. If they nest on-site, they may be exposed to contaminants through dermal and inhalation pathways; however, they may be primarily exposed to soil contaminants through their diet.

The northern cardinal is included because it is an omnivorous bird, and this receptor population is not represented by any state-listed species. This passerine bird would be exposed to chemicals bioaccumulated in plants and invertebrates. While foraging, the cardinal may inadvertently ingest small quantities of soil. The cardinal is not a ground-nesting species and, therefore, exposure by means of dermal absorption and inhalation would likely be limited.

Quantification of Exposure

The purpose of the ecological exposure assessment is to define the exposure concentrations or doses from site-related contaminants that could potentially pose adverse effects to ecological receptors. This includes estimation of doses received through defined routes of exposure.

As previously noted, in assessing the potential ecological risk posed by the hypothetical discharge of groundwater contaminants to surface water, the PRA considered the future potential impact of groundwater on aquatic receptors as it may contribute to future contamination of sediment and surface water. Because groundwater from AOC FS-17 may move downgradient toward Red Brook and Long Ponds, the risks associated with the potential exposure of pelagic aquatic receptors by contaminated groundwater were addressed in the PRA. The potential risk to pelagic aquatic receptors inhabiting these ponds was qualitatively evaluated by comparing the total and dissolved concentrations of individual COCs detected in AOC FS-17 groundwater to the aquatic benchmark values presented in Table O-2 of the RAH [the majority of which were derived from federal Ambient Water Quality Criteria (AWQC)].

Exposure estimates were based conservatively on the current measured concentrations of COCs in AOC FS-17 groundwater without corrections for possible dilution or attenuation by chemical, physical, or biological processes acting upon the groundwater before its potential discharge to surface water. It was also conservatively assumed that aquatic receptors would be

exposed to COCs in surface water at current groundwater concentrations without dilutions by the surface water itself. In addition, COC concentrations would be reduced by chemical or physical processes within the receiving surface water that could affect bioavailability.

While the aforementioned assumptions resulted in a conservative quantification of surface water exposures to pelagic aquatic receptors, similar assumptions regarding potential risks to benthic receptors using groundwater-derived data could not be made because a complex variety of chemical interactions and transformations can occur at the point of groundwater discharge to the receiving sediments. Various physical/chemical properties of the sediments (e.g., organic carbon content and redox conditions) can greatly affect the bioavailability of hydrophobic (i.e., with large *n*-octanol/water partition coefficient) and ionizable COCs. For example, hydrophobic contaminants in discharging groundwater may partition to the solid-phase sediment and become less bioavailable within the interstitial (pore) water that may be a major exposure medium for the benthos (i.e., organisms inhabiting the sediment). The uncertainty concerning the potential discharge of AOC FS-17 groundwater to surface water, and the physical/chemical properties of the potential receiving sediments and surface waters, make predicting risks to benthic receptors difficult. As a result, possible groundwater COC-associated body burdens in the primary producers (aquatic vegetation) inhabiting the ponds cannot be reasonably determined, nor can contaminant levels be estimated for higher trophic levels. Thus, the groundwater COC-associated exposure doses for aquatic food chain indicator species (e.g., waterfowl) that potentially inhabit Red Brook and Long Ponds were not quantified.

The ecological exposure dose was modeled for the terrestrial indicator species selected to represent potential receptors that may occur in AOC FS-17. While all potential pathways were discussed, only those that would likely result in the largest intakes of contaminants were quantified. The dermal contact and inhalation exposure pathways are generally of little importance relative to ingestion; therefore, the exposure doses for these pathways were not quantified for any model receptor. The doses (via ingestion) were calculated for both the maximum and mean concentrations of each COC. The results of the exposure modeling are presented in Tables 2-35 through 2-52.

The following models were used to estimate risk to receptors at various trophic levels.

Herbivore
Meadow vole

$$HD = \frac{\{[(PC)(PI)] + [(SC)(SI)] + [(WI)(WC)]\} \times HRF}{HBW}$$

where:

HD = estimated exposure dose to an herbivore via food chain (mg/kg/day),
PC = concentration in plant (mg/g),
PI = ingestion rate of plant (g/day)(daily ingestion rate)(proportion of vegetation in the diet),
SC = soil or sediment concentration (mg/g),
SI = soil or sediment ingestion rate (g/day),
WI = intake rate of drinking water (L/day),
WC = concentration in surface water (mg/L),
HBW = body weight of herbivore (kg), and
HRF = home range factor—area of contamination/home range.

<u>and</u>

PC = ($SCF_{soil/sediment}$)(mean and maximum soil or sediment concentrations)

where:

PC = concentration in plant
$SCF_{soil/sediment}$ = soil- or sediment-to-plant concentration factor (mg contaminant/g dry soil or sediment)/(mg contaminant/g dry plant)

Insectivore
Short-tailed shrew
Upland sandpiper
Grasshopper sparrow

$$ID = \frac{\{[(IC)(IT)] + [(SC)(SI)] + [(WI)(WC)]\} \times HRF}{IBW}$$

where:

ID = estimated exposure dose to an insectivore via food chain (mg/kg/day),

IC = invertebrate concentration (mg/g),
IT = ingestion rate of invertebrates (g/day),
SC = soil or sediment concentration (mg/g),
SI = ingestion rate of soil/sediment (g/day),
WI = intake rate of drinking water (L/day),
WC = concentration in surface water (mg/L),
IBW = body weight of insectivore (kg),
HRF = home range factor—area of contamination/home range,

and

IC = (BAF_{inv})(soil or sediment concentration).

where:

IC = invertebrate concentration (mg/g),
BAF_{inv} = bioaccumulation factor for invertebrates

Omnivore
White-footed mouse
Northern cardinal

$$OD = \frac{\{[(PC)(PI)] + [(IC)(IT)] + [(SC)(SI)] + [(WC)(WI)]\} \times HRF}{OBW}$$

where:
OD = estimated exposure dose to an omnivore via food chain (mg/kg/day),
PC = concentration in plant (mg/g),
PI = ingestion rate of plant (g/day)=(daily ingestion rate)(proportion of vegetation in the diet),
IC = invertebrate concentration (mg/g),
IT = ingestion rate of invertebrates (g/day)(daily ingestion rate)(proportion of invertebrates in the diet),
WC = concentration in surface water (mg/L),
WI = intake rate of drinking water (L/day),
SC = soil or sediment concentration (mg/g),
SI = ingestion rate of soil or sediment (g/day),
OBW = body weight of omnivore (kg),
HRF = home range factor—area of contamination/home range,

and

PC = ($SCF_{soil/sediment}$)(mean and maximum soil or sediment concentrations).

where:
PC = concentration in plant,
$SCF_{soil/sediment}$ = soil- or sediment-to-plant concentration factor(mg contaminant/g dry plant)/ (mg contaminant/g dry soil or sediment),

and

IC = (BAF_{inv})(soil or sediment concentration).
where:
IC = invertebrate concentration,
BAF_{inv} = bioaccumulation factor for invertebrates

Carnivore
Red fox
Northern harrier
Short-eared owl

$$CD = \frac{\{[(C_b)(RI)] + [(C_m)(MI)] + [(SC)(SI)] + [(WC)(WI)]\} \times HRF}{CBW}$$

where:
CD = estimated exposure dose to carnivore via the food chain (mg/kg/day),
C_b = whole body concentration of small bird (mg/g),
C_m = whole body concentration of small mammal (mg/g),
BI = ingestion rate of diet consisting of small bird (diet g/day),
MI = ingestion rate of diet consisting of small mammals (diet g/day),
SC = soil or sediment concentration (mg/g),
SI = ingestion rate of soil (g/day),
CBW = body weight of carnivore (kg),
WC = concentration in surface water (mg/L),
WI = intake rate of drinking water (L/day),
HRF = home range factor—area of contamination/home range,

and

Cb = (BAFbird)(Cf)(Ffrac),
Cm = (BAFmammal)(Cf)(Ffrac),
BAFbird/mammal = bioaccumulation factor for an herbivorous bird or mammal
Cf = whole body concentration in small mammal/bird,
Ffrac = fraction of diet composed of food item,

and

PC = ($SCF_{soil/sediment}$)(mean and maximum soil or sediment concentrations).

where:
PC = concentration in plant and
$SCF_{soil/sediment}$ = soil- or sediment-to-plant concentration factor
(mg contaminant/g dry plant)(mg contaminant/g dry soil or sediment).

Ecological Effects Assessment

The PRA used the following endpoints for evaluating potential effects on terrestrial wildlife:

- A reduction in population or production of local vertebrate or plant groups.
- Any toxic effect on an individual of a state-protected species sufficient to impair survival or reproduction.

It was assumed that, by protecting the individual, all higher levels of biological organization within the ecosystem (i.e., populations and communities) are protected. Potential impacts on terrestrial species were evaluated by estimating an acceptable dose, or oral benchmark value, for each of the major receptor groups (herbivorous, omnivorous, insectivorous, and carnivorous mammals) and insectivorous, omnivorous, and carnivorous birds. These estimated oral benchmark values were then compared with the modeled daily dietary intakes to determine if maximum and mean detected surface soil concentrations in AOC FS-17 were acceptable. The derivation of the oral benchmark values for each receptor group were obtained from Sample et al. 1996, and the RAH and are presented in the calculations of HIs.

The ecological endpoint for plants was based on protection of the most sensitive species. Phytotoxicity values were obtained from the RAH. These benchmark values for soils were set to approximate the lowest concentrations at which a measurable effect on plant growth or germination would be expected for plants growing in the soil.

For purposes of evaluating estimated risks to potential aquatic receptors, aquatic benchmark values provided in Table O-2 of the RAH were used. In many cases these values represent the federal AWQC (USEPA 1991), which are used as benchmarks to evaluate potential for effects on pelagic aquatic organisms. Where AWQC values were not available for a COC, other aquatic benchmarks presented in Table O-2 were used.

The toxicity data and derivation of oral benchmark values for wildlife and the acceptable exposure concentrations for plants and aquatic populations are discussed in the following sections. These data were used to calculate benchmark values for both wildlife indicator species and plants.

Ecological Benchmarks

Benchmark values for terrestrial vegetation were obtained using phytotoxicity information contained in Tables O-3 and O-4 of the RAH. The phytotoxicity values used as benchmarks were based on protection of the most sensitive vegetation species. Benchmarks for the surface soil COCs in AOC FS-17 are presented in Tables 2-53 and 2-54. These benchmark values for soils approximate the lowest soil concentrations at which a measurable effect on plant growth or germination would be expected.

For purposes of evaluating risk to potential aquatic receptors, contaminant concentrations detected in surface water were compared with aquatic benchmark values provided in Table O-2 of the RAH. Many of these values are federal AWQC, Freshwater Chronic Criteria (USEPA 1991). The AWQC are used as benchmarks to predict potential for effects on pelagic aquatic organisms (i.e., aquatic organisms inhabiting the water column of surface water). For the metals cadmium, copper, lead, nickel, and zinc, the AWQC can vary with water hardness. For these metals, a hardness value of 14 mg $CaCO_3$/L was assumed, as described in Table G-4 of the RAH. Where AWQC values were unavailable for a COC, other aquatic benchmarks presented in Table O-2 were used. The aquatic benchmark values used to evaluate risks posed by COCs detected in groundwater from AOC FS-17 are presented in Tables 2-55 and 2-56.

The oral benchmark value used as the ecological benchmark for terrestrial wildlife was based on the maximum dose (mg of chemical/kg of body weight/day) that was not expected to have a long-term adverse effect upon the animal. These doses were taken from current literature, where available (Sample et al. 1996). In the absence of appropriate literature values, doses were obtained from the RAH, Appendix O. When possible, the highest no observable adverse effect level (NOAEL) from a chronic study of oral exposure in which organisms from the same taxonomic class were used for determining the acceptable concentrations, although such studies were rare. The NOAEL was defined as the dose at which no adverse effects were observed in the exposed animals. This type of data was not always available. In cases where a NOAEL for a specific chemical is not available for either wildlife or laboratory species but a lowest observed adverse effects level (LOAEL) has been determined experimentally, the NOAEL can be estimated by applying an uncertainty factor of 10 to the LOAEL. In USEPA methodology (USEPA 1995), the LOAEL can be reduced by a factor of up to 10 to derive the NOAEL. No data were found for any of the contaminants considered, which suggests the use of a LOEAL-NOEAL adjustment factor of less than 10. Tables 2-57 and 2-58 summarize the values used presenting test species, endpoints, reference studies, and the benchmarks used.

The seven animal receptor groups used in the PRA were herbivorous mammal, omnivorous mammal, insectivorous mammal, carnivorous mammal, insectivorous bird, omnivorous bird, and carnivorous bird. When possible, the toxicity benchmark value selected for each animal trophic group was based on a test species from the same animal group (e.g., the toxicity value for a herbivorous mammal model receptor was obtained from test data on herbivorous mammals) and on laboratory tests using reproductive endpoints because reproduction is considered key to the survival of a population. When a trophic-specific toxicity value was unavailable, the toxicity

value for an herbivore was used because it was assumed that absorption could be greater in organisms at this trophic-level because herbivores have longer gastrointestinal tracts than carnivores. When avian toxicity benchmarks were unavailable, mammalian toxicity data were used instead.

The estimated acceptable daily doses for specific receptor populations were obtained from the RAH and were used as oral reference doses to evaluate estimated risks from potential exposure to the COC detected in surface soil at AOC FS-17. These COC-specific estimated acceptable daily doses are presented in Tables 2-59 through 2-76 and termed Adjusted Oral Benchmark values. These values were subsequently compared to the estimated daily exposures by COC for each model receptor species to quantify estimated risks from potential exposure to COCs in surface soil at AOC FS-17.

Estimated exposure doses for the white-footed mouse and the meadow vole were compared to the acceptable daily doses for an herbivorous mammal. Estimated exposure doses for the short-tailed shrew were compared to the acceptable daily doses for a carnivorous mammal because acceptable daily doses for insectivorous mammals such as the shrew were unavailable. The shrew ingests large soil invertebrates, such as earthworms, and 4,4'-dichlorodiphenyltrichloroethane (4,4'-DDT) can potentially bioaccumulate in earthworms. Insectivores, omnivores, and carnivores typically receive less exposure to inorganic COCs than herbivores from food ingestion because of the difference in trophic status. Carnivores may gain exposures to higher doses of the organic COCs that biomagnify through trophic transfer within the ecological food chain. Predators may be severely affected if they ingest prey containing organic contaminants. The shrew's exposure doses, therefore, were compared to benchmark values for a carnivorous mammal rather than for an herbivorous mammal.

Daily exposure doses estimated for the upland sandpiper and the grasshopper sparrow were compared to acceptable daily doses for a carnivorous bird. Because of dietary preferences by upland sandpiper and grasshopper sparrow (i.e., large insects rather than plant matter), there is the potential for 4,4'-DDT to bioaccumulate in their food items. In addition, DDT can cause eggshell thinning and thus decrease the reproductive success of individual birds. The raptors can potentially experience higher exposure doses of the organic COCs, which typically biomagnify through trophic transfer within the ecological food-chain.

2.6.2.3 Risk Characterization

The AOC FS-17 baseline ecological assessment follows the methodology for a Tier III ecological risk assessment, as outlined in the RAH using HQs to calculate an HI. The HI was cumulative by exposure pathway and, where risks were elevated, by each chemical class (i.e., VOC, SVOC, pesticides/PCBs, and inorganics). For each COC, an HQ was calculated by dividing the exposure concentration (i.e., maximum or mean detected concentrations in media) or, for food-chain exposures to terrestrial model receptors, the calculated exposure dose (i.e., maximum or mean oral dose) by a benchmark or oral reference dose. The HI is the sum of the

calculated HQs for all the COCs for a given chemical class and exposure route (e.g., ingestion) within the pathway:

$$HI = \sum \text{(maximum or mean detected concentration/benchmark value)}$$
or
$$HI = \sum \text{(calculated maximum or mean oral dose/oral reference dose)}.$$

HIs were developed for both maximum and mean detected concentrations for surface soil or groundwater by comparing the maximum and mean detected concentrations with appropriate benchmark values or by using the maximum and mean concentrations in surface soil to calculate maximum and mean oral doses for comparisons with the oral reference doses.

The ecological PRA represents a Tier III analysis. While HIs >1 indicate the potential for adverse effects, these HIs do not necessarily indicate an appreciable effect based on applicable assessment of endpoints (i.e., population effects, reproduction effects, etc.). With the exception of nonmobile benthic invertebrates and terrestrial plants, an HI of 10 or more is an appropriate risk management criterion because of the uncertainty inherent in the exposure and hazard estimates; the appropriate assessment endpoint is protection of populations rather than individuals. An HI of 10 is probably adequate to protect most animal populations in the AOC FS-17 Study Area because they have home ranges larger than the AOC area and the benchmarks are based on the no effects levels.

Risks to Terrestrial Vegetation

The evaluation of risks to plants at AOC FS-17 was based on maximum and mean detected concentrations of COCs in surface soil compared to benchmark levels known or predicted to be toxic to vegetation. HQs were calculated for each COC and were summed to derive an HI for terrestrial vegetation using maximum or mean detected concentrations. Tables 2-53 and 2-54 present results of the risk characterization for terrestrial vegetation. The following is a summary of the results of the risk calculations.

Using maximum detected concentrations in surface soils, lead was found to be the greatest contributor to risk among the inorganic COCs, with an HQ of 26. Other inorganics with HQs greater than 1.0 were chromium (3.8), copper (1.3), and zinc (1.6). The major organic contributor to risk was 2-methylnaphthalene (HQ = 14), followed by naphthalene (4.8), phenanthrene (2.4), fluorine (1.6), and total xylenes (1.1). Lead was also the major contributor to risk using mean detected concentrations, with an HQ of 7.6, followed by 2-methylnaphthalene (2.8), and chromium (1.9). Other organic and inorganic compounds detected in surface soils at AOC FS-17 contributed to the HIs; however, they were not the major contributors to risks.

Terrestrial vegetation Hazard Index		
	Maximum COC concentration	Mean COC concentration
VOC	1.4	0.29
SVOC	24	5
Pesticides/ PCBs	0.03	0.008
Inorganics	34	12
Total HI	59	17

Risks to Aquatic Receptors

The evaluation of risks to aquatic receptors was based on HIs calculated using maximum and mean detected concentrations in groundwater with determination of both total and dissolved inorganic concentrations. The results of the risk characterization for aquatic receptors using groundwater data from AOC FS-17 are presented in Tables 2-55 and 2-56. The following is a summary of the calculated HIs for aquatic receptors.

Aquatic receptor Hazard Indices				
Hazard Index	Maximum COC concentration		Mean COC concentration	
	Total	Dissolved	Total	Dissolved
Pesticides/ PCBs	20	Not available	11	Not available
Inorganics	270	18.00	88	4.3
Total	290	18.00	100	4.3

Using total maximum detected concentrations in groundwater (i.e., unfiltered groundwater), all COCs were major contributors to risks (Table 2-55). Lead, aluminum, copper, and 4,4′DDT were the greatest contributors to risks, with HQs equal to 150, 79, 18, and 20, respectively.

Using dissolved maximum detected concentrations in groundwater (i.e., filtered groundwater), aluminum, lead, and copper were contributors to risk with HQs of 7.7, 5.4, and 3.0, respectively.

The risk characterization using total mean detected concentrations again suggested that aluminum, lead, and 4,4'-DDT were the greatest contributors to risks with HQs equal to 40, 35, and 11, respectively (Table 2-56). Iron and copper were the only other contributors to risks with HQs equal to 6.1 and 4.9, respectively. Using dissolved mean detected concentrations, only copper and lead had HQs greater than 1 (1.0 and 2.7, respectively).

Exposure concentrations for pelagic aquatic receptors were based on an evaluation of COCs detected in the groundwater and were conservatively based on currently measured concentrations. In quantifying exposure, it was conservatively assumed that aquatic receptors would be exposed to the contaminant levels measured in the groundwater and that contaminant levels would not be diluted by surface water inputs and bioavailable fractions would not be reduced by chemical, physical, or biological processes occurring in the surface waters. In Tables 2-55 and 2-56, the HIs for aquatic receptors using both total and dissolved concentrations in groundwater exceeded a value of 1.0. If aquatic receptors were exposed to these groundwater COC concentrations in surface water, then adverse biological effects to pelagic aquatic receptors would be expected. For both maximum and mean groundwater COC concentrations for unfiltered groundwater (total), several HQs exceed a value of 1.0. Based on maximum and mean groundwater COC concentrations using filtered groundwater (dissolved), several inorganic HQs exceed 1.0, but the risk is reduced compared with total detected values. Dissolved concentrations of inorganic COCs are more indicative of actual risk to pelagic aquatic receptors because this is typically the bioavailable fraction of the total concentration and because the federal AWQC are derived using contaminant concentrations dissolved in water. Although the results of the Tier III analysis of groundwater at AOC FS-17 indicate that potential groundwater discharge to surface water may result in potential for adverse biological effects among aquatic organisms, the realization of these effects is unlikely.

Further consideration of dissolved data illustrates that potential site risks are not meaningful when compared to risks associated with MMR maximum background results. Tables 2-78 and 2-55 present the MMR background and site aquatic risk characterization, respectively. Using dissolved site data, the HI for aquatic receptors is 18 and the HI based on MMR maximum background concentrations for dissolved results is 29, or 161% of the total risk estimated using site data. This percentage, although not possible in reality, provides a mathematical indication that background risks to aquatic receptors contribute to aquatic receptor risks to a far greater degree than site-related constituents. Remediation based on these results would do little to reduce risks because remediation to levels below background cannot reduce risks at a site.

Risks to Terrestrial Receptors

The evaluation of risk to terrestrial vertebrate receptors at AOC FS-17 was based on risks associated with terrestrial food chains. Risks were evaluated by estimating exposure doses based on the organisms' feeding habits and habitat preferences (life history). HQs were calculated for

each COC detected in surface soil at AOC FS-17 and were summed to derive HIs for the model receptor species.

HIs were developed for each model receptor likely to reside in AOC FS-17. Tables 2-59 through 2-76 present the risk characterizations using maximum and mean detected COC concentrations in surface soils. The following is a summary of the risk characterization for terrestrial model receptors.

Summary of estimated risks to terrestrial model receptors		
Terrestrial model receptors	HI based on maximum COC concentration	HI based on mean COC concentration
White-footed mouse	1.2	0.3
Meadow vole	3.6	0.8
Northern short-tailed shrew	2.4	0.8
Red fox	2.0	0.4
Upland sandpiper	1.5	0.4
Grasshopper sparrow	0.1	0.02
Northern harrier	0.02	0.01
Short-eared owl	0.1	0.04
Northern cardinal	5.6	1.9

For the omnivorous white-footed mouse, the total HI using maximum detected surface soil concentrations was 1.2 (Table 2-59). No single COC had an HQ greater than 1. The COC with the highest HQ was total xylene (HQ = 0.5). Using mean detected concentrations, the total HI was 0.3. No single COC had an HQ greater than 1. Total xylene had the highest HQ, which was 0.1 (Table 2-60). Because the total HI for maximum detected concentrations in surface soil for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

Using maximum detected soil concentrations, the total HI for the meadow vole was 3.6 (Table 2-61). The primary COCs contributing to risk were total xylene (HQ = 1.6) and naphthalene (HQ = 1.2) (Table 2-61). Risk calculations using mean soil concentrations resulted in a total HI of 0.8 (Table 2-62). No single COC had an HQ greater than 1. The COC with the highest HQ was total xylene (HQ = 0.33). Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the insectivorous northern short-tailed shrew, the total HI using maximum detected surface soil concentrations was 2.4 (Table 2-63). No single COC had an HQ greater than 1. The COC with the highest HQ was total xylene (HQ = 0.75). Using mean concentrations, the total HI was 0.8 (Table 2-64). No single COC had an HQ greater than 1. The COC with the highest HQ was lead (HQ = 0.16). Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the red fox, the total HI using maximum detected surface soil concentrations was 2.0 (Table 2-65). No single COC had an HQ greater than 1. The COC with the highest HQ was zinc (HQ = 0.6). Mean detected surface soil concentrations showed that the total HI was 0.4. No single COC had an HQ greater than 1. Zinc had the highest HQ, which was 0.3. Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the upland sandpiper, the total HI using maximum detected surface soil concentration was 1.5 (Table 2-67). No single COC had an HQ greater than 1. The COC with the highest HQ was 4,4'-DDT (HQ = 0.76. Using mean detected concentrations, no single COC had an HQ greater than 1. The pesticide 4,4'-DDT had the highest HQ, which was 0.19. Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the insectivorous grasshopper sparrow, the total HI using maximum detected surface soil concentrations was 0.1 (Table 2-69). No single COC had an HQ greater than 1. The COC with the highest HQ was 4,4'-DDT (HQ = 0.04). Using mean detected concentrations, total HI for the grasshopper sparrow was 0.02, and no single COC had an HQ greater than 1. The pesticide 4,4'-DDT had the highest HQ, which was 0.01 (Table 2-70). Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

Concerning the northern harrier, using maximum and mean detected surface soil concentrations, the total HI was less than 1 (HI = 0.02 maximum concentrations; HI = 0.01 mean concentrations), and no single COC had an HQ greater than 1 (Tables 2-71 and 2-72). Zinc had the highest HQs, which were HQ = 0.01 (maximum concentrations) and HQ = 0.003 (mean concentrations). Because the total HI for maximum detected surface soil concentrations for all

COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

Estimated risks to the short-eared owl were also very low for most COCs, with maximum and mean total HIs less than 1 (HI = 0.1 maximum concentrations; HI = 0.04 mean concentrations) (Tables 2-73 and 2-74). Zinc had the highest HQs, which were 0.07 (maximum concentrations) and 0.02 (mean concentrations).

For the omnivorous northern cardinal, total HI using maximum detected concentrations in surface soil was 5.6 (Table 2-75). The primary contributors to risk were naphthalene (HQ = 1.97), and 4,4'-DDT (HQ = 1.2, Table 2-75). Using the mean detected soil concentrations, total HI was 1.9. No single COC had an HQ greater than 1. The COC with the highest HQ was 4,4'-DDT (HQ = 0.94) (Table 2-76). Because the total HIs for maximum detected surface soil concentrations for COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

Ecological Risk Characterization Summary

While HIs> 1.0 indicate the potential for adverse effects, these HIs do not necessarily indicate an appreciable effect based on applicable assessment of endpoints (i.e., population effects, reproduction effects, etc.). Furthermore, concerning the evaluation of potential impacts to terrestrial vegetation at AOC FS-17, organics and inorganics could pose a threat to these receptors using maximum soil data. Organics include xylenes, 2-methylnaphthalene, fluorene, naphthalene, and phenanthrene. Inorganics include chromium, copper, lead, and zinc (Table 2-53). Using mean soil concentrations, only 2-methylnaphthalene, chromium, and lead have HQ values that exceed unity. It should be noted that benchmarks for several inorganic COCs listed in Table O-4 of the RAH were presented as a range of values, not a single benchmark value. The benchmark values used to calculate HQs for inorganic COCs were the lowest number in the range for each COC. The use of the high-end value in each range would result in HQs less than 1.0 for all inorganics except lead using maximum detected soil concentrations and HQs less than 1.0 for all inorganics using mean detected soil concentrations. Maximum and mean HIs represent estimated cumulative adverse impacts of surface soil COCs on terrestrial vegetation. However, because plants are immobile, they experience concentrations at one location at the site only and not at several locations. To evaluate potential impacts to terrestrial vegetation properly, concentrations detected location-by-location should be used to estimate potential risks to organisms that tend to remain at one location. Mean concentrations probably more accurately represent COC concentrations that may be experienced by terrestrial plants than maximum concentrations.

To discriminate between the level of potential risk posed by naturally occurring background concentrations for these inorganic compounds from that posed by concentrations of the inorganic COC contributed by past activities at AOC FS-17, the potential risk to terrestrial vegetation associated with maximum MMR background soil concentrations was also characterized.

Potential risks to terrestrial vegetation associated with maximum MMR background soil concentrations were derived and are presented in Table 2-77. When comparing the HI for maximum COC concentrations in soil (HQ = 59, Table 2-53) to the HI (3.6) representing MMR background levels in soil, the HI for the site was approximately 94% higher than the HI representing MMR background levels in soil. The site supports very little vegetation because of paved surfaces and compacted, sandy soil.

Potential risks associated with COCs detected in AOC FS-17 groundwater to potential pelagic aquatic receptors were only qualitatively evaluated. It was conservatively assumed that aquatic receptors would be exposed to concentrations in groundwater and that contaminant levels would not be diluted by surface water inputs nor would toxicity be reduced by chemical, physical, or biological processes while migrating through subsurface soil or at the point of potential discharge. Using the maximum total (unfiltered) detected groundwater concentrations, 4,4'-DDT, aluminum, cadmium, chromium, copper, iron, lead, and zinc contribute to risk (Table 2-55). Concentrations of contaminants in the dissolved fraction are considered more indicative of actual risk to pelagic aquatic receptors because the federal AWQC are derived from contaminant concentrations dissolved in water and dissolved concentrations in surface water generally reflect what concentration is bioavailable to pelagic aquatic receptors. It was suggested (but unlikely) from AOC FS-17 filtered groundwater data that aluminum, copper, and lead may pose a potential threat to pelagic aquatic receptors, using maximum detected concentrations.

To gain a perspective on the predicted risk to aquatic receptors, Table 2-78 is presented as a characterization of the potential aquatic risks associated with maximum background concentrations for total and dissolved inorganic compounds in MMR groundwater. The calculated HI (29) for maximum dissolved concentrations in MMR background groundwater is 29. The calculated HI representing aquatic risks associated with maximum dissolved COC concentrations detected in AOC FS-17 groundwater is 18. Using mean detected concentrations for AOC FS-17, which may be more indicative of true exposure potential, only copper and lead have HQs greater than 1.0, and the risk from these COCs is lower than the risk from background dissolved concentrations. Therefore, further investigation of potential aquatic risks attributed to AOC FS-17 groundwater is not necessary based on background conditions existing in groundwater within MMR.

For aquatic receptors, the HI is 290 using total concentration data (unfiltered samples). The HI for background inorganics (total concentration basis) for aquatic receptors is 34, approximately 12% of the total HI and 13% of the inorganic HI. Using dissolved data, the HI for aquatic receptors is 18, and the HI based on MMR maximum background concentrations for dissolved results is 29, or 161% of the total and 28% of the inorganic HI. These percentages, although not possible in reality, provide a mathematical indication that background risks to aquatic receptors contributes to aquatic receptor risks to a far greater degree than site-related constituents. Remediation based on these results would do little to reduce risks because remediation to levels below background cannot reduce risks at a site.

The results of the Tier III analysis for terrestrial wildlife, and resulting risk estimates for the exposure pathways quantified in this ecological PRA, indicated that COCs in surface soil at AOC FS-17 pose little threat to individual wildlife such as the terrestrial model receptor species. The PRA used the following assessment endpoints to evaluate potential adverse effects to terrestrial wildlife attributed the presence of COCs in surface soil:

- A reduction in population or productivity within local vertebrate populations or plant communities.
- Any toxic effect on an individual of a state-protected species sufficient to impair survival or reproduction.

The white-footed mouse, meadow vole, northern short-tailed shrew, fox, and cardinal are not state-protected species but are indigenous to MMR. Therefore, the potential for a reduction in reproductive success or population size for these model receptors within the proximity of AOC FS-17 is considered a significant impact. However, HIs for these receptor species indicate that individual animals are not at risk. Therefore, potential effects on the local breeding population of these model receptors is not expected. In addition, the model receptor species may or may not use AOC FS-17 habitats because of poor habitat quality relative to other areas in MMR. The receptor species were selected based on a review of information identifying species known or expected to occur at MMR and types of habitats present in AOC FS-17. Based on observations made during the September 1995 site walkover, AOC FS-17 is of poor habitat quality, and habitat is limited to areas surrounding the site.

Should some of the model receptors inhabit or forage in AOC FS-17, continuously or intermittently, it is not likely that AOC FS-17 would support bird or mammal populations that represent significant portions of the total population existing within MMR because of the relatively small area of AOC FS-17 (1 acre). If herbivorous, insectivorous, and omnivorous receptor species were present on the site and significantly affected as a result of exposure to COCs in surface soil, the loss of these individuals from the breeding population may not affect the size of the larger population in the region. Individual animals that may inhabit AOC FS-17 and represent a food source for raptors or predators may represent an insignificant fraction of the diet for these carnivores.

The upland sandpiper and the grasshopper sparrow are state-protected species but, based on the HIs for these model receptors, a potential threat does not exist for individual upland sandpipers and grasshopper sparrows by the dietary exposure pathway. In addition, upland sandpipers and grasshopper sparrows are not expected to use AOC FS-17 based on the physical characteristics of the site and poor habitat quality relative to other areas in the MMR.

Dermal and inhalation pathways of exposure were not evaluated in this Tier III PRA. Adherence of contaminated soil to the skin of a receptor organism or inhalation of COCs adhered to particulates could result in exposure risks that are greater than those quantified in this ecological PRA. However, exposure via these routes was judged to be minor when qualitatively compared to the food-chain exposure pathway.

2.6.3 Conclusions for Human Health and Ecological Risk for AOC FS-17

Actual or threatened releases of hazardous substances from AOC FS-17 do not present an imminent and substantial endangerment to public health, welfare, or the environment. AOC–17 does not pose any unacceptable human health or ecological risk.

2.6.4 Human Health PRA for AOC FS-19

The objectives of the PRA at AOC FS-19 were to characterize the potential current and future risks to human health from exposure to contaminants at AOC FS-19. For risk assessment purposes, the AOC was defined by the contaminated soil and groundwater that may serve as exposure media for human receptors. Because portions of AOC FS-19 are accessible to workers and trespassers, one of the objectives of the risk assessment was to evaluate human health risks to these groups from existing contamination. The evaluation includes current risks as well as future potential risks, assuming the area becomes residential.

For AOC FS-19, a PRE for human health risks to groundwater was performed as part of the SI (ABB-ES 1992). A PRE for human health risks to soils was not conducted because TPH results cannot be assessed quantitatively in risk assessment. To fully characterize human health risks at AOC FS-19 in the RI, a Tier III PRA analysis was performed. The basic steps of the PRA are contaminant identification, exposure assessment, toxicity assessment, and risks characterization.

2.6.4.1 Contaminant Identification

Fixed-base laboratory analytical results from the final RI report (HAZWRAP 1998b) for surface soil, subsurface soil test borings, and groundwater were evaluated in the PRA. An evaluation of duplicate sample results, blank results, detection limits, detection frequency, TICs, and a comparison against inorganic background concentrations were performed to establish the usability of these data for the PRA.

Because a PRE was not previously conducted for AOC FS-19, COCs were not previously identified. COCs were selected in the PRA by comparing maximum detected chemical concentrations to RECs and HECs provided for contaminant screening in Appendix F of the RAH. Maximum detected chemical concentrations exceeding RECs/HECs were considered COCs. Essential macronutrients (calcium, magnesium, potassium, and sodium) were not considered COCs. Chemical constituents with a detection frequency of less than 5% for data sets greater than 20 samples were not considered COCs. A comparison of chemical concentrations to MMR background was also conducted, but no COCs were eliminated based on this comparison.

Based on the COC selection process, environmental media of concern at AOC FS-19 are surface soil, subsurface soil, groundwater, and surface waters receiving groundwater discharge from the AOC. The human health COCs selected for further evaluation are summarized in Tables 2-79 through 2-82. Potential COCs for human health receptors for surface water were

identified based on a conservative comparison of groundwater concentrations detected at AOC FS-19 to risk-based concentrations for surface water presented in the RAH. These potential COCs for surface water are not quantitatively carried through the PRA because the actual concentrations that may discharge from groundwater into surface water such as Edmunds Pond have not been predicted.

2.6.4.2 Exposure Assessment

Potentially exposed populations and potential exposure pathways were identified based on current and future land use. For current land use, construction workers and trespassers (children and adults) were identified. For future land use, construction workers, trespassers (children and adults), and residents (children and adults) were identified.

Potential exposure pathways identified for construction workers under current and future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,
- ingestion of surface soil, and
- dermal contact with surface soil.

Trespassers at AOC FS-19 may include children and adolescents who play on the site and adults who walk across the site. Potential exposure pathways identified for trespassers (children and adults) under current and future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,
- ingestion of surface soil, and
- dermal contact with surface soil.

Potential exposure pathways identified for residents (children and adults) under future land use include:

- inhalation of VOCs and/or fugitive dusts from surface soil,
- ingestion of surface soil,
- dermal contact with surface soil,
- ingestion of groundwater,
- dermal contact with groundwater,
- ingestion of surface waters receiving groundwater discharge from AOC FS-19, and
- dermal contact with surface waters receiving groundwater discharge from AOC FS-19.

Potential exposures were quantified using standardized dose equations based on USEPA risk assessment guidance and integrated into the equations used to estimate risk for AOC FS-19. The risk estimates are based on both maximum and mean detected COC concentrations. Table 2-83 summarizes the equations and parameters used to estimate site risks.

2.6.4.3 Toxicity Assessment

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. USEPA has performed the toxicity assessment for numerous chemicals and has made available the resulting toxicity information and toxicity values, which have undergone extensive peer review. The toxicity values consist of CPFs and noncarcinogenic reference doses. These toxicity values are evaluated and selected for use in the PRA based on their applicability to the specific COCs and types of exposures identified at AOC FS-19.

CPFs have been developed by USEPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CPFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen in mg/kg-day to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CPF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer potency factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied.

RfDs have been developed by USEPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

Table 2-84 provides a summary of the CPFs and RfDs used to estimate risk for the AOC FS-19 PRA.

2.6.4.4 Risk Characterization

In the risk characterization, excess lifetime cancer risk and noncarcinogenic hazard potential are estimated based on the chemical dose received by a receptor and the toxicity per unit intake of the contaminant.

Excess lifetime cancer risks are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g., 1×10^{-6} or 1E-6). An excess lifetime cancer risk of 1×10^{-6} indicates that as a plausible

upper bound, and individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the HQ (or the ration of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's reference dose). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the HI can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Tables 2-85 through 2-96 provide the risk/HQ/HI estimates based on current and future land use for the exposure scenarios evaluated in the PRA. For each exposure scenario, chemical-specific carcinogenic risks and noncarcinogenic HQs were estimated for the exposure pathways associated with each contaminated medium. Total pathway carcinogenic risks and noncarcinogenic HIs (e.g., risks from all COCs for dermal contact) were also calculated. Total carcinogenic risks and noncarcinogenic HIs (e.g., risks from all COCs and all exposure pathways combined) were also calculated. Summary of risk and HI for FS-19 are given in Tables 2-96a.

Cancer and noncancer risks are summarized for AOC FS-19 in Table 2-97. For the current exposure scenario, cancer risk estimates are between 1.0E-07 and 3.15E-07 for arithmetic mean concentrations and between 1.46E-07 and 4.66E-07 for maximum concentrations. These risk levels are below USEPA's target risk range. As measured by HIs, noncancer effects are not likely, as HIs are less than 1.0.

For the future exposure scenario, total lifetime cancer risk estimates are between 1.52E-05 and 8.44E-05 for arithmetic mean concentrations and between 2.4E-05 and 1.83E-04 for the maximum concentrations. There is potential for excess cancer in the future scenario to the residential adult as evidenced by an estimated risks slightly exceeding 1E-04. This is primarily due to total (unfiltered samples) concentrations of arsenic and beryllium in groundwater. The total HI for the adult (3.76) exceeds 1.0, indicating a potential for noncarcinogenic effects. The exceedance is attributed to total concentrations of manganese in groundwater. The maximum total concentrations of arsenic and manganese are above the maximum total concentration for MMR background, whereas beryllium is below the MMR background concentrations.

Neither a CSF nor an RfD is available for lead. Instead, blood lead concentrations have been accepted as the best measure of exposure. USEPA has developed the IEUBK model to assess chronic, noncancer exposures of children to lead. Version 0.99d of the model was used to evaluate exposures of child residents (in the future) to lead (USEPA 1994).

The maximum and arithmetic average of lead concentrations in surface soil and groundwater were used as the input for the model. Default values for lead in air and dietary ingestion were used. No contribution from paint ingestion was included. A blood lead level of 10 μg/dL is the

benchmark to evaluate lead exposure. Based on the above assumptions, the maximum soil concentration (119 mg/kg), and maximum groundwater concentration (18.5 μg/L), projected blood lead levels of 96.33% of the exposed child population (0 to 84 months of age) would be expected to be below 10 μg/dL and 3.67% would be expected to be above 10 μg/dL. Based on the average soil concentration (63 mg/kg) and average groundwater concentration (4.5 μg/L), projected blood lead levels of 99.94% of the exposed child population (0 to 84 months of age) would be expected to be below 10 μg/dL and 0.06% would be expected to be above 10 μg/dL.

2.6.5 Ecological PRA for AOC FS-19

To fully characterize ecological risks at AOC FS-19, a Tier III analysis was performed. The steps of the Tier III analysis include contaminant identification, exposure assessment, effects assessment, and risk characterization. These components of the PRA are summarized below.

2.6.5.1 Contaminant Identification

Fixed-base laboratory analytical results from the final RI report (HAZWRAP 1998b) for surface soil, subsurface soil test borings, and groundwater were evaluated in the PRA. An evaluation of duplicate sample results, blank results, detection limits, detection frequency, TICs, and a comparison against inorganic background concentrations were performed to establish the usability of these data for the PRA.

Because an ecological PRE was not previously conducted for AOC FS-19, COCs were not previously identified. COCs were selected in the PRA by comparing maximum detected chemical concentrations to ecological HECs provided for contaminant screening in the RAH (Appendix F). Maximum detected chemical concentrations exceeding HECs were considered COCs. Essential macronutrients (calcium, magnesium, potassium, and sodium) were not considered COCs. Chemical constituents with a detection frequency of less than 5% for data sets greater than 20 samples were not considered COCs. A comparison of chemical concentrations to MMR background was also conducted, but no COCs were eliminated based on this comparison. Based on the COC selection process, environmental media of concern at AOC FS-19 are surface soil, subsurface soil, groundwater, and surface waters receiving groundwater discharge from the AOC. The ecological COCs selected for further evaluation are summarized in Tables 2-98 and 2-99.

2.6.5.2 Exposure Assessment

The purpose of the ecological exposure assessment was to identify and quantify site-specific exposure pathways for representative indicator species identified at AOC FS-19. For the coastal plain pond, pitch pine/scrub oak barren, and sandplain grassland/coastal heathland habitats identified in the PRA, site-specific receptor species were identified based on a survey of the site and surrounding environment conducted during November 1993 and January 1994. AOC FS-19, an abandoned vehicle fueling facility and hazardous waste storage facility, has been unused since 1965. USTs were removed in 1989. Building No. 3493, which covered an area approximately

20 feet by 40 feet and once existed within AOC FS-19, has been demolished. Concrete remnants of the building foundation remain in the subsurface; however, the ground surface is unpaved and vegetated. Topography of AOC FS-19 is flat, but just off-site to the east, the ground gradually slopes upward and becomes wooded at the top of a hill. Additional wooded areas (approximately 12 acres) abut the site but are not within the AOC boundaries.

The wildlife expected within the area is thought to be limited to the surrounding grassy fields and the adjacent wooded area. The habitat for AOC FS-19 can be described as an edge community consisting of the on-site flat open field and the abutting small pitch pine area. The open grassy area in AOC FS-19 spans 0.05 acre and is considered the area accessible to terrestrial receptors.

Identification of Indicator Species

Nine indicator species identified in Appendix P of the RAH were considered representative receptor species that may continuously inhabit AOC FS-19; they were selected for evaluation in the PRA. The following species were selected:

- white-footed mouse *(Peromyscus lenopus),*
- meadow vole *(Microtus pennsylvanicus),*
- northern short-tailed shrew *(Blatina brevicauda),*
- northern cardinal *(Cardinalis cardinalis),*
- grasshopper sparrow *(Ammodramus savannarum),*
- upland sandpiper *(Banramia longicauda),*
- northern harrier *(Circus cyaneus),*
- short-eared owl *(Asioflammeus), and*
- red fox *(Vulpes vulpes).*

The white-footed mouse is an omnivorous, small burrowing mammal with limited range and likely to live in open/old field, forest edge, and forest habitats.

The meadow vole is an herbivore and is typically found in grass-dominated fields, bog mat areas, and marshes. The vole maintains networks of runways consisting of cleared vegetation. Voles also burrow to a limited degree.

The short-tailed shrew was selected as representative of small mammal insectivores. The shrew might be expected to occur in the field and edge community habitats similar to those found at AOC FS-19. These small mammals construct nests underground and runways within the upper surface layer of soil.

The red fox, a terrestrial mammalian carnivore, was selected as a model receptor because it preys on both birds and burrowing mammals, like rodents, and is known to feed on carrion. The home range of the red fox is approximately 210 acres. Given the small size of the site and the

presence of heavy traffic on I&E Road, carnivores like the red fox would not continuously inhabit the site, but they may occasionally forage on-site in darkness.

Representative avian receptor species include the state-listed endangered upland sandpiper, the northern cardinal, and the grasshopper sparrow, a state species of special concern. All these species may be found at AOC FS-19. The northern cardinal was selected as a model receptor because it is usually found in edge community habitats and is representative of an avian omnivore (i.e., its diet consists of plants and insects). The cardinal is a small-to-medium-size bird that is frequently present in forest edge habitats. This bird nests above ground within shrubs, low trees, and thickets or other tangled vegetation.

The upland sandpiper and grasshopper sparrow were selected as model receptors because they most commonly occur in early successional, old field habitats similar to the open field area of AOC FS-19 and might also utilize the pitch pine and scrub oak forest edge habitat at AOC FS-19. In addition, these model receptors represent avian insectivores (i.e., diet consisting of primarily insects) and construct their nests on the ground.

The northern harrier *(Circus cyaneus)*, a state threatened species and short-eared owl *(Asio flammeus)* are representative of raptors. The home range of the northern harrier ranges from 1.5 km^2 to 2.1 km^2 while the short-eared owl ranges over an area of 0.2 km^2. These receptors commonly forage in the open fields where their diet consists of small mammals, such as voles and small birds. However, they may more frequently utilize other areas that offer better quality habitat to their prey, such as old fields and wetland habitats. It seems unlikely that AOC FS-19 could support a significant population of small mammals that could serve as a significant food source for avian or mammalian carnivores.

Identification of Exposure Pathways

Exposure pathways are the means by which ecological receptors come into contact with contaminated environmental media. Exposure to the environmental media may occur through direct contact with contaminated media or indirect exposure via the food chain.

Groundwater and surface soil (see Table 2-100) are the environmental media that were evaluated in this ecological PRA. Groundwater is not considered an exposure medium at AOC FS-19 with regard to its contribution to possible contaminant loading to sediment in Edmunds Pond. However, it may ultimately discharge downgradient into the surface water at Edmunds Pond. For the PRA, groundwater data for AOC FS-19 were qualitatively evaluated as to potential risk to pelagic aquatic biota inhabiting Edmunds Pond.

Table 2-100 shows that the maximum surface soil concentrations of arsenic, cadmium, chromium, cyanide, lead, manganese, vanadium, and zinc exceed maximum concentrations for MMR background. However, the average concentrations for arsenic, cadmium, cyanide, and manganese were less than the maximum concentration for MMR background. The average concentrations for the analytes detected in surface soil were computed using a data set of only

three samples collected from the areas of suspected petroleum-related contamination. Based on the small surface soil data set representing the most highly contaminated areas of AOC FS-19 and the average concentrations' being less than MMR background, it is likely that detected concentrations of arsenic, cadmium, cyanide, and manganese in surface soil represent naturally occurring levels. The average concentrations of chromium and vanadium only slightly exceed the MMR background and probably represent ambient levels. However, surface soil concentrations of lead and zinc were 2- to 3-fold higher than MMR background and may be related to activities at AOC FS-19. The elevated lead concentrations in the surface soil samples may be the result of residual contamination remaining in the backfill within the excavated areas from which the USTs were removed. The USTs had been filled with MOGAS, which has a high lead content. The elevated zinc concentrations in the surface soil samples may also be the result of residual soil contamination in the backfill within the excavated areas. A few of the USTs removed also contained waste oil, which may have been mixed with discarded battery fluid. However, the elevated lead and zinc levels in the surface soil represent a small confined area of metal contamination (approximately 0.015 acres). This area would have little impact on the ecological receptors foraging area as it represents a small portion of the available foraging habitat. It is unlikely that ecological receptors would forage in this area to any great extent as better sustaining habitats are nearby.

Given the history of AOC FS-19, the detected concentrations of 4,4'-DDT and dieldrin are not likely to be related to AOC FS-19 activities but are likely to be the result of historical pesticide spraying on the base.

Exposure pathways exist between an environmental medium (e.g., surface soil) and receptors (e.g., soil invertebrates, flora, and mobile terrestrial receptors) in direct contact with a medium. Exposure pathways to herbivores and insectivores are also expected to occur indirectly through food chain transfer of soil contaminants.

Receptor species may ingest contaminated food items, such as insects or vegetation. An exposure pathway is considered potentially complete if there is a way for the ecological receptor to take in the contaminant. The three major exposure routes for ecological receptors are ingestion of food and water, inhalation/respiration, and direct contact. Many of the COCs have the potential to bioconcentrate, bioaccumulate, and biomagnify contaminants through food chains (see Appendix J of the RAH). The ecological receptor's foraging behavior can significantly influence the consumption of contaminated food items. For example, consumption of prey items such as the white-footed mouse or shrew by higher trophic-level organisms can present a significant indirect exposure pathway that may contribute greatly to the overall exposure of these receptors to site contaminants.

Some pathways, such as dermal contact and inhalation, could not be quantified because of the absence of species-specific exposure information. While all potential pathways are discussed, those that will likely result in the largest contaminant intakes were quantified.

The white-footed mouse is a small, burrowing omnivore. According to dietary information provided in Appendix P of the RAH, its diet consists of approximately 80% plant material and 17% invertebrates. Incidental soil ingestion accounts for the remaining 3% of its diet. Therefore, this animal would be chronically exposed to soil contaminants by means of incidental soil ingestion, inhalation, and dermal contact and indirectly through ingestion of potentially contaminated food items.

The meadow vole is an herbivore that consumes seeds, grasses, and sedges. This animal would also be exposed to contaminants by means of incidental soil ingestion, inhalation, dermal contact, and potential ingestion of contaminated plant matter.

The northern short-tailed shrew is a representative of the insectivore trophic level. The shrew would similarly be exposed through dermal contact, incidental soil ingestion, inhalation, and by means of the food chain.

Based on its life history, the red fox might be exposed to contaminants primarily through the food chain. If the red fox were to have a den on-site, the receptor may also be exposed to COCs through dermal contact and inhalation routes of exposure.

The upland sandpiper is a ground-nesting bird; therefore, it may be exposed to soil contaminants by means of incidental soil ingestion, inhalation, and dermal exposure. Also, these birds are insectivores and may be exposed through uptake of chemicals into insects.

The grasshopper sparrow is a ground-nesting insectivorous bird and therefore may be exposed to contaminants by means of incidental soil ingestion, inhalation, and dermal exposure, as well as uptake via the food chain, as both species feed on insects.

The northern cardinal is included because it is an omnivorous bird, and this receptor population is not represented by any state-listed species. This passerine bird would be exposed to chemicals bioaccumulated into plants and invertebrates. While foraging, the cardinal may inadvertently ingest small quantities of soil. The cardinal is not a ground nesting species; therefore, exposure by means of dermal absorption and inhalation would be limited.

The northern harrier and the short-eared owl are also ground-nesting species. If they nest on-site, they may be exposed to contaminants through dermal and inhalation pathways; however, they might be primarily exposed to soil contaminants through their diets.

Quantification of Exposure

The purpose of the ecological exposure assessment is to define the exposure concentrations or doses from site-related contaminants that could potentially pose a threat to ecological receptors. This definition includes estimates of doses received through defined routes of exposure.

As previously noted, in assessing the potential ecological risk posed by the hypothetical discharge of groundwater contaminants to the surface water, the PRA considered the future potential impact of the groundwater as it may contribute to future sediment and surface water contamination. Because groundwater from AOC FS-19 flows downgradient and eventually discharges to Edmunds Pond, the risks associated with the potential exposure of pelagic aquatic receptors to contaminated groundwater is addressed in the PRA. The potential risks to pelagic aquatic receptors inhabiting Edmunds Pond were qualitatively evaluated by comparing the total and dissolved concentrations of COCs detected in AOC FS-19 groundwater to the aquatic benchmark values presented in Table 0-2 of the RAH or to available federal AWQC and guidelines (USEPA 1991).

Exposure estimates were based conservatively on the current measured concentrations of COCs in AOC FS-19 groundwater without corrections for possible dilution or attenuation by chemical, physical, or biological processes. It was also conservatively assumed that aquatic receptors will be exposed to the COCs in surface water at current groundwater concentrations without dilution by the surface water itself nor reduced by chemical or physical processes within the receiving surface waters.

While the aforementioned assumptions resulted in a conservative quantification of surface water exposures to pelagic aquatic receptors, similar risks to benthic receptors using groundwater-derived data could not be made. To pelagic aquatic receptors, similar assumptions regarding future potential sediment contaminant concentrations cannot be made. The characteristics of the sediments will influence the availability and the specification of the COCs. The potential transformations may occur at the point of groundwater discharge, and contaminants may be transformed into less toxic forms through natural biodegradation processes. Also, a COC may or may not be completely dissolved in sediment pore water or may be strongly sorbed to sediment constituents such as organic matter, thus resulting in a contaminant's being less bioavailable. The locations of discharge of the groundwater and the physical and chemical characteristics of the sediment in Edmunds Pond that would receive groundwater discharge cannot be predicted based on currently available data. As a result, possible groundwater COC-associated body burdens of the primary producers (aquatic vegetation) inhabiting Edmunds Pond cannot be reasonably determined, nor can contaminant levels be determined for higher trophic levels. Thus, the groundwater COC-associated exposure doses for food chain indicator species that inhabit Edmunds Pond cannot be quantified.

The ecological exposure dose was modeled for the terrestrial indicator species selected to represent species that may occur in AOC FS-19. The doses were calculated for both the mean and maximum concentrations of each COC. The results of the modeling are provided in Tables 2-101 through 2-118.

Ecological Effects Assessment

The PRA used the following endpoints for evaluating potential effects on terrestrial wildlife:

- A reduction in population or production of local vertebrate or plant groups.
- Any toxic effect on an individual of a state-protected species sufficient to impair survival or reproduction.

It is assumed that, by protecting the individual, all levels of the ecosystem (i.e., populations and communities) are protected. Potential impacts on terrestrial species are evaluated by estimating an "acceptable applied daily dose" for each of the major receptor groups: herbivorous mammal, carnivorous mammal, herbivorous bird, and carnivorous bird. These estimated acceptable doses are then compared with the modeled daily intakes to determine if acceptable soil or sediment concentrations found on-site are acceptable.

The ecological endpoint for plants was based on protection of the most sensitive species. Phytotoxicity values were obtained from the RAH. These values for soils were set to approximate the lowest concentrations at which a measurable effect on plant growth or germination could be expected for plants growing in soil.

For the purposes of this risk assessment, the federal AWQC (USEPA 1991) were used as benchmarks to quantify potential impacts to pelagic aquatic populations (i.e., aquatic populations inhabiting the water column). These criteria were designed to protect approximately 95% of the aquatic populations potentially exposed. For chemicals that did not have AWQC values, aquatic benchmark values provided in Table O-2 were used, as described in the RAH. In Table G-4 of the RAH, the values for cadmium, chromium, nickel, lead, and zinc were adjusted for water hardness (mg $CaCo_3$/L) of 14 mg/L using hardness equations for AWQC.

The toxicity data and derivation of acceptable applied daily doses for wildlife and the acceptable exposure concentrations for plants and aquatic populations are discussed below. These data were used to calculate benchmark values for both wildlife indicator species and plants.

Ecological Benchmarks

Benchmark values for terrestrial vegetation were obtained using phytotoxicity information contained in Tables O-3 and O-4 of the RAH. The phytotoxicity values used as benchmarks were based on protection of the most sensitive vegetation species. Benchmarks for the surface soil COC in AOC FS-19 are presented in Tables 2-119 and 2-120. These benchmark values for soils approximate the lowest soil concentrations at which a measurable effect on plant growth or germination would be expected.

The "acceptable applied daily dose" used as the terrestrial wildlife benchmark was based on the maximum dose (mg of chemical/kg of body weight/day) that was not expected to have a long-term adverse effect upon the animal. These doses were taken from current literature where available (Sample et al. 1996). In the absence of appropriate literature values, doses were obtained from Table O-1 in Appendix O of the RAH. When possible, the highest NOAEL from a chronic study of oral exposure in which organisms from the same taxonomic class were used

for determining the acceptable concentrations, although such studies were rare. The NOAEL is defined as the dose at which no adverse effects were observed in the exposed animals. This type of data is not always available. Therefore, the acceptable applied daily dose was extrapolated from other toxicological studies and the appropriate uncertainty factors were applied.

The four animal receptor groups are herbivorous mammal, carnivorous mammal, herbivorous bird, and carnivorous bird. When possible, the toxicity benchmark value selected for each animal trophic group was based on a test species from the same animal group (e.g., the toxicity value for an herbivorous mammal was based on the test data on herbivorous mammals) and on laboratory tests using reproductive endpoints because reproduction is essential to the survival of a population. When a trophic-specific toxicity value was unavailable, the toxicity value for an herbivore was used because it is assumed that absorption would be greater due to the longer gut length in herbivores. Frequently, benchmarks were not available for birds. Therefore, mammal toxicity data were used.

The estimated acceptable daily doses or benchmark values for receptor populations were obtained from the literature or the RAH as appropriate. These values were compared to estimated daily doses calculated for each of the identified receptor species. These COC-specific estimated and acceptable daily doses are presented in Tables 2-121 through 2-138.

Estimated exposure doses for the white-footed mouse and the meadow vole were compared to the acceptable daily doses for an herbivorous mammal. Estimated exposure doses for the short-tailed shrew were compared to the acceptable daily doses for a carnivorous mammal because acceptable daily doses for insectivorous mammals such as the shrew were not available in the RAH. The shrew consumes large soil invertebrates, such as earthworms, and two of the COCs, dieldrin and DDT, can potentially bioaccumulate in earthworms. Herbivores experience less exposure from food ingestion than insectivores, omnivores, and carnivores. Carnivores can potentially experience higher exposure doses of the organic contaminants that biomagnify through the food chain transfer. Predators can be severely affected if they ingest prey containing organic contaminants. For these reasons, the shrew's exposure doses were compared to acceptable daily doses for a carnivorous mammal rather than an herbivorous mammal.

Daily exposure doses estimated for the upland sandpiper and the grasshopper sparrow were compared to acceptable daily doses for a carnivorous bird. Because of the dietary preferences of the upland sandpiper and grasshopper sparrow (i.e., large insects rather than plant matter), there is the potential for dieldrin and DDT to bioaccumulate in their food items. In addition, DDT can cause eggshell thinning and thus decrease the reproductive success of individual birds. The raptors can potentially experience higher exposure doses of the organic contaminants that biomagnify through the food chain transfer.

Aquatic benchmark values for use in the PRA were taken from Appendix 0, Table 0-2 of the RAH. Table 0-2 provides freshwater aquatic benchmarks for several contaminants. Aquatic benchmark values represent the maximum acceptable toxicant concentration (MATC) as the selected benchmark for aquatic risk evaluation. The MATC is an estimate of the chronic toxicity

threshold that is the geometric mean of the no observed-effect-concentration and lowest-observed-effect-concentration. When the listed test organism from the toxicological studies was not applicable to the organism being assessed, an appropriate surrogate species with a quantified MATC value was selected.

2.6.5.3 Risk Characterization

The AOC FS-19 PRA follows the methodology for a Tier III ecological risk assessment, as outlined in the RAH, using HQs to calculate an HI. The HI is cumulative by exposure pathway and, where risks were elevated, by chemical class. For each COC, an HQ is calculated by dividing the exposure concentration (maximum or mean) or the food-chain exposure doses for terrestrial model receptors by a benchmark value. The HI is the sum of the HQ values for all contaminants within the pathway:

$HI = \sum$ (observed contaminant concentration/benchmark value)
or
$HI = \sum$ (estimated exposure dose/benchmark value).

HIs were developed for both maximum and mean detected concentrations for each medium by comparing the detected concentrations with appropriate benchmark values. Values greater than 1.0 did not necessarily indicate a potential ecological hazard but, instead, suggested that the potential for biological effects among receptors exposed to COCs by the pathway be evaluated.

Risk to Terrestrial Vegetation

The evaluation of risk to plants at AOC FS-19 is based on concentrations of contaminants in soil known or predicted to be toxic to vegetation. HQs are calculated for each COC and then summed to derive an HI for terrestrial vegetation.

Tables 2-119 and 2-120 present the contaminant concentrations, benchmark values, calculated HQs, and resultant HIs for maximum and mean contaminant concentrations in the on-site soils. The terrestrial vegetation HIs are summarized as follows:

Terrestrial Vegetation Hazard Index

Hazard Index	Maximum COC Concentrations	Mean COC Concentrations
Inorganics	3.17	2.0
SVOCs	0.16	0.2
VOCs	0.002	0.003
Pesticides/PCBs	0.17	0.096
TOTAL	3.5	2.3

For surface soils, none of the mean concentrations had HQs exceeding 1.0. Lead is the only COC maximum concentration that generated an HQ greater than 1.0 (HQ = 1.9). The inorganic COCs contributed to the overall HI that exceeded 1.0. When characterizing the potential risk posed to terrestrial vegetation from the contaminants present in on-site soils, the greater the HI, the greater the likelihood of potential risk to these receptors. HIs greater than 1.0 indicate that terrestrial vegetation may be affected by contaminant concentrations in the soils.

The results of the Tier III analysis suggest that risk to terrestrial plants may be present, based on the cumulative HI. However, considering the limited size of the site, and the fact that, with the exception of lead, no individual contaminant had an HQ over 1.0, the actual risk to terrestrial vegetation may be limited.

Risk to Aquatic Receptors

The evaluation of risks to aquatic receptors was based on HIs developed using on-site groundwater concentrations with both total and dissolved inorganic concentrations. HIs developed for AOC FS-19 and the selected benchmarks used to calculate a compound specific HQ are provided in the RAH. They consist primarily of AWQC values.

HIs for the groundwater concentrations in this area were calculated and are presented in Tables 2-139 and 2-140. These tables present the contaminant concentrations, benchmarks, calculated HQs, and resultant HIs for maximum and mean contaminant concentrations in the aquatic media.

The aquatic HIs are summarized as follows:

Aquatic Hazard Indices

	Maximum Contaminant Concentration		Mean Contaminant Concentration	
Hazard Index	Total	Dissolved	Total	Dissolved
Inorganics	81.6	6.0	21.3	2.9
TOTAL	81.6	6	21.3	2.9

While HIs>1.0 indicate the potential for adverse effects, these HIs do not necessarily indicate an appreciable effect based on applicable assessment of endpoints (i.e., population effects, reproduction effects, etc.). With the exception of nonmobile benthic invertebrates and terrestrial plants, an HI of 10 or more is an appropriate risk management criterion because of the uncertainty inherent in the exposure and hazard estimates; the appropriate assessment endpoint is protection of populations rather than individuals. An HI of 10 is probably adequate to protect

most animal populations in the AOC FS-19 Study Area because they have home ranges larger that the AOC area.

Exposure concentrations for pelagic aquatic receptors were based on an evaluation of COCs detected in the groundwater and were conservatively based on currently measured concentrations. In quantifying exposure, it was conservatively assumed that aquatic receptors would be exposed to the contaminant levels currently measured in the groundwater and that contaminant levels would not be diluted by surface water inputs. It was also assumed that bioavailable fractions would not be reduced by chemical, physical, or biological processes occurring in the surface waters. In Tables 2-139 and 2-140, the HIs for aquatic receptors using both total and dissolved concentrations in groundwater exceed 1.0. If aquatic receptors were exposed to these groundwater COC concentrations in surface water, then adverse effects to pelagic aquatic receptors would be expected. For maximum groundwater COC concentrations for unfiltered groundwater, all HQs for individual COCs exceed 1.0 (Table 2-139). Based on mean groundwater COC concentrations for unfiltered groundwater, HQs for copper, and lead, exceed 1.0. Dissolved groundwater concentrations for inorganic COCs are considered more indicative of actual risk to pelagic aquatic receptors because this is typically the bioavailable fraction and because the AWQC are derived from contaminant concentrations dissolved in water. According to filtered groundwater data, as shown in Tables 2-139 and 2-140, lead dissolved in groundwater could pose a potential threat to potential aquatic receptors.

Risks to Terrestrial Receptors

The evaluation of risk to terrestrial vertebrate receptors at AOC FS-19 was based on the risks associated with the terrestrial food chain. The risks were evaluated by estimating the exposure dose based on the organisms' feeding habits and habitat preferences. For each selected terrestrial vertebrate receptor, a daily maximum or mean exposure dose of a COC in units of mg COC per body weight of the animal is compared to a COC-specific adjusted oral benchmark value in the same units. These adjusted oral benchmark values or terrestrial wildlife benchmarks were obtained from current literature values and Table 0 in the RAH. In Table 0, the terrestrial wildlife benchmarks have been grouped by vertebrate group and trophic position. The four groups include herbivorous mammal, carnivorous mammal, herbivorous bird, and carnivorous bird. A terrestrial wildlife benchmark group was selected for each selected vertebrate receptor species based on the feeding strategy and trophic position of the vertebrate receptor. Comparing a COC exposure dose for a particular vertebrate receptor species to an adjusted COC benchmark value produces a COC-specific HQ. The HQ represents the potential risk posed by a COC to the vertebrate receptor. The COC-specific HQs are summed to derive an HI. The HI represents the potential cumulative risk posed by COCs to the vertebrate receptor.

HIs were developed for each indicator species likely to reside in AOC FS-19. Tables 2-121 through 2-138 present the contaminant concentrations, benchmark values, calculated HQs and resultant HIs for maximum and mean contaminant concentrations. The food chain HIs are summarized as follows.

Food Chain Exposure Hazard Index Summary

TERRESTRIAL SPECIES	Maximum HI	Mean HI
Meadow vole	0.4	0.3
Northern short-tailed shrew	1.4	0.9
Upland sandpiper	4.4	2.0
Grasshopper sparrow	0.1	0.1
White-footed mouse	0.2	0.1
Northern harrier	0.004	0.003
Short-eared owl	0.003	0.002
Red fox	0.0002	0.0001
Northern cardinal	5.3	2.5

The meadow vole grasshopper sparrow, white-footed mouse, northern harrier, short-eared owl, and the red fox are not expected to experience adverse effects associated with individual exposures to COCs in surface soil. The HIs based on maximum detected surface soil concentrations, as shown above, are less than 1.

For the insectivorous northern short-tailed shrew, the total HI using maximum detected concentrations in surface soil was 1.4 (Table 2-125). No single COC had an HQ greater than 1. The COC with the highest HQ was arsenic (HQ = 0.36). Using mean concentrations, the total HI was 0.9 (Table 2-126). No single COC had an HQ greater than 1. The COC with the highest HQ was arsenic (HQ = 0.27). Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the upland sandpiper, the total HI using maximum detected concentration in surface soil was 4.4 (Table 2-127). The pesticide 4,4'-DDT was the primary contributor to risk with an HI of 4.4. The total HI using mean concentration data was 2.0 with 4,4'-DDT as the primary contributor to risk (HQ = 1.8) (Table 2-128). Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

For the northern cardinal, the total HI using maximum detected concentrations in surface soil was 5.3 (Table 2-129). The pesticide 4,4'-DDT (HQ = 3.3) and cyanide (HQ = 1.7) were the primary contributors to risk. The total HI using mean concentrations was 2.5. The pesticide 4,4'-DDT (HQ = 1.4) was the primary contributor. Because the total HI for maximum detected surface soil concentrations for all COCs was less than 10, HQs were not summed by chemical class for this terrestrial model receptor.

Risk Characterization Summary

As the evaluation presented herein represents a Tier III analysis, values greater than 1.0 are not necessarily indicative of a potential hazard, but they do suggest that the potential ecological effects of the COCs in the evaluated media should be considered further or qualified.

The potential risks associated with groundwater COCs originating from the site to pelagic aquatic receptors in Edmunds Pond were qualitatively evaluated. It was conservatively assumed that aquatic receptors will be exposed to the concentrations of COCs measured in the on-site groundwater and that contaminant levels will not be diluted by surface water inputs, nor will toxicity be reduced by chemical, physical, or biological processes while migrating through subsurface or at the point of discharge. Concentrations of contaminants in the dissolved fraction are considered more indicative of actual risk to pelagic aquatic receptors because the AWQC are derived from contaminant concentrations dissolved in water, and dissolved concentrations in surface water represent what is bioavailable to aquatic receptors. For filtered groundwater data, lead dissolved in groundwater could pose a potential threat to aquatic receptors. However, to gain a perspective on the predicted risk, Table 2-77 characterizes the potential aquatic risks associated with maximum background concentrations for dissolved inorganic compounds in MMR groundwater. The calculated HI (272) for maximum dissolved background concentrations in MMR groundwater is higher than the HI for AOC FS-19 representing aquatic risks associated with dissolved COC concentrations detected in one-site groundwater. Therefore, further investigation of potential aquatic risks attributed to AOC FS-19 groundwater is not warranted based on naturally occurring background conditions existing within MMR. Additionally, a high level of uncertainty is associated with estimated risk for surface water exposures using groundwater concentrations. Risks would be grossly overestimated because concentrations in groundwater would likely diminish greatly after upwelling into surface water bodies.

HIs representing predicted adverse effects associated with surface soil COCs to terrestrial vegetation exceed 1.0. Therefore, potential adverse impacts to terrestrial vegetation may have occurred. Maximum and mean COC concentrations are presented on a sitewide basis for AOC FS-19, and HIs represent cumulative adverse impacts of the COCS. Because, plants are immobile, they experience concentrations at only one location, not several. To evaluate risks to ground vegetation properly, concentrations detected location-by-location should be used to estimate potential risks to organisms that tend to remain at one location. Because this is not practical however, mean concentrations may accurately evaluate COC concentrations that may be experienced by terrestrial plants. To discriminate the level of potential risk posed by naturally occurring background concentrations of these inorganic compounds versus that posed by concentrations of the inorganic compounds contributed by past on-site activities, the potential terrestrial risks associated with maximum MMR background soil concentrations were also characterized. The derivation of these HIs is presented in Tables 2-78. When comparing the HI for mean COC concentrations in soil to the HI representing MMR background levels in soil, the HI for the site is only approximately 30% higher than the HI representing MMR background levels in soil. However, considering the limited size of the site, the incremental risk above

background, and the fact that no contaminant had an HQ over 1.0, further consideration of risk to terrestrial vegetation is not considered to be warranted.

The results of the Tier III analysis for terrestrial wildlife indicate that the risk estimates for the quantified exposure pathways at AOC FS-19 pose little or no threat to individual wildlife species. The PRA used the following assessment endpoints for evaluating potential adverse impacts to terrestrial wildlife attributed to the presence of COCs in surface soil:

- A reduction in population or production of local vertebrate or plant groups.
- Any toxic effect on an individual of a state-protected species sufficient to impair survival or reproduction.

The northern short-tailed shrew and the northern cardinal are not state-protected species but are indigenous to MMR. Therefore, the potential reduction in population sizes or reduction of local vertebrate species is considered a significant impact. Although the HIs for these receptors is slightly greater than 1, it is not expected that individual animals will be at an appreciable risk because the HI does not exceed 10 and the toxicity values used in the assessment were NOAELs. Therefore, potential effects on the local breeding population of these receptor species are likewise not expected due to the very low HI. In addition, it is unknown whether the receptor species use AOC FS-19 habitats, because the model receptors were selected based on types of habitats in AOC FS-19 and a review of information identifying species known or expected to occur at MMR. No formal ecological field surveys were conducted as part of the Tier III analysis to confirm that the selected receptor species actually are present at the site or that a suitable habitat exists to support the receptors.

It is not likely that AOC FS-19 supports bird or mammal populations that represent a significant portion of the total population within MMR because of the small grass area of AOC FS-19 (approximately 0.07 acre). If the insectivorous and omnivorous receptor species are on-site and were significantly affected as a result of exposure to COCS, the loss of these individuals may not affect the MMR population size. Animals that may inhabit AOC FS-19 and are prey for raptors or predators may not represent a significant portion of the diet for the carnivores inhabiting MMR.

Population density, which is defined as the number of individuals inhabiting a measurable area, can be significant when estimating an effect of a COC on a species population. The habitat requirements of a species control its population density. Density is a dynamic quantity, changing as animals or birds are born, die, and migrate. Density is measured at a particular time and can only be meaningfully compared to measurements taken at approximately the same time in other years. The population densities of the selected receptor species have not been measured for AOC FS-19 or for MMR.

The upland sandpiper is a state-protected species, and based on the estimated HIs for the species, potential dietary exposure to surface soil COCs may cause toxic effects in individual upland sandpipers. For this reason, and based on the results of Tier III risk analysis, some risk to

the upland sandpiper may exist. However, a degree of uncertainty is introduced into the risk estimates for this species because the upland sandpiper may not use the site. Based on the physical characteristics of AOC FS-19, the habitat quality of AOC FS-19 for this bird is low compared to other areas in the MMR. If upland sandpipers use AOC FS- 19, it should be noted that the COC body burdens of the on-site portion of their diet (soil macroinvertebrates) were modeled values and were not measured.

Dermal and inhalation exposure pathways were not evaluated in this Tier III PRA. Contaminated soil adhering to a target organism's skin or particulates that are directly inhaled may result in increased exposure and risk. However, exposure via these routes was judged to be minor when qualitatively compared to the food chain exposure route.

2.6.6 Conclusions for Human Health and Ecological Risk for AOC FS-19

Actual or threatened releases of hazardous substances from AOC FS-19 do not present an imminent and substantial endangerment to public health, welfare, or, the environment. The AOC FS-19 does not pose any unacceptable human health and ecological risks.

2.7 DESCRIPTION OF NO FURTHER ACTION ALTERNATIVE

The No Further Action alternative for AOC FS-17 and FS-19 allows for unrestricted use of the sites because no remedial action is necessary to protect human health and the environment. No additional structures will be removed from AOC FS-17 and AOC FS-19. Additional soils will not be excavated. Groundwater will not be treated in situ, nor will it be extracted and treated. Additional soil and groundwater sampling will not be performed with respect to the sites.

2.8 DOCUMENTATION OF NO SIGNIFICANT CHANGES

AFCEE presented a Proposed Plan for No Further Action at AOC FS-17 and AOC FS-19 source areas at a public information meeting held on December 9, 1998, at the Otis Theater, Building 5219, Turpentine Road, MMR, and at a public hearing held on January 8, 1999, at Building 330, MMR. There have been no significant changes made to the No Further Action alternative presented in the Proposed Plan.

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3. RESPONSIVENESS SUMMARY

This Responsiveness Summary has been prepared to meet the requirements of Sections 113(k)(2)(B)(iv) and 117(b) of CERCLA as amended by SARA, which requires response to "... significant comments, criticisms, and new data submitted in written or oral presentations" on a Proposed Plan for remedial action. The purpose of this Responsiveness Summary is to document AFCEE's responses to questions and comments expressed during the comment period by the public, potentially responsible parties, and governmental bodies in written and oral comments regarding the *Proposed Plan For No Further Action for Soils and Groundwater at the FS-17 and FS-19 Sites at the Massachusetts Military Reservation* (MMR 1998).

3.1 OVERVIEW

No Further Action is the selected action for AOC FS-17 and AOC FS-19 soils and groundwater. The No Further Action decision has not been changed from the No Further Action decision presented to the public in the Proposed Plan. Community representatives have not provided comments to the Proposed Plan.

3.2 BACKGROUND AND COMMUNITY INVOLVEMENT

The National Guard Bureau (NGB) and AFCEE have held regular informational meetings, issued fact sheets, and held public meetings to keep the community and other interested parties informed of activities at the two AOCs covered in this ROD. The NGB was responsible for the IRP at MMR until 1996, when AFCEE assumed this responsibility.

Throughout MMR's history, community concern and involvement have been high. The NGB, AFCEE, USEPA, and MADEP have kept the community and other interested parties apprised of site activities through informational meetings, fact sheets, news releases, public hearings, and TEAC meetings. TEAC was organized in 1986 by NGB to provide a forum for public input on the MMR response activities. Membership in TEAC comprised USEPA, MADEP, and representatives from local, regional, and state groups. Beginning with the October 7, 1992 TEAC meeting, members of the public could attend these bimonthly meetings. TEAC is no longer in existence.

During May 1991, an MMR Community Relations Plan was released that outlined a program to address community concerns and keep citizens informed and involved in the remediation process at MMR. In July 1994, and again in December 1996, an updated draft Community Relations Plan was issued to incorporate concerns and feedback provided by the community and to document changes in AFCEE policy.

In October 1993, a Senior Management Board was created to advise AFCEE on IRP activities. A person from each of the four towns surrounding MMR is among the Board

members, along with the regulatory agencies and the Adjunct General's Office of the Commonwealth of Massachusetts. PATs were also created to address specific issues at MMR; these issues including plume containment, long-range water supplies, innovative technologies, and public information. PATs have representation from the community, local business, regulatory agencies, and AFCEE.

AFCEE published a notice of the Proposed Plan Meeting and the Proposed Plan Hearing for AOC FS-17 and AOC FS-19 in the *Falmouth and Mashpee Enterprises*, the *Cape Cod Times*, and the *Bourne and Sandwich Enterprises* on November 27, 1998. The notices indicated that the comment period would extend from December 9, 1998, through January 8, 1999. Before the start of the comment period, AFCEE made the RI reports, the Feasibility Study, and Proposed Plan available for public review at the U.S. Coast Guard library at MMR and at the main public libraries in Bourne, Falmouth, Mashpee, and Sandwich, Massachusetts. The Proposed Plan has also been made part of the Administrative Record available for public review at the AFCEE IRP office at MMR and at the Falmouth Public Library.

From December 9, 1998, to January 8, 1999, AFCEE held a 30-day public comment period to accept public comments on the No Further Action decision presented for AOC FS-17 and AOC FS-19 in the Proposed Plan. On December 8, 1998, AFCEE held a Public Meeting at the Otis Theater, Building 5219, Turpentine Road, MMR, to present and discuss the Proposed Plan. On January 5, 1999, AFCEE held a Public Hearing at Building 330, MMR, to accept verbal comments on the Proposed Plan. No representatives of the general public attended the public meeting for AOC FS-17 and AOC FS-19. No representatives of the general public attended the Public Hearing for AOC FS-17 and AOC FS-19. Because no public attended the Public Hearing, no comments were received from the public at the hearing. No formal comments were submitted by the public through any venue during the public comment period extending from December 9, 1998, through January 8, 1999. A transcript of the January 5, 1999, Public Hearing is included in Appendix D. AFCEE's responses to the comments received at the hearing and during the public comment period are included in Appendix C.

3.3 SUMMARY OF COMMENTS RECEIVED AND RESPONSE TO THOSE COMMENTS

No comments were received from the public regarding the No Further Action decisions for AOC FS-17 and AOC FS-19. Because no comments were received, there are no responses.

3.4 NO FURTHER ACTION DECISION CONCERNS

The public has not expressed any concerns regarding the No Further Action decisions for AOC FS-17 and FS-19.

4. STATE ROLE

The Commonwealth of Massachusetts has reviewed the SI, RI, Feasibility Study reports, and Proposed Plan and concurs with the proposed remedial action decisions. The Commonwealth has also reviewed these documents to determine if the decision complies with applicable or relevant and appropriate laws and regulations of the Commonwealth. A copy of the letter of concurrence from the Commonwealth of Massachusetts is attached as Appendix E to this ROD.

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APPENDIX A
FIGURES

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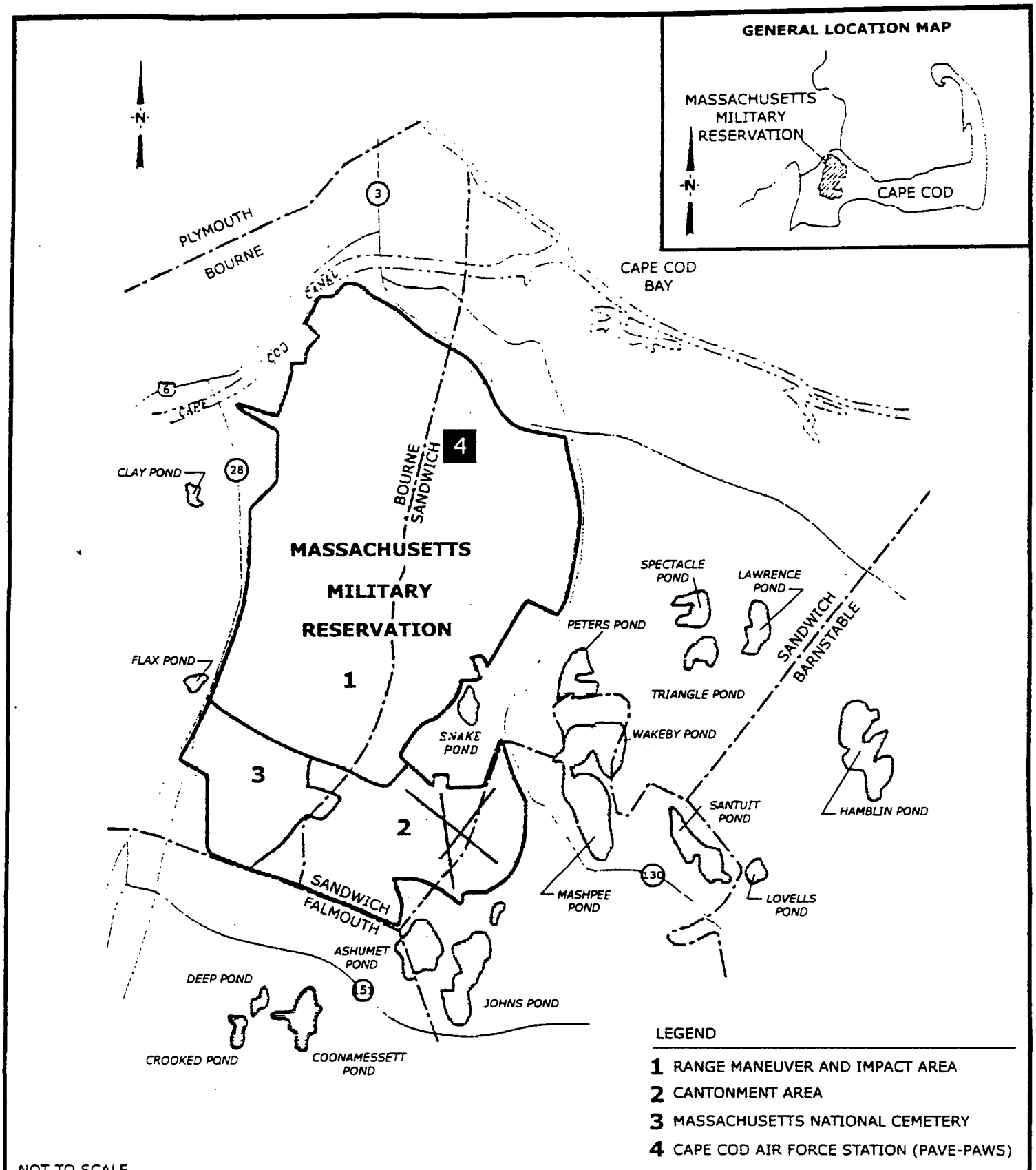
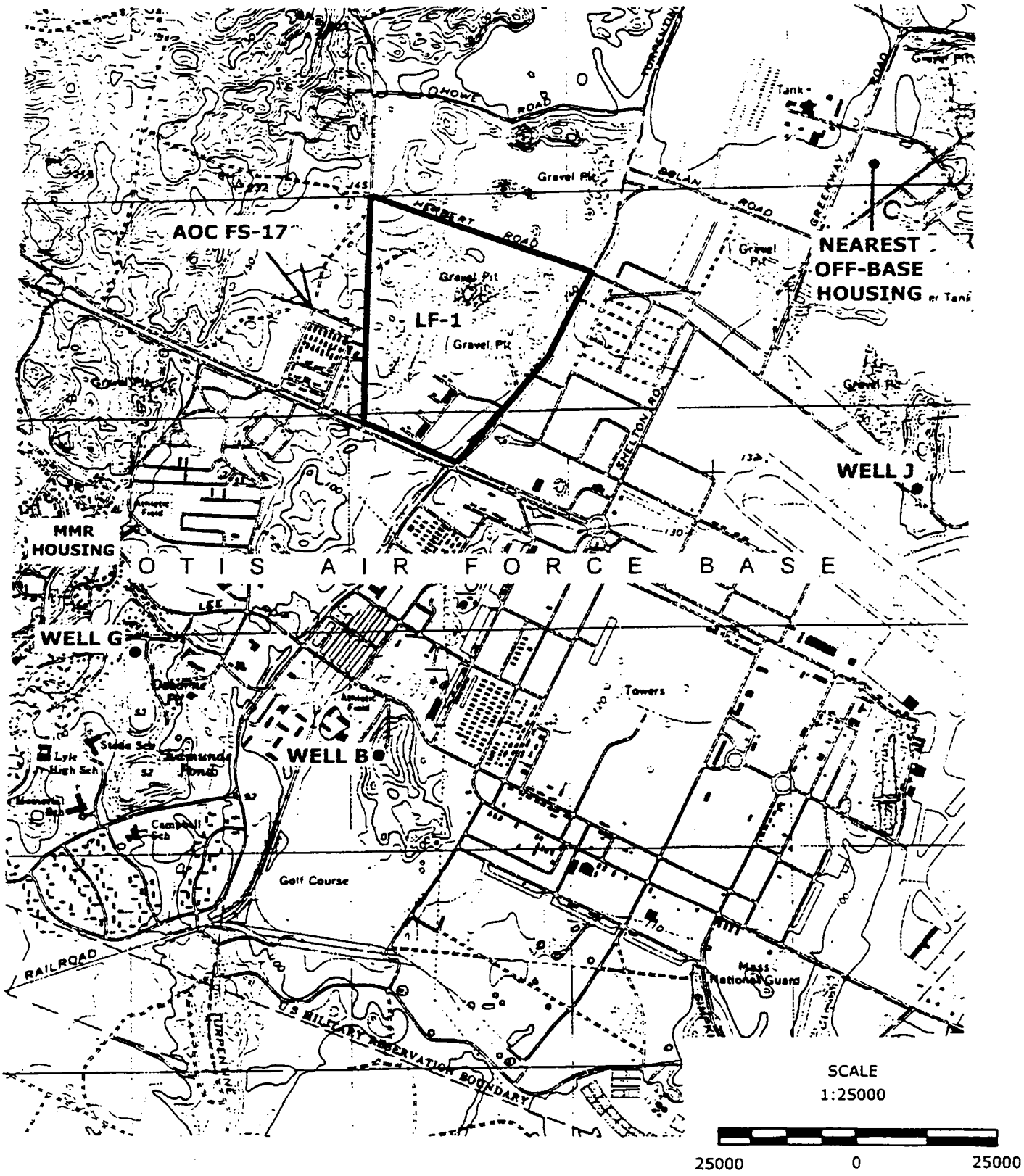


LOCATION MAP

MASSACHUSETTS MILITARY RESERVATION

FIGURE NO. 2-1

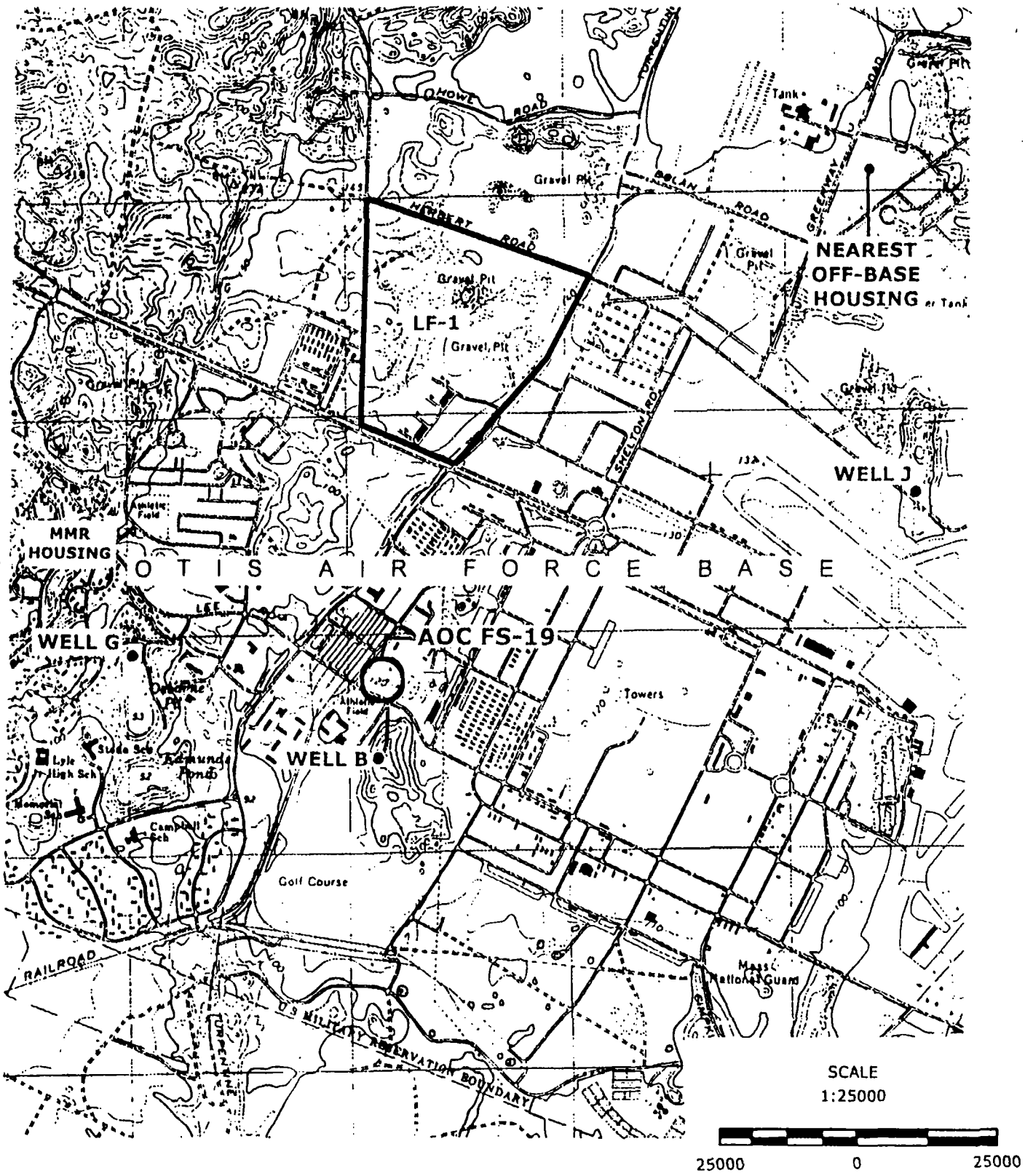


AOC FS-17

SITE AND NEARBY LAND USE CHARACTERISTICS

MASSACHUSETTS MILITARY RESERVATION

FIGURE NO. 2-2



AOC FS-19

SITE AND NEARBY LAND USE CHARACTERISTICS

MASSACHUSETTS MILITARY RESERVATION

FIGURE NO. 2-3

NOTE:
1. PHYSICAL FEATURES SHOWN ON THIS FIGURE WERE EXISTING AT THE TIME OF THE RI FIELD INVESTIGATIONS CONDUCTED IN 1993/1994.

3692
3693
3694
DRY WELL
FRENCH DRAIN
BREAK IN PAVEMENT
USTs - CPT 104 AND 105
FUEL ISLAND
CONCRETE PAVEMENT
LEACHING WELL
139.1
140.1
140
139.3
140.3
138.5
140.1
136.7
140
FRANK PERKINS ROAD
RAMEY ROAD
N

KEY

BREAK IN PAVEMENT/STAINED SOIL	UNDERGROUND STORAGE TANKS	EDGE OF ASPHALT PAVEMENT	FUEL ISLAND	SCALE	
CONCRETE PAD	FRENCH DRAIN	140.1 SURFACE ELEVATION	WOODED AREA	1" = 50'	
FORMER BUILDING FOUNDATION	AUTO REPAIR BAYS	140 TOPOGRAPHIC CONTOUR LINES	TELEPHONE POLE	0	50
EXISTING BUILDING			LEACHING WELL		

CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

AOC FS-17 REMEDIAL INVESTIGATION

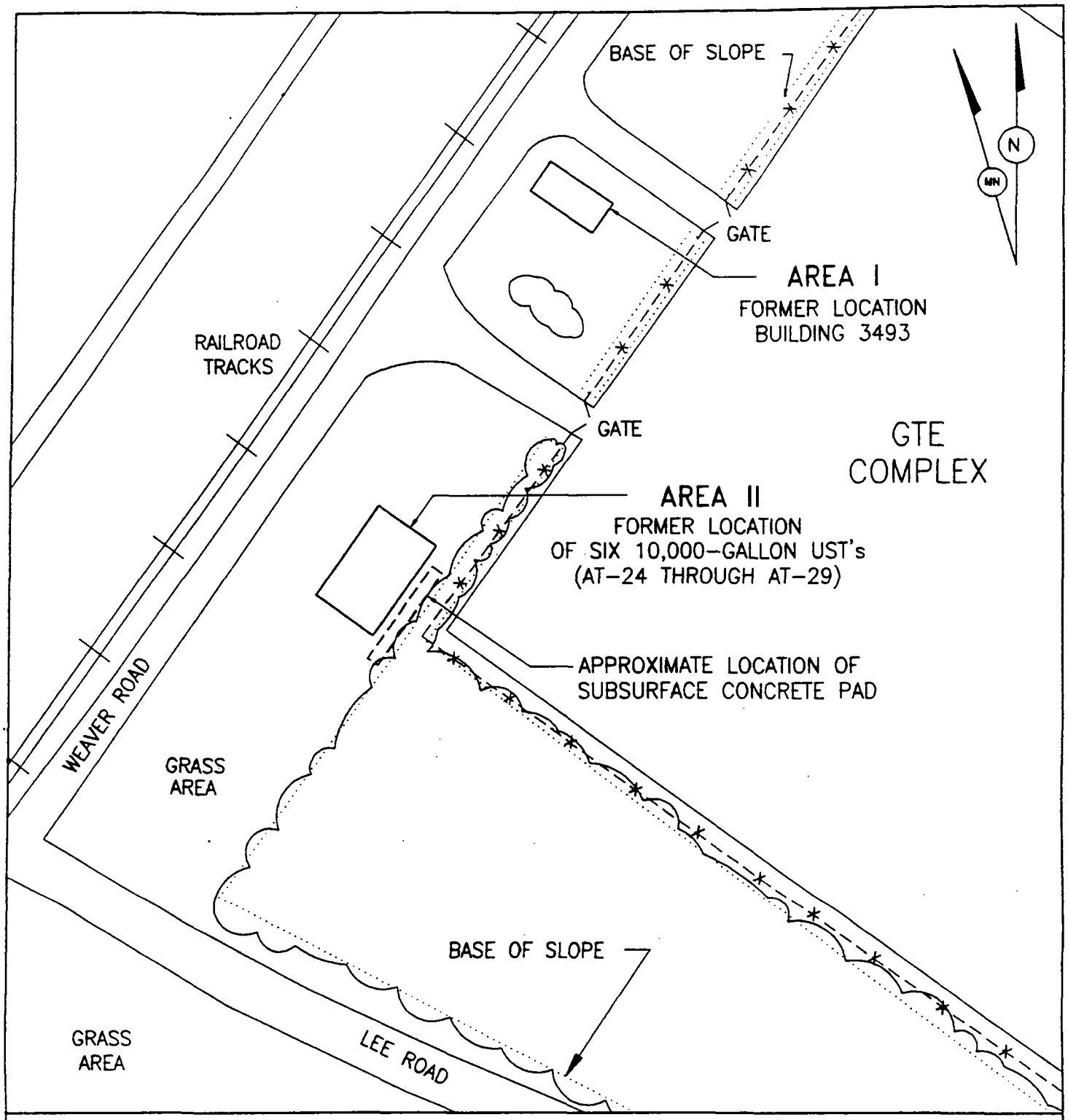
17_BASE.DWG

MAP OF SITE FEATURES

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-4

LAST REVISED 6/20/94



KEY

SCALE
1" = 80'

0 80 160

WOODED AREA

SLOPE

FENCE

APPROXIMATE LOCATION OF SUBSURFACE CONCRETE PAD

19_SITE.DWG

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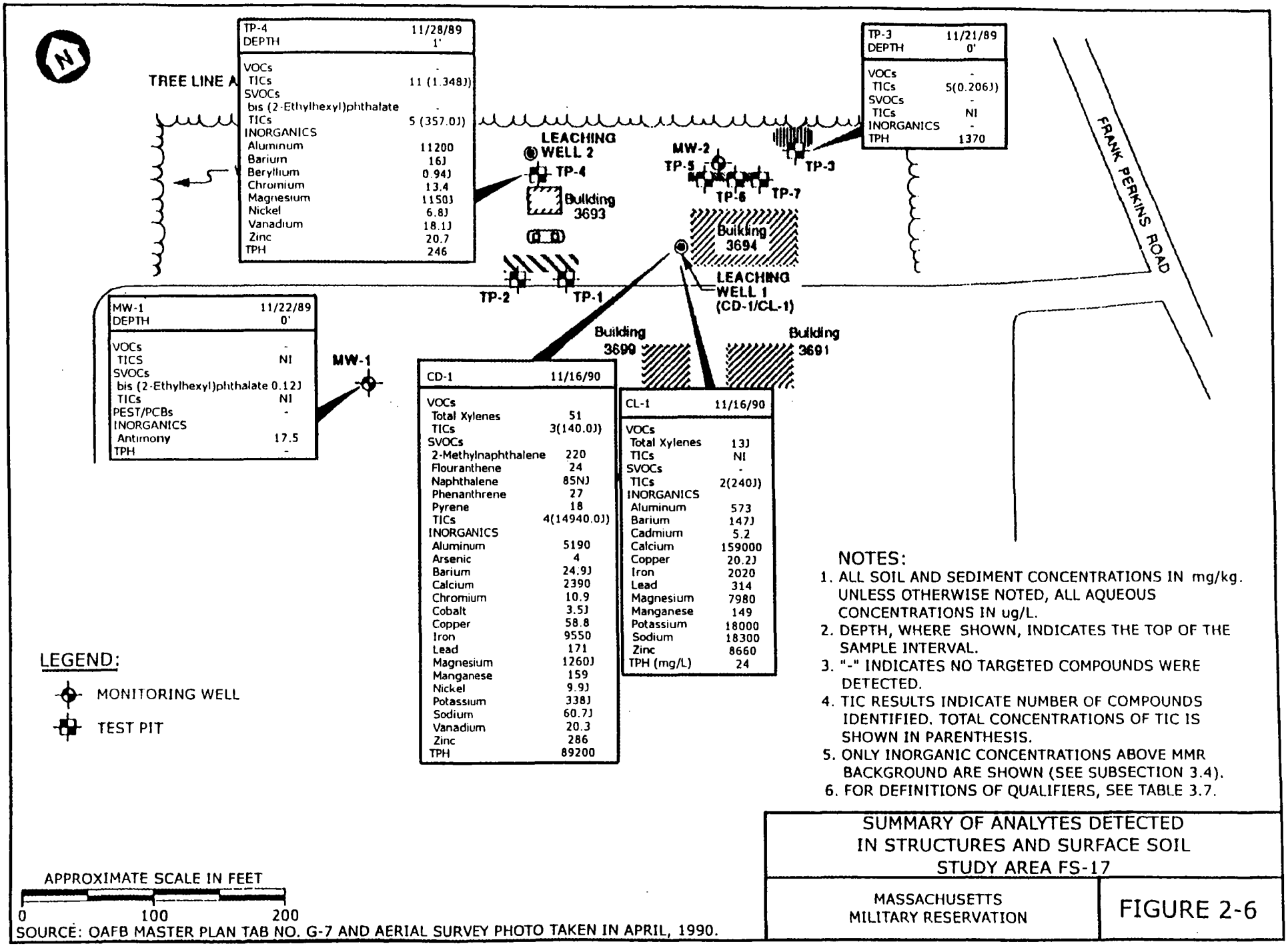
AOC FS-19 REMEDIAL INVESTIGATION

MAP OF SITE FEATURES

MASSACHUSETTS MILITARY RESERVATION

Figure No.2-5

LAST REVISED: 11-17-95



NOTES:

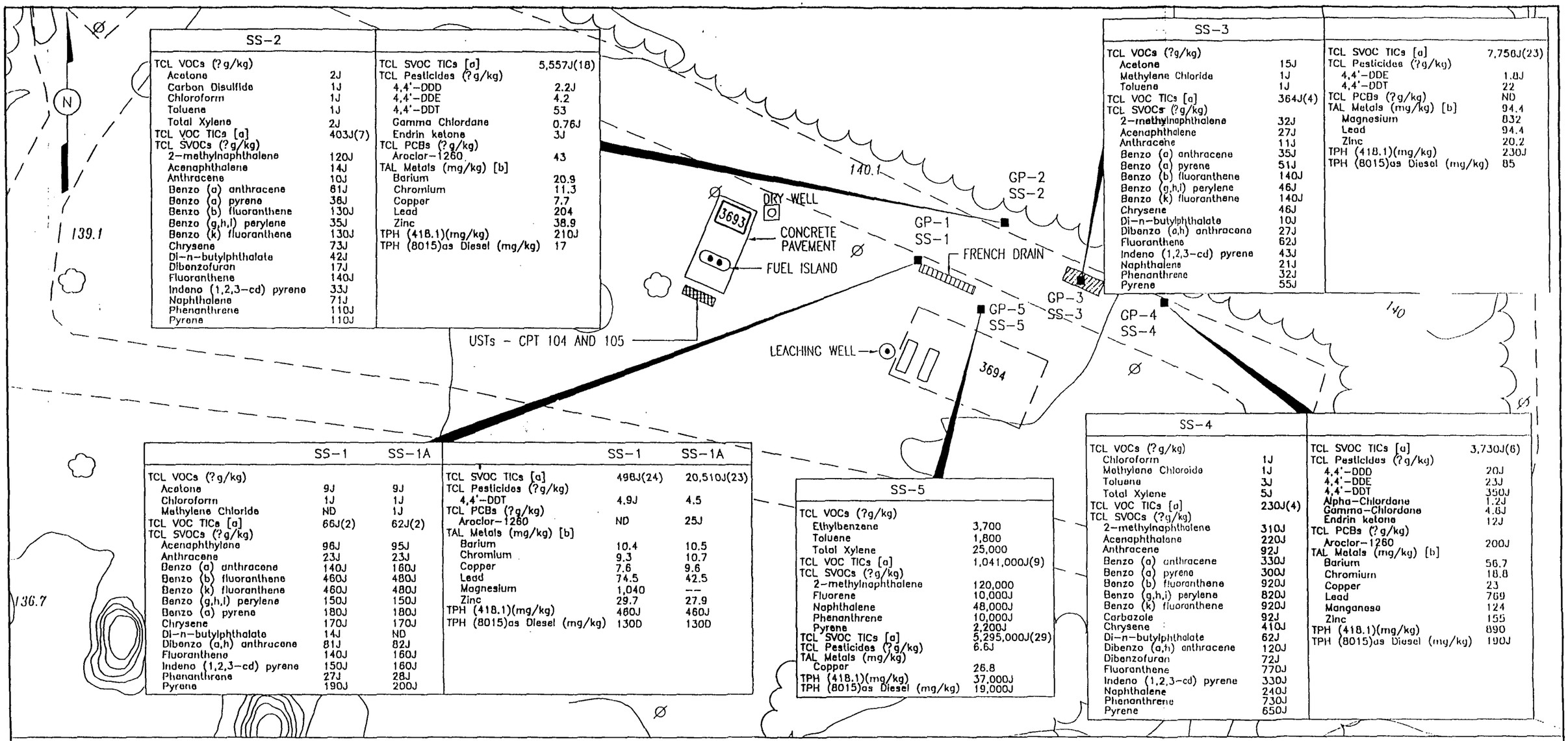
1. ALL SOIL AND SEDIMENT CONCENTRATIONS IN mg/kg. UNLESS OTHERWISE NOTED, ALL AQUEOUS CONCENTRATIONS IN ug/L.
2. DEPTH, WHERE SHOWN, INDICATES THE TOP OF THE SAMPLE INTERVAL.
3. "-" INDICATES NO TARGETED COMPOUNDS WERE DETECTED.
4. TIC RESULTS INDICATE NUMBER OF COMPOUNDS IDENTIFIED. TOTAL CONCENTRATIONS OF TIC IS SHOWN IN PARENTHESIS.
5. ONLY INORGANIC CONCENTRATIONS ABOVE MMR BACKGROUND ARE SHOWN (SEE SUBSECTION 3.4).
6. FOR DEFINITIONS OF QUALIFIERS, SEE TABLE 3.7.

SOURCE: OAFB MASTER PLAN TAB NO. G-7 AND AERIAL SURVEY PHOTO TAKEN IN APRIL, 1990.

SUMMARY OF ANALYTES DETECTED IN STRUCTURES AND SURFACE SOIL STUDY AREA FS-17

MASSACHUSETTS MILITARY RESERVATION

FIGURE 2-6



SS-2	
TCL VOCs (?g/kg)	
Acetone	2J
Carbon Disulfide	1J
Chloroform	1J
Toluene	1J
Total Xylene	2J
TCL VOC TICs [a]	403J(7)
TCL SVOCs (?g/kg)	
2-methylnaphthalene	120J
Acenaphthalene	14J
Anthracene	10J
Benzo (a) anthracene	61J
Benzo (a) pyrene	36J
Benzo (b) fluoranthene	130J
Benzo (g,h,i) perylene	35J
Benzo (k) fluoranthene	130J
Chrysene	73J
Di-n-butylphthalate	42J
Dibenzofuran	17J
Fluoranthene	140J
Indeno (1,2,3-cd) pyrene	33J
Naphthalene	71J
Phenanthrene	110J
Pyrene	110J

TCL SVOC TICs [a]	5,557J(18)
TCL Pesticides (?g/kg)	
4,4'-DDD	2.2J
4,4'-DDE	4.2
4,4'-DDT	53
Gamma Chlordane	0.76J
Endrin ketone	3J
TCL PCBs (?g/kg)	
Aroclor-1260	43
TAL Metals (mg/kg) [b]	
Barium	20.9
Chromium	11.3
Copper	7.7
Lead	204
Zinc	38.9
TPH (418.1)(mg/kg)	210J
TPH (8015)as Diesel (mg/kg)	17

SS-3	
TCL VOCs (?g/kg)	
Acetone	15J
Methylene Chloride	1J
Toluene	1J
TCL VOC TICs [a]	364J(4)
TCL SVOCs (?g/kg)	
2-methylnaphthalene	32J
Acenaphthalene	27J
Anthracene	11J
Benzo (a) anthracene	35J
Benzo (a) pyrene	51J
Benzo (b) fluoranthene	140J
Benzo (g,h,i) perylene	46J
Benzo (k) fluoranthene	140J
Chrysene	46J
Di-n-butylphthalate	10J
Dibenzo (a,h) anthracene	27J
Fluoranthene	62J
Indeno (1,2,3-cd) pyrene	43J
Naphthalene	21J
Phenanthrene	32J
Pyrene	55J

TCL SVOC TICs [a]	7,756J(23)
TCL Pesticides (?g/kg)	
4,4'-DDE	1.8J
4,4'-DDT	22
TCL PCBs (?g/kg)	ND
TAL Metals (mg/kg) [b]	94.4
Magnesium	832
Lead	94.4
Zinc	20.2
TPH (418.1)(mg/kg)	230J
TPH (8015)as Diesel (mg/kg)	85

	SS-1	SS-1A
TCL VOCs (?g/kg)		
Acetone	9J	9J
Chloroform	1J	1J
Methylene Chloride	ND	1J
TCL VOC TICs [a]	66J(2)	62J(2)
TCL SVOCs (?g/kg)		
Acenaphthylene	96J	95J
Anthracene	23J	23J
Benzo (a) anthracene	140J	160J
Benzo (b) fluoranthene	460J	480J
Benzo (k) fluoranthene	460J	480J
Benzo (g,h,i) perylene	150J	150J
Benzo (a) pyrene	180J	180J
Chrysene	170J	170J
Di-n-butylphthalate	14J	ND
Dibenzo (a,h) anthracene	81J	82J
Fluoranthene	140J	160J
Indeno (1,2,3-cd) pyrene	150J	160J
Phenanthrene	27J	28J
Pyrene	190J	200J

	SS-1	SS-1A
TCL SVOC TICs [a]	498J(24)	20,510J(23)
TCL Pesticides (?g/kg)		
4,4'-DDT	4.9J	4.5
TCL PCBs (?g/kg)		
Aroclor-1260	ND	25J
TAL Metals (mg/kg) [b]		
Barium	10.4	10.5
Chromium	9.3	10.7
Copper	7.6	9.6
Lead	74.5	42.5
Magnesium	1,040	--
Zinc	29.7	27.9
TPH (418.1)(mg/kg)	460J	460J
TPH (8015)as Diesel (mg/kg)	130D	130D

SS-5	
TCL VOCs (?g/kg)	
Ethylbenzene	3,700
Toluene	1,800
Total Xylene	25,000
TCL VOC TICs [a]	1,041,000J(9)
TCL SVOCs (?g/kg)	
2-methylnaphthalene	120,000
Fluorene	10,000J
Naphthalene	48,000J
Phenanthrene	10,000J
Pyrene	2,200J
TCL SVOC TICs [a]	5,295,000J(29)
TCL Pesticides (?g/kg)	6.6J
TAL Metals (mg/kg)	
Copper	26.8
TPH (418.1)(mg/kg)	37,000J
TPH (8015)as Diesel (mg/kg)	19,000J

SS-4	
TCL VOCs (?g/kg)	
Chloroform	1J
Methylene Chloride	1J
Toluene	3J
Total Xylene	5J
TCL VOC TICs [a]	230J(4)
TCL SVOCs (?g/kg)	
2-methylnaphthalene	310J
Acenaphthalene	220J
Anthracene	92J
Benzo (a) anthracene	330J
Benzo (a) pyrene	300J
Benzo (b) fluoranthene	920J
Benzo (g,h,i) perylene	820J
Benzo (k) fluoranthene	920J
Carbazole	92J
Chrysene	410J
Di-n-butylphthalate	62J
Dibenzo (a,h) anthracene	120J
Dibenzofuran	72J
Fluoranthene	770J
Indeno (1,2,3-cd) pyrene	330J
Naphthalene	240J
Phenanthrene	730J
Pyrene	650J

TCL SVOC TICs [a]	3,730J(6)
TCL Pesticides (?g/kg)	
4,4'-DDD	20J
4,4'-DDE	23J
4,4'-DDT	350J
Alpha-Chlordane	1.2J
Gamma-Chlordane	4.6J
Endrin ketone	12J
TCL PCBs (?g/kg)	
Aroclor-1260	200J
TAL Metals (mg/kg) [b]	
Barium	56.7
Chromium	18.8
Copper	23
Lead	769
Manganese	124
Zinc	155
TPH (418.1)(mg/kg)	890
TPH (8015)as Diesel (mg/kg)	190J

KEY

- BREAK IN PAVEMENT/STAINED SOIL
- CONCRETE PAD
- FORMER BUILDING FOUNDATION
- EXISTING BUILDING
- UNDERGROUND STORAGE TANKS
- FRENCH DRAIN
- AUTO REPAIR BAYS
- EDGE OF ASPHALT PAVEMENT
- 140.1 SURFACE ELEVATION
- 140 TOPOGRAPHIC CONTOUR LINES
- FUEL ISLAND
- WOODED AREA
- TELEPHONE POLE
- LEACHING WELL
- GP-1 SS-1 GEOPROBE LOCATION AND SURFACE SOIL LOCATION
- ND INDICATES COMPOUND NOT DETECTED
- J INDICATES ESTIMATED CONCENTRATION
- [a] TICs REPRESENT TENTATIVELY IDENTIFIED COMPOUNDS. RESULTS ARE ESTIMATED AND THE NUMBER OF TICs IDENTIFIED ARE IN PARENTHESES.
- [b] ONLY METALS EXCEEDING MAXIMUM MMR BACKGROUND ARE PRESENTED
- \- INDICATES COMPOUND DETECTED BUT AT A CONCENTRATION LESS THAN MAXIMUM MMR BACKGROUND
- TPH ANALYZED BY METHOD 418.1 AND MODIFIED METHOD 8015

SCALE
1" = 50'
0 50

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AOC FS-17 REMEDIAL INVESTIGATION

17_SOIL.DWG

CLP TCL AND TAL SURFACE SOIL ANALYSES SUMMARY

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-7

NOTE:
1. PHYSICAL FEATURES SHOWN ON THIS FIGURE WERE EXISTING AT THE TIME OF THE RI FIELD INVESTIGATIONS CONDUCTED IN 1993/1994.

GP-13
MW-7
GP-10
3692
GP-9
3693
DRY WELL
140.1
GP-12
GP-2
SS-2
GP-3
SS-3
FRENCH DRAIN
BREAK IN PAVEMENT
GP-1
SS-1
MW-2
GP-5
SS-5
GP-4
SS-4
139.1
MW-3
MW-5
MW-1
USTs - CPT 104 AND 105
FUEL ISLAND
GP-8
MW-6
TB-1A
TB-1
TB-2
GP-6
3694
GP-11
GP-7
MW-4
140.3
CONCRETE PAVEMENT
138.5
140.1
LEACHING WELL
139.3
140
FRANK PERKINS ROAD
N
136.7
140
RAMEY ROAD

KEY

BREAK IN PAVEMENT/STAINED SOIL	UNDERGROUND STORAGE TANKS	EDGE OF ASPHALT PAVEMENT	FUEL ISLAND	MW-3	MONITORING WELL LOCATION
CONCRETE PAD	FRENCH DRAIN	140.1 SURFACE ELEVATION	WOODED AREA	TB-1	SOIL BORING LOCATION
FORMER BUILDING FOUNDATION	AUTO REPAIR BAYS	140 TOPOGRAPHIC CONTOUR LINES	TELEPHONE POLE	GP-2	GEOPROBE LOCATION
EXISTING BUILDING			LEACHING WELL	GP-1 SS-1	GEOPROBE LOCATION AND SURFACE SOIL LOCATION

SCALE
1" = 50'
0 50

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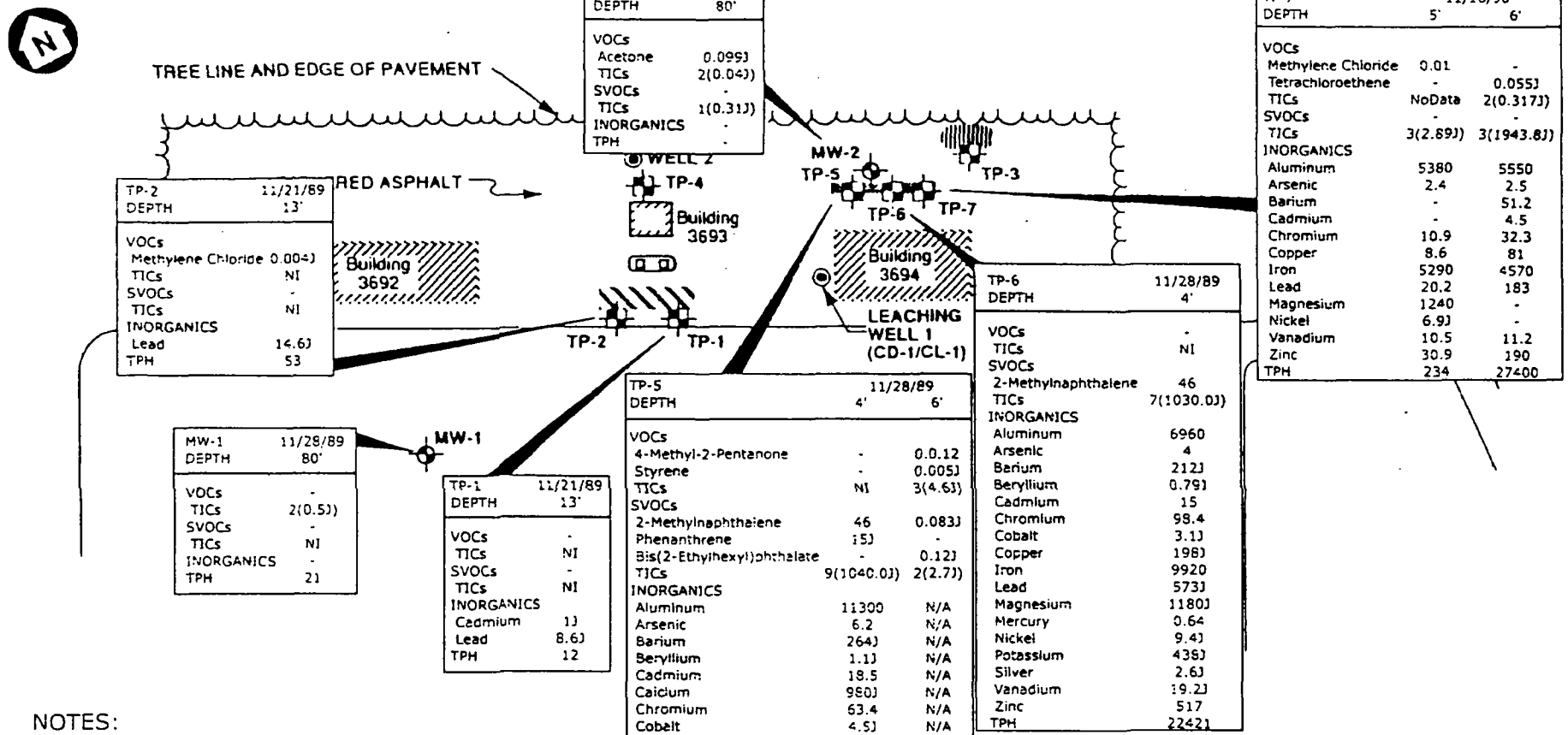
AOC SS-17 REMEDIAL INVESTIGATION

17_SALOC.DWG

FIELD EXPLORATION LOCATIONS

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-7a



MW-2	11/30/89
DEPTH	80'
VOCs	
Acetone	0.099J
TICs	2(0.04J)
SVOCs	-
TICs	1(0.31J)
INORGANICS	-
TPH	-

TP-2	11/21/89
DEPTH	13'
VOCs	
Methylene Chloride	0.004J
TICs	NI
SVOCs	-
TICs	NI
INORGANICS	
Lead	14.6J
TPH	53

MW-1	11/28/89
DEPTH	80'
VOCs	-
TICs	2(0.5J)
SVOCs	-
TICs	NI
INORGANICS	-
TPH	21

TP-1	11/21/89
DEPTH	13'
VOCs	-
TICs	NI
SVOCs	-
TICs	NI
INORGANICS	
Cadmium	1J
Lead	8.6J
TPH	12

TP-5	11/28/89	
DEPTH	4'	6'
VOCs		
4-Methyl-2-Pentanone	-	0.0.12
Styrene	-	0.005J
TICs	NI	3(4.6J)
SVOCs		
2-Methylnaphthalene	46	0.083J
Phenanthrene	15J	-
Bis(2-Ethylhexyl)phthalate	-	0.12J
TICs	9(1040.0J)	2(2.7J)
INORGANICS		
Aluminum	11300	N/A
Arsenic	6.2	N/A
Barium	264J	N/A
Beryllium	1.1J	N/A
Cadmium	18.5	N/A
Calcium	980J	N/A
Chromium	63.4	N/A
Cobalt	4.5J	N/A
Copper	324J	N/A
Iron	13900	N/A
Lead	1800J	N/A
Magnesium	1630	N/A
Mercury	0.32	N/A
Nickel	15.1	N/A
Potassium	705J	N/A
Silver	6.5J	N/A
Vanadium	28.1J	N/A
Zinc	426	N/A
TPH	18408	39

TP-6	11/28/89
DEPTH	4'
VOCs	-
TICs	NI
SVOCs	
2-Methylnaphthalene	46
TICs	7(1030.0J)
INORGANICS	
Aluminum	6960
Arsenic	4
Barium	212J
Beryllium	0.79J
Cadmium	15
Chromium	98.4
Cobalt	3.1J
Copper	198J
Iron	9920
Lead	573J
Magnesium	1180J
Mercury	0.64
Nickel	9.4J
Potassium	438J
Silver	2.6J
Vanadium	19.2J
Zinc	517
TPH	22421

TP-7	11/16/90	
DEPTH	5'	6'
VOCs		
Methylene Chloride	0.01	-
Tetrachloroethene	-	0.055J
TICs	NoData	2(0.317J)
SVOCs	-	-
TICs	3(2.89J)	3(1943.8J)
INORGANICS		
Aluminum	5380	5550
Arsenic	2.4	2.5
Barium	-	51.2
Cadmium	-	4.5
Chromium	10.9	32.3
Copper	8.6	81
Iron	5290	4570
Lead	20.2	183
Magnesium	1240	-
Nickel	6.9J	-
Vanadium	10.5	11.2
Zinc	30.9	190
TPH	234	27400

NOTES:

1. ALL SOIL AND SEDIMENT CONCENTRATIONS IN mg/kg. UNLESS OTHERWISE NOTED, ALL AQUEOUS CONCENTRATIONS IN ug/L.
2. DEPTH, WHERE SHOWN, INDICATES THE TOP OF THE SAMPLE INTERVAL.
3. "-" INDICATES NO TARGETED COMPOUNDS WERE DETECTED.
4. TIC RESULTS INDICATE NUMBER OF COMPOUNDS IDENTIFIED. TOTAL CONCENTRATIONS OF TIC IS SHOWN IN PARENTHESIS.
5. ONLY INORGANIC CONCENTRATIONS ABOVE MMR BACKGROUND ARE SHOWN (SEE SUBSECTION 3.4).
6. FOR DEFINITIONS OF QUALIFIERS, SEE TABLE 3.7.

LEGEND:

MONITORING WELL

TEST PIT

APPROXIMATE SCALE IN FEET

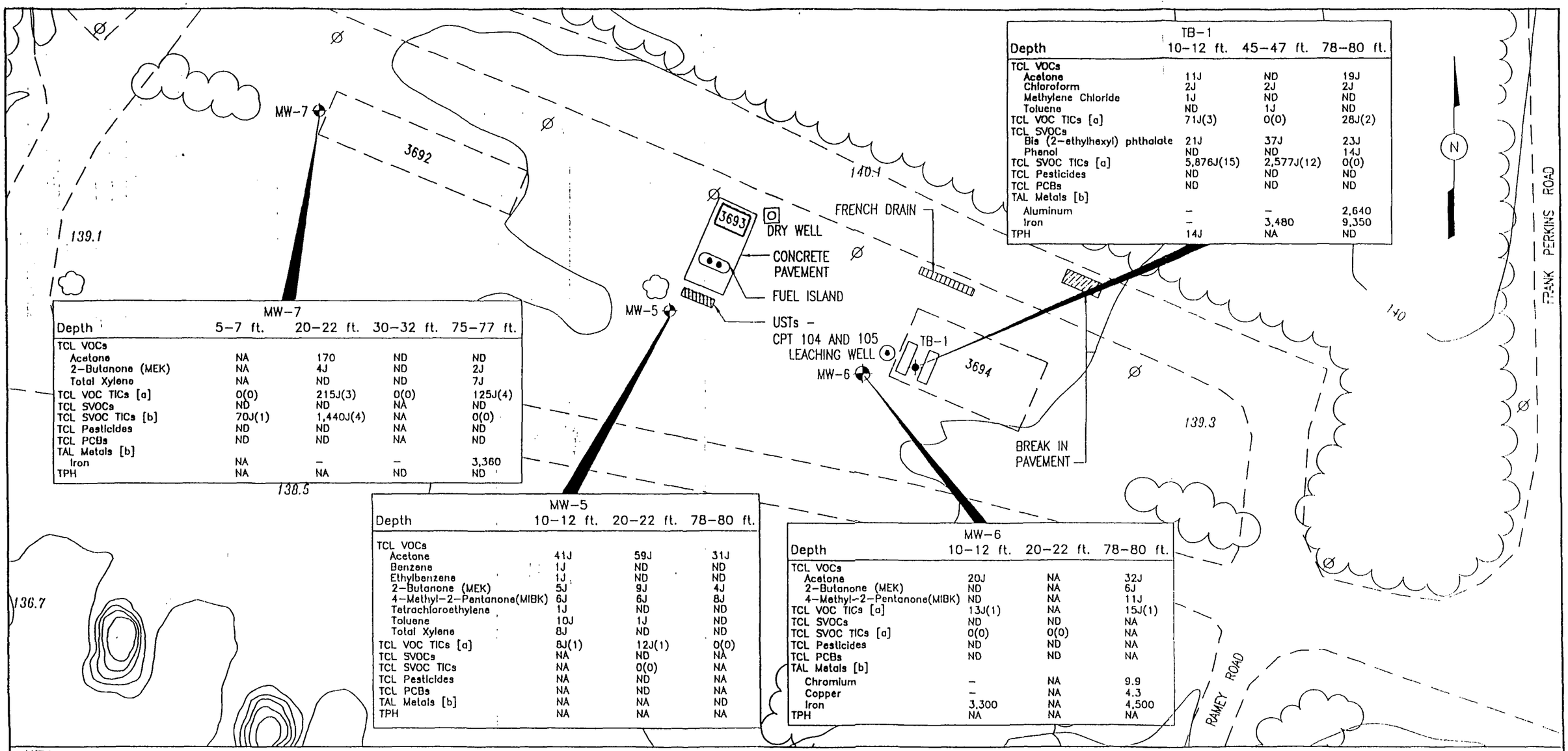
0 100 200

SOURCE: OAFB MASTER PLAN TAB NO. G-7 AND AERIAL SURVEY PHOTO TAKEN IN APRIL, 1990.

SUMMARY OF ANALYTES DETECTED IN SUBSURFACE SOIL STUDY AREA FS-17

MASSACHUSETTS MILITARY RESERVATION

FIGURE 2-8



Depth	TB-1 10-12 ft.	45-47 ft.	78-80 ft.
TCL VOCs			
Acetone	11J	ND	19J
Chloroform	2J	2J	2J
Methylene Chloride	1J	ND	ND
Toluene	ND	1J	ND
TCL VOC TICs [a]	71J(3)	0(0)	28J(2)
TCL SVOCs			
Bis (2-ethylhexyl) phthalate	21J	37J	23J
Phenol	ND	ND	14J
TCL SVOC TICs [a]	5,876J(15)	2,577J(12)	0(0)
TCL Pesticides	ND	ND	ND
TCL PCBs	ND	ND	ND
TAL Metals [b]			
Aluminum	-	-	2,640
Iron	-	3,480	9,350
TPH	14J	NA	ND

Depth	MW-7 5-7 ft.	20-22 ft.	30-32 ft.	75-77 ft.
TCL VOCs				
Acetone	NA	170	ND	ND
2-Butanone (MEK)	NA	4J	ND	2J
Total Xylene	NA	ND	ND	7J
TCL VOC TICs [a]	0(0)	215J(3)	0(0)	125J(4)
TCL SVOCs	ND	ND	NA	ND
TCL SVOC TICs [b]	70J(1)	1,440J(4)	NA	0(0)
TCL Pesticides	ND	ND	NA	ND
TCL PCBs	ND	ND	NA	ND
TAL Metals [b]				
Iron	NA	-	-	3,360
TPH	NA	NA	ND	ND

Depth	MW-5 10-12 ft.	20-22 ft.	78-80 ft.
TCL VOCs			
Acetone	41J	59J	31J
Benzene	1J	ND	ND
Ethylbenzene	1J	ND	ND
2-Butanone (MEK)	5J	9J	4J
4-Methyl-2-Pentanone(MIBK)	6J	6J	8J
Tetrachloroethylene	1J	ND	ND
Toluene	10J	1J	ND
Total Xylene	8J	ND	ND
TCL VOC TICs [a]	8J(1)	12J(1)	0(0)
TCL SVOCs	NA	ND	NA
TCL SVOC TICs	NA	0(0)	NA
TCL Pesticides	NA	ND	NA
TCL PCBs	NA	ND	NA
TAL Metals [b]	NA	NA	ND
TPH	NA	NA	NA

Depth	MW-6 10-12 ft.	20-22 ft.	78-80 ft.
TCL VOCs			
Acetone	20J	NA	32J
2-Butanone (MEK)	ND	NA	6J
4-Methyl-2-Pentanone(MIBK)	ND	NA	11J
TCL VOC TICs [a]	13J(1)	NA	15J(1)
TCL SVOCs	ND	ND	NA
TCL SVOC TICs [a]	0(0)	0(0)	NA
TCL Pesticides	ND	ND	NA
TCL PCBs	ND	ND	NA
TAL Metals [b]			
Chromium	-	NA	9.9
Copper	-	NA	4.3
Iron	3,300	NA	4,500
TPH	NA	NA	NA

KEY

- BREAK IN PAVEMENT/STAINED SOIL
- CONCRETE PAD
- FORMER BUILDING FOUNDATION
- EXISTING BUILDING
- UNDERGROUND STORAGE TANKS
- FRENCH DRAIN
- AUTO REPAIR BAYS
- EDGE OF ASPHALT PAVEMENT
- 140.1 SURFACE ELEVATION
- 140 TOPOGRAPHIC CONTOUR LINES
- FUEL ISLAND
- WOODED AREA
- TELEPHONE POLE
- LEACHING WELL
- MW-3 MONITORING WELL LOCATION
- TB-1 SOIL BORING LOCATION
- WATER TABLE CONTOUR LINE
- NA INDICATES COMPOUND NOT ANALYZED
- ND INDICATES COMPOUND NOT DETECTED
- J INDICATES ESTIMATED CONCENTRATION

[a] TICs REPRESENT TENTATIVELY IDENTIFIED COMPOUNDS. RESULTS ARE ESTIMATED AND THE NUMBER OF TICs IDENTIFIED ARE IN PARENTHESES.

[b] ONLY METALS EXCEEDING MAXIMUM MMR BACKGROUND ARE PRESENTED

- INDICATES COMPOUND DETECTED BUT AT A CONCENTRATION LESS THAN MAXIMUM MMR BACKGROUND

VOCs, SVOCs, PESTICIDES AND PCBs ARE REPORTED IN ?g/kg. TPH AND METALS ARE REPORTED IN mg/kg.

SCALE
1" = 50'
0 50

17_SSOIL.DWG

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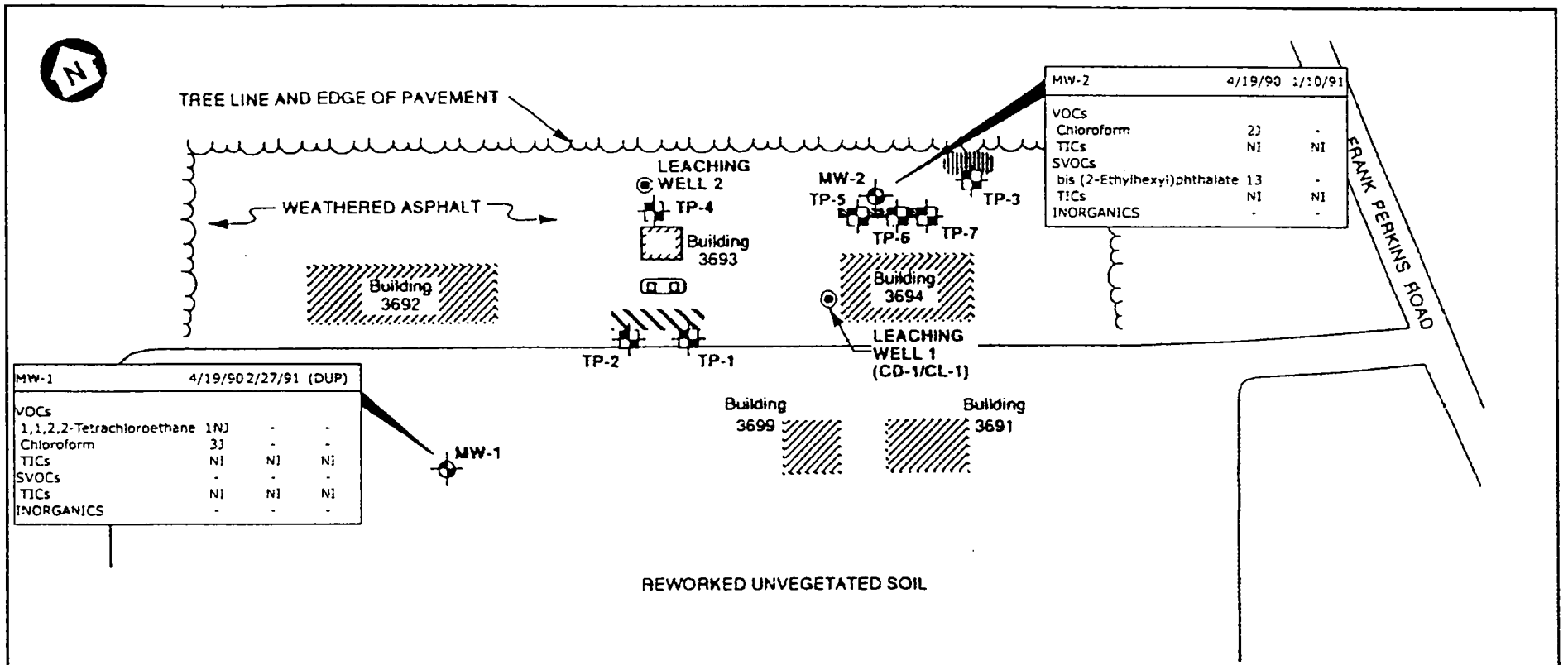
AOC FS-17 REMEDIAL INVESTIGATION
CLP TCL AND TAL
SUBSURFACE SOIL ANALYSIS SUMMARY
MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-9

LAST REVISED: 6-23-94



MW-2	4/19/90	1/10/91
VOCs		
Chloroform	2J	-
TICs	NI	NI
SVOCs		
bis (2-Ethylhexyl)phthalate	13	-
TICs	NI	NI
INORGANICS	-	-

MW-1	4/19/90	2/27/91	(DUP)
VOCs			
1,1,2,2-Tetrachloroethane	1NJ	-	-
Chloroform	3J	-	-
TICs	NI	NI	NI
SVOCs	-	-	-
TICs	NI	NI	NI
INORGANICS	-	-	-

NOTES:

1. ALL SOIL AND SEDIMENT CONCENTRATIONS IN mg/kg. UNLESS OTHERWISE NOTED, ALL AQUEOUS CONCENTRATIONS IN ug/L.
2. DEPTH, WHERE SHOWN, INDICATES THE TOP OF THE SAMPLE INTERVAL.
3. "-" INDICATES NO TARGETED COMPOUNDS WERE DETECTED.
4. TIC RESULTS INDICATE NUMBER OF COMPOUNDS IDENTIFIED. TOTAL CONCENTRATIONS OF TIC IS SHOWN IN PARENTHESIS.
5. ONLY INORGANIC CONCENTRATIONS ABOVE MMR BACKGROUND ARE SHOWN (SEE SUBSECTION 3.4).
6. FOR DEFINITIONS OF QUALIFIERS, SEE TABLE 3.7.

LEGEND:

MONITORING WELL

TEST PIT

APPROXIMATE SCALE IN FEET

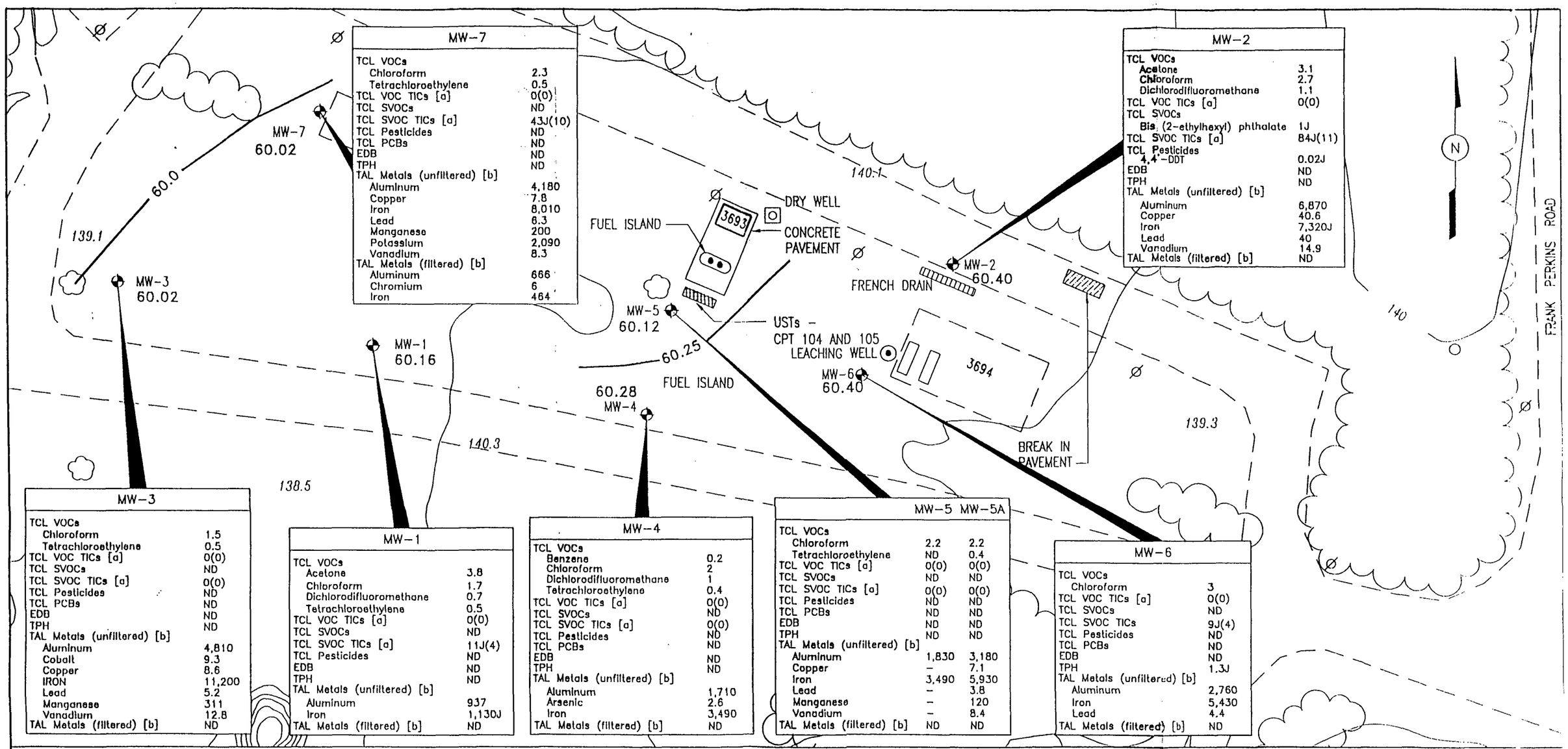
0 100 200

SOURCE: OAFB MASTER PLAN TAB NO. G-7 AND AERIAL SURVEY PHOTO TAKEN IN APRIL, 1990.

SUMMARY OF ANALYTES DETECTED IN GROUNDWATER STUDY AREA FS-17

MASSACHUSETTS MILITARY RESERVATION

FIGURE 2-10



MW-7	
TCL VOCs	
Chloroform	2.3
Tetrachloroethylene	0.5
TCL VOC TICs [a]	0(0)
TCL SVOCs	ND
TCL SVOC TICs [a]	43J(10)
TCL Pesticides	ND
TCL PCBs	ND
EDB	ND
TPH	ND
TAL Metals (unfiltered) [b]	
Aluminum	4,180
Copper	7.8
Iron	8,010
Lead	6.3
Manganese	200
Potassium	2,090
Vanadium	8.3
TAL Metals (filtered) [b]	
Aluminum	666
Chromium	6
Iron	464

MW-2	
TCL VOCs	
Acetone	3.1
Chloroform	2.7
Dichlorodifluoromethane	1.1
TCL VOC TICs [a]	0(0)
TCL SVOCs	
Bis (2-ethylhexyl) phthalate	1J
TCL SVOC TICs [a]	84J(11)
TCL Pesticides	
4,4'-DDT	0.02J
EDB	ND
TPH	ND
TAL Metals (unfiltered) [b]	
Aluminum	6,870
Copper	40.6
Iron	7,320J
Lead	40
Vanadium	14.9
TAL Metals (filtered) [b]	ND

MW-3	
TCL VOCs	
Chloroform	1.5
Tetrachloroethylene	0.5
TCL VOC TICs [a]	0(0)
TCL SVOCs	ND
TCL SVOC TICs [a]	0(0)
TCL Pesticides	ND
TCL PCBs	ND
EDB	ND
TPH	ND
TAL Metals (unfiltered) [b]	
Aluminum	4,810
Cobalt	9.3
Copper	8.6
IRON	11,200
Lead	5.2
Manganese	311
Vanadium	12.8
TAL Metals (filtered) [b]	ND

MW-1	
TCL VOCs	
Acetone	3.8
Chloroform	1.7
Dichlorodifluoromethane	0.7
Tetrachloroethylene	0.5
TCL VOC TICs [a]	0(0)
TCL SVOCs	ND
TCL SVOC TICs [a]	11J(4)
TCL Pesticides	ND
EDB	ND
TPH	ND
TAL Metals (unfiltered) [b]	
Aluminum	937
Iron	1,130J
TAL Metals (filtered) [b]	ND

MW-4	
TCL VOCs	
Benzene	0.2
Chloroform	2
Dichlorodifluoromethane	1
Tetrachloroethylene	0.4
TCL VOC TICs [a]	0(0)
TCL SVOCs	ND
TCL SVOC TICs [a]	0(0)
TCL Pesticides	ND
TCL PCBs	ND
EDB	ND
TPH	ND
TAL Metals (unfiltered) [b]	
Aluminum	1,710
Arsenic	2.6
Iron	3,490
TAL Metals (filtered) [b]	ND

MW-5	MW-5A
TCL VOCs	
Chloroform 2.2	2.2
Tetrachloroethylene ND	0.4
TCL VOC TICs [a] 0(0)	0(0)
TCL SVOCs ND	ND
TCL SVOC TICs [a] 0(0)	0(0)
TCL Pesticides ND	ND
TCL PCBs ND	ND
EDB ND	ND
TPH ND	ND
TAL Metals (unfiltered) [b]	
Aluminum 1,830	3,180
Copper –	7.1
Iron 3,490	5,930
Lead –	3.8
Manganese –	120
Vanadium –	8.4
TAL Metals (filtered) [b] ND	ND

MW-6	
TCL VOCs	
Chloroform	3
TCL VOC TICs [a]	0(0)
TCL SVOCs	ND
TCL SVOC TICs	9J(4)
TCL Pesticides	ND
TCL PCBs	ND
EDB	ND
TPH	1.3J
TAL Metals (unfiltered) [b]	
Aluminum	2,760
Iron	5,430
Lead	4.4
TAL Metals (filtered) [b]	ND

KEY

- BREAK IN PAVEMENT/STAINED SOIL
- CONCRETE PAD
- FORMER BUILDING FOUNDATION
- EXISTING BUILDING
- UNDERGROUND STORAGE TANKS
- FRENCH DRAIN
- AUTO REPAIR BAYS
- EDGE OF ASPHALT PAVEMENT
- 140.1 SURFACE ELEVATION
- 140 TOPOGRAPHIC CONTOUR LINES
- FUEL ISLAND
- WOODED AREA
- TELEPHONE POLE
- LEACHING WELL
- MW-3 MONITORING WELL LOCATION
- WATER TABLE CONTOUR LINE
- ND INDICATES COMPOUND NOT DETECTED
- J INDICATES ESTIMATED CONCENTRATION
- [a] TICs FOR VOC AND SVOC DATA ARE ESTIMATED CONCENTRATIONS, THE NUMBER OF TICs IDENTIFIED ARE REPORTED IN PARENTHESIS
- [b] ONLY METALS EXCEEDING MAXIMUM MMR BACKGROUND ARE PRESENTED
- \- INDICATES COMPOUND DETECTED BUT AT A CONCENTRATION LESS THAN MAXIMUM MMR BACKGROUND

TCL VOCs, SVOCs, PESTICIDES, PCBs, EDB AND METALS ARE REPORTED IN ?g/L
TPH REPORTED IN mg/L

SCALE
1" = 50'
0 50

17_DATA2.DWG

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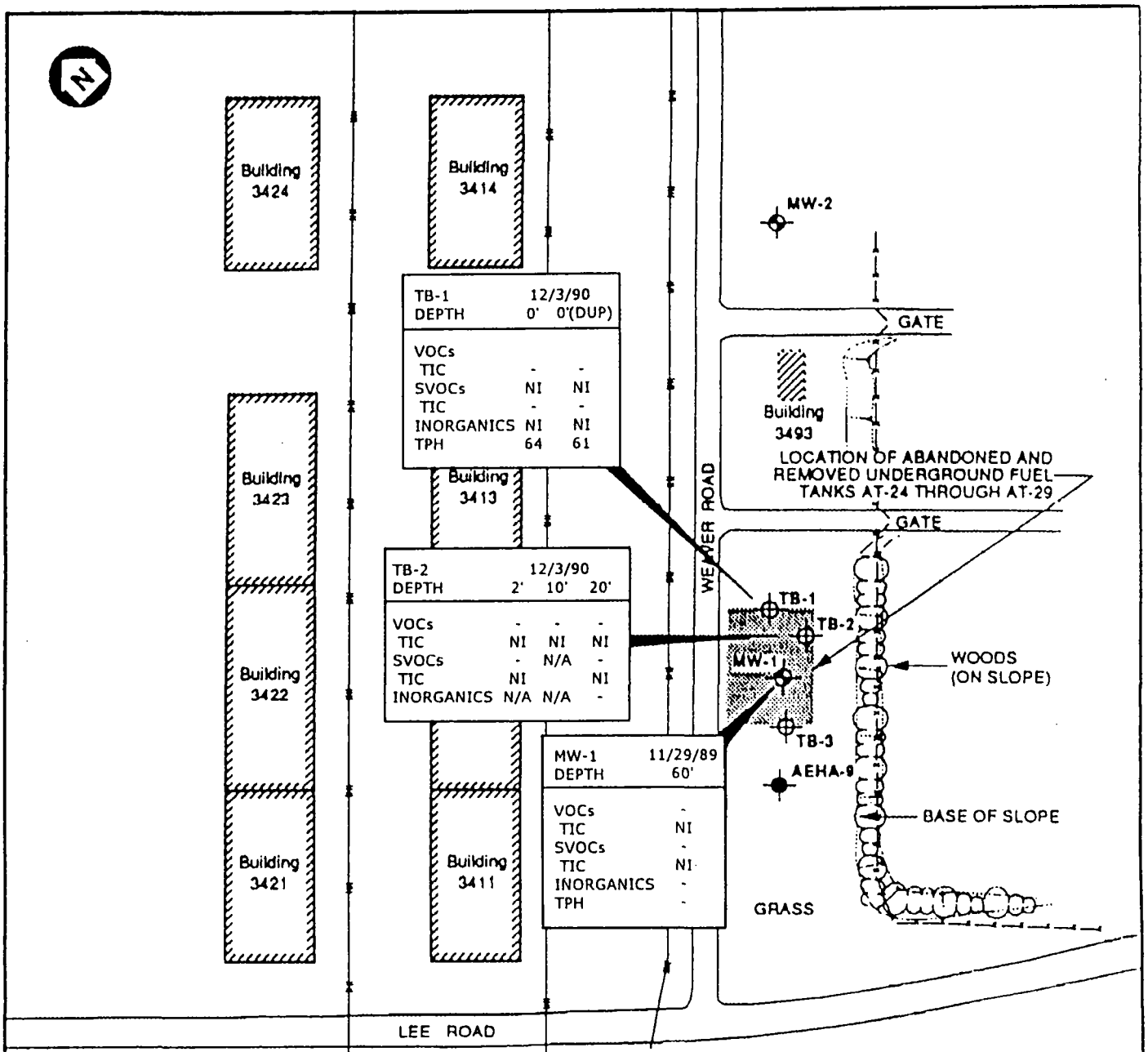
AOC FS-17 REMEDIAL INVESTIGATION

CLP TCL AND TAL GROUNDWATER ANALYSIS SUMMARY

MASSACHUSETTS MILITARY RESERVATION Figure No. 2-11

LAST REVISED: 6-21-94



LEGEND:

- MONITORING WELL LOCATION
- EXISTING MONITORING WELL
- SOIL BORING LOCATION

NOTES:

1. ALL SOIL AND SEDIMENT CONCENTRATIONS IN mg/kg . UNLESS OTHERWISE NOTED, ALL AQUEOUS CONCENTRATIONS IN ug/L.
2. DEPTH, WHERE SHOWN, INDICATES THE TOP OF THE SAMPLE INTERVAL.
3. "-" INDICATES NO TARGETED COMPOUNDS WERE DETECTED.
4. TIC RESULTS INDICATE NUMBER OF COMPOUNDS IDENTIFIED. TOTAL CONCENTRATIONS OF TIC IS SHOWN IN PARENTHESIS.
5. ONLY INORGANIC CONCENTRATIONS ABOVE MMR BACKGROUND ARE SHOWN (SEE SUBSECTION 3.4).
6. FOR DEFINITIONS OF QUALIFIERS, SEE TABLE 3.7.

APPROXIMATE SCALE IN FEET

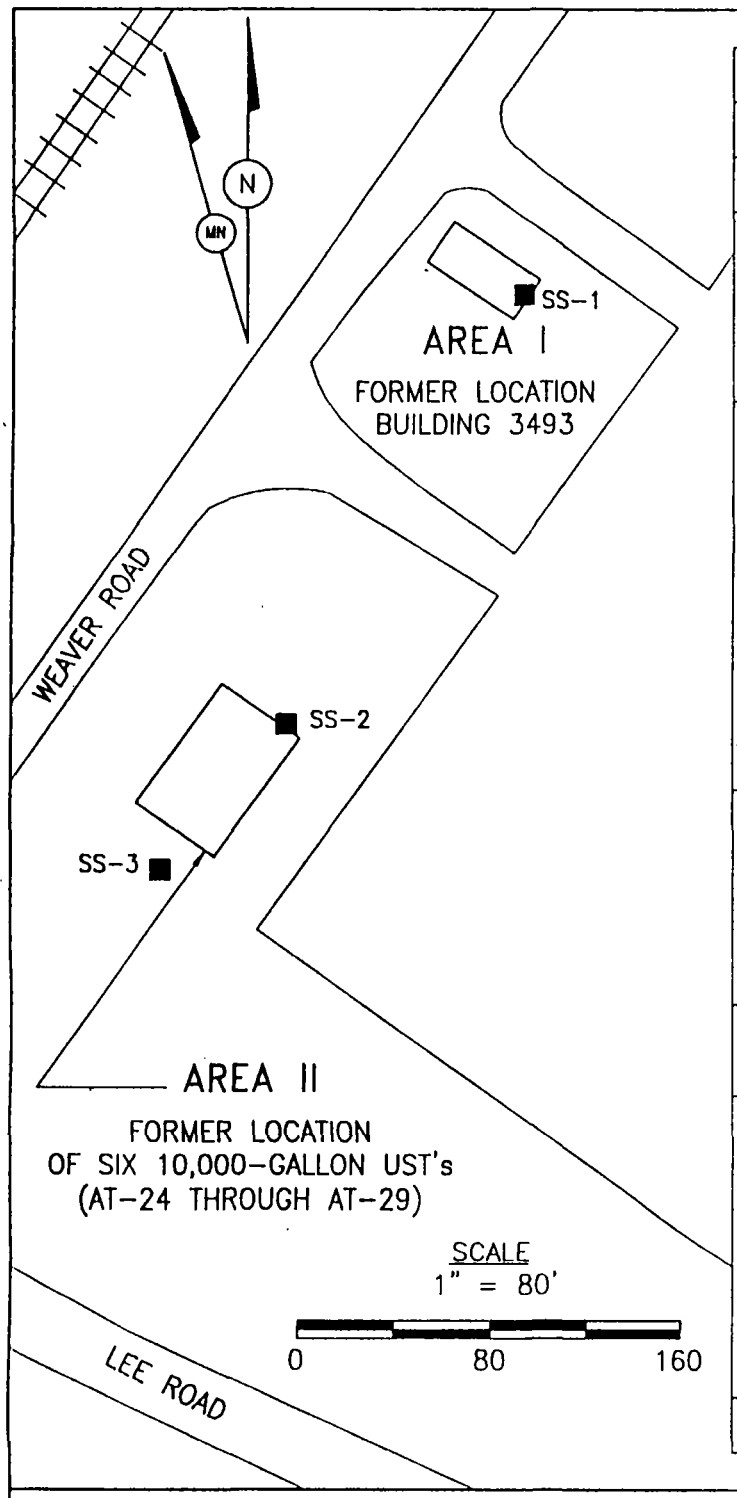
0 100 200

SOURCE: OAFB MASTER PLAN TAB NO. G-7 AND AERIAL SURVEY PHOTO TAKEN IN APRIL, 1990, AND FIELD OBSERVATIONS IN APRIL, 1993.

SUMMARY OF ANALYTES DETECTED IN SOIL
STUDY AREA FS-19

MASSACHUSETTS MILITARY RESERVATION

FIGURE 2-12



AREA I AND AREA II

CLP DATA

ANALYSIS/ COMPOUND	SURFACE SOIL SAMPLES: SS-1	SS-2	SS-2A	SS-3
TCL VOC				
METHYLENE CHLORIDE	ND	1J	1J	ND
ACETONE	5J	ND	ND	ND
CHLOROFORM	ND	1J	1J	1J
TOLUENE	ND	1J	ND	2J
TOTAL XYLENE	ND	3J	ND	ND
TOTAL VOCs	5J	6J	2J	3J
TCL VOC TICs	82(3)	73(2)	76(2)	24(3)
CLP SVOC				
NAPHTALENE	29J	ND	ND	ND
2-METHYLNAPHTHALENE	38J	ND	ND	ND
ACENAPHTHYLENE	ND	ND	ND	22J
PHENANTHRENE	35J	41J	35J	110J
ANTHRACENE	ND	ND	ND	11J
DI-N-BUTYLPHTHALATE	20J	12J	ND	ND
FLUORANTHENE	38J	74J	76J	170J
PYRENE	35J	65J	72J	130J
BENZO (A) ANTHRACENE	ND	46J	42J	64J
CHRYSENE	36J	51J	48J	89J
BENZO (B) FLUORANTHENE	46J	92J	88J	160J
BENZO (K) FLUORANTHENE	46J	92J	88J	160J
BENZO (A) PYRENE	17J	43J	37J	64J
INDENO (1,2,3-CD) PYRENE	24J	35J	33J	49J
DIBENZO (A,H) ANTHRACENE	ND	ND	ND	29J
BENZO (G,H,I) PERYLENE	22J	30J	28J	45J
TOTAL SVOCs	388J	581J	545J	1,103J
TCL SVOC TICs	7,241(23)	2,866(15)	2,117(11)	12,188(23)
CLP PESTICIDES				
DIELDRIN	70	21	18	120
4,4'-DDE	110	44	39	11
4,4'-DDD	19J	12J	12J	ND
4,4'-DDT	930J	280J	380J	27J
METHOXYCHLOR	16J	31	34	ND
ENDRIN KETONE	17	30	32	ND
ALPHA CHLORDANE	ND	ND	1.3J	ND
GAMMA CHLORDANE	1.9J	2.6J	3J	ND
TOTAL PESTICIDES	1,163.9J	420.6J	519.3J	158J
TCL PCB				
AROCLOR-1260	260	420	540	ND
TAL INORGANICS				
ALUMINUM	13,800	–	–	–
ARSENIC	4.8	–	–	–
BARIUM	57.9	15.9	15.7	16.4
CALCIUM	1,280	–	–	–
CHROMIUM	11.5	7.1	–	7.9
COPPER	ND	–	–	–
IRON	13,900	–	–	–
LEAD	119	40.8	36.2	29.9
MAGNESIUM	1,300	1,030	1,000	–
NICKEL	6	5.3	–	–
POTASSIUM	717	–	–	–
VANADIUM	22.5	–	–	18.7
ZINC	68	38.2	41.6	21.6
TPH (METHOD 418.1)	93J	50J	48J	ND
TPH (MODIFIED METHOD 8015)	37	ND	14	16

NOTES:

ALL VOLATILE, SEMI-VOLATILE, PESTICIDE, AND PCB CONCENTRATIONS REPORTED IN ?g/kg. ALL METALS AND TPH CONCENTRATIONS REPORTED IN mg/kg.

REPORTED METALS CONCENTRATIONS ARE EXCEEDANCES OF MMR MAXIMUM BACKGROUND CONCENTRATIONS (MMR RISK ASSESSMENT HANDBOOK). SEE TABLE 5-2 FOR COMPLETE LISTING OF METALS DETECTED AND ASSOCIATED CONCENTRATIONS.

KEY

SS-3 ■	SURFACE SOIL SAMPLING LOCATION
ND	INDICATES COMPOUND NOT DETECTED
–	DID NOT EXCEED MAXIMUM MMR BACKGROUND CONCENTRATIONS
J	SEE SECTION 3.6.4 FOR EXPLANATION OF DATA QUALIFIERS
TICs	TIC CONCENTRATION WITH NUMBER OF TICs IDENTIFIED

19_SSB.DWG

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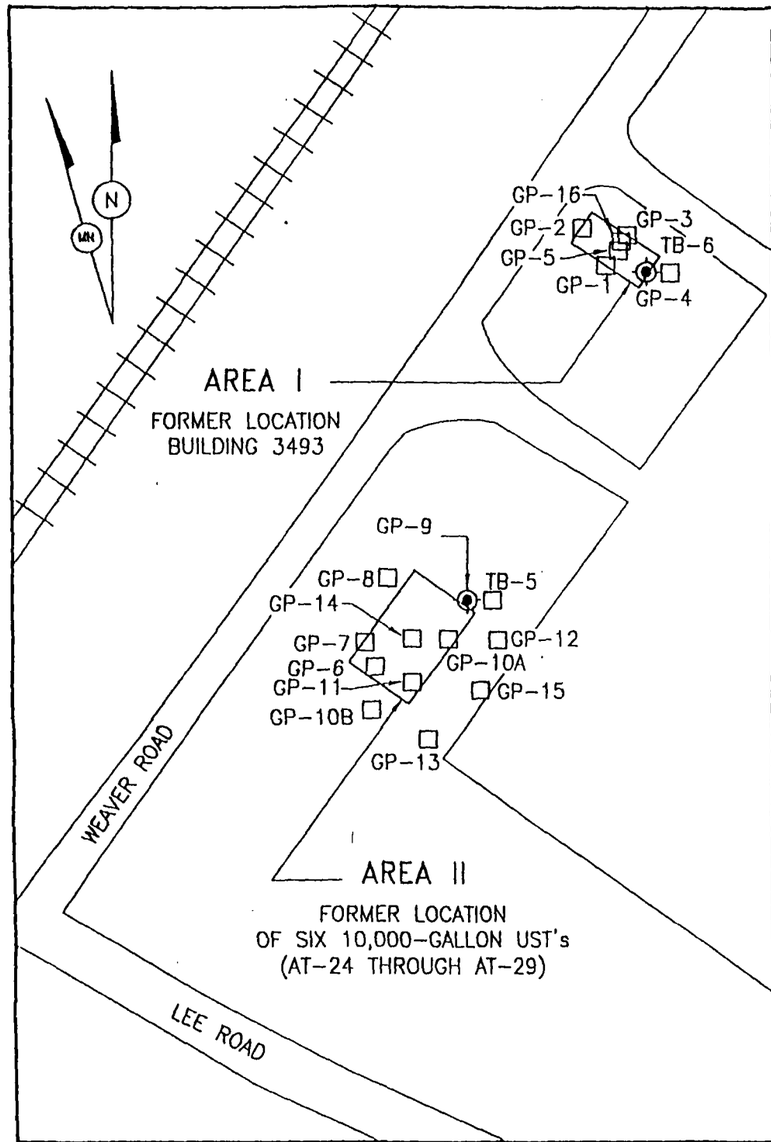
AOC FS-19 REMEDIAL INVESTIGATION

SURFACE SOIL CONTAMINATION MAP

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-13

LAST REVISED: 11-17-95



AREA I
CONFIRMATION DATA
FIXED-BASE LABORATORY

GEOPROBE:	GP-5 (8-9')	GP-16 (8-9')
VOCs	ND	ND
TPH (418.1)	27	ND
TPH (8015)	ND	ND

AREA I
SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-1 (8-9')	GP-2 (8-9')	GP-3 (8-9')	GP-4 (8-9')	GP-5 (8-9')	GP-16 (8-9')
VOCs	ND	ND	ND	ND	ND	ND
TPH (418.1)	48	32	107	406	89	ND
TEST BORING:	TB-6 (10-12')					
VOCs	ND					
TPH (418.1)	23					

AREA II
CONFIRMATION DATA
FIXED-BASE LABORATORY

GEOPROBE:	GP-8 (8-9')	GP-9 (8-9')	GP-11 (8-9')	GP-13 (8-9')	GP-14 (8-9')
VOCs					
Trichloroethylene	ND	ND	ND	1.3	ND
Toluene	ND	ND	3.5	1.3J	2.1J
Ethylbenzene	ND	ND	1.3J	ND	ND
M,P-Xylenes	ND	ND	4.4	2.7	ND
O-Xylenes	ND	ND	2.1	1.3J	ND
Total Xylenes	ND	ND	6.6	4	ND
TPH (418.1)	57	230	2,100	520	19
TPH (8015)	16	11	1,500D	290D	ND

AREA II
SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-6 (8-9')	GP-7 (8-9')	GP-8 (8-9')	GP-9 (8-9')	GP-10A (8-9')	GP-11 (8-9')
VOCs	ND	ND	ND	ND	ND	ND
TPH (418.1)	116	48	72	448	70	186

GEOPROBE:	GP-12 (8-9')	GP-13 (8-9')	GP-14 (8-9')	GP-15 (8-9')
VOCs	ND	ND	ND	ND
TPH (418.1)	55	106	11B	ND

TEST BORING:	TB-5 (10-12')
VOCs	ND
TPH (418.1)	3,850

NOTES:

ALL VOLATILE CONCENTRATIONS REPORTED IN ?g/kg.
ALL TPH CONCENTRATIONS REPORTED IN mg/kg.
VOCs - VOCs ANALYZED BY METHOD 8010/8020.
TPH(8015) - ANALYZED BY MODIFIED METHOD 8015.
TPH(418.1) - TPH ANALYZED BY METHOD 418.1.

KEY

GP-16 □ GEOPROBE LOCATION

RAILROAD TRACKS

TB-6 ⊙ SOIL BORING LOCATION

ND INDICATES COMPOUND NOT DETECTED

D,J,B SEE SECTION 3.6.4 FOR EXPLANATION OF DATA QUALIFIERS.

SCALE
1" = 80'
0 80 160

19_8-12.DWG

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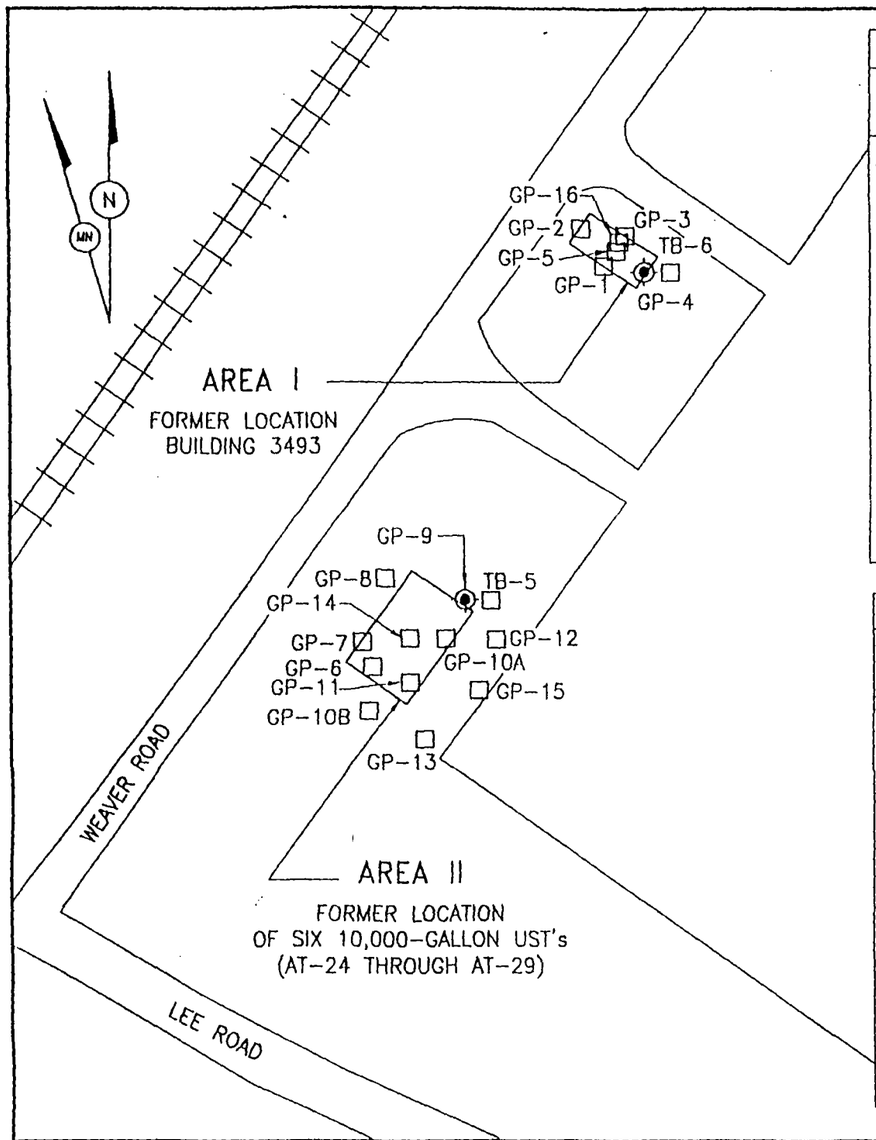
AOC FS-19 REMEDIAL INVESTIGATION

8' - 12' SUBSURFACE SOIL CONTAMINATION MAP

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-14



AREA I

CONFIRMATION DATA
FIXED-BASE LABORATORY

GEOPROBE:	GP-2 (16-17')
VOCs	ND
TPH (418.1)	65
TPH (8015)	16
TEST BORING:	TB-6 (15-17')
VOCs	ND
TPH (418.1)	ND
TPH (8015)	ND

AREA I

SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-1 (16-17')	GP-2 (16-17')	GP-3 (16-17')	GP-4 (16-17')	GP-5 (16-17')	GP-16 (16-17')
VOCs	ND	ND	ND	ND	NS	ND
TPH (418.1)	170	100	26	25	NS	ND
TEST BORING:	TB-6 (15-17')					
VOCs	ND					
TPH (418.1)	4.1J					

AREA II

SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-6 (16-17')	GP-7 (16-17')	GP-8 (16-17')	GP-9 (16-17)	GP-10B (16-17')	GP-11 (16-17')	GP-12 (16-17')	GP-13 (16-17')	GP-14 (16-17')	GP-15 (16-17')
VOCs	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TPH (418.1)	60	49	82	285	20	158	57	85	18B	ND
TEST BORING:	TB-5 (15-17')									
VOCs	ND									
TPH (418.1)	7.6J									

NOTES:

ALL VOLATILE CONCENTRATIONS REPORTED IN ?g/kg.
ALL TPH CONCENTRATIONS REPORTED IN mg/kg.
VOCs - VOCs ANALYZED BY METHOD 8010/8020.
TPH(8015) - ANALYZED BY MODIFIED METHOD 8015.
TPH(418.1) - TPH ANALYZED BY METHOD 418.1.

KEY

GP-16 □ GEOPROBE LOCATION
RAILROAD TRACKS
TB-6 SOIL BORING LOCATION
NS INDICATES INTERVAL NOT SAMPLED
ND INDICATES COMPOUND NOT DETECTED
B,J SEE SECTION 3.6.4 FOR EXPLANATION OF DATA QUALIFIERS.

SCALE
1" = 80'
0 80 160

19_15-17.DWG

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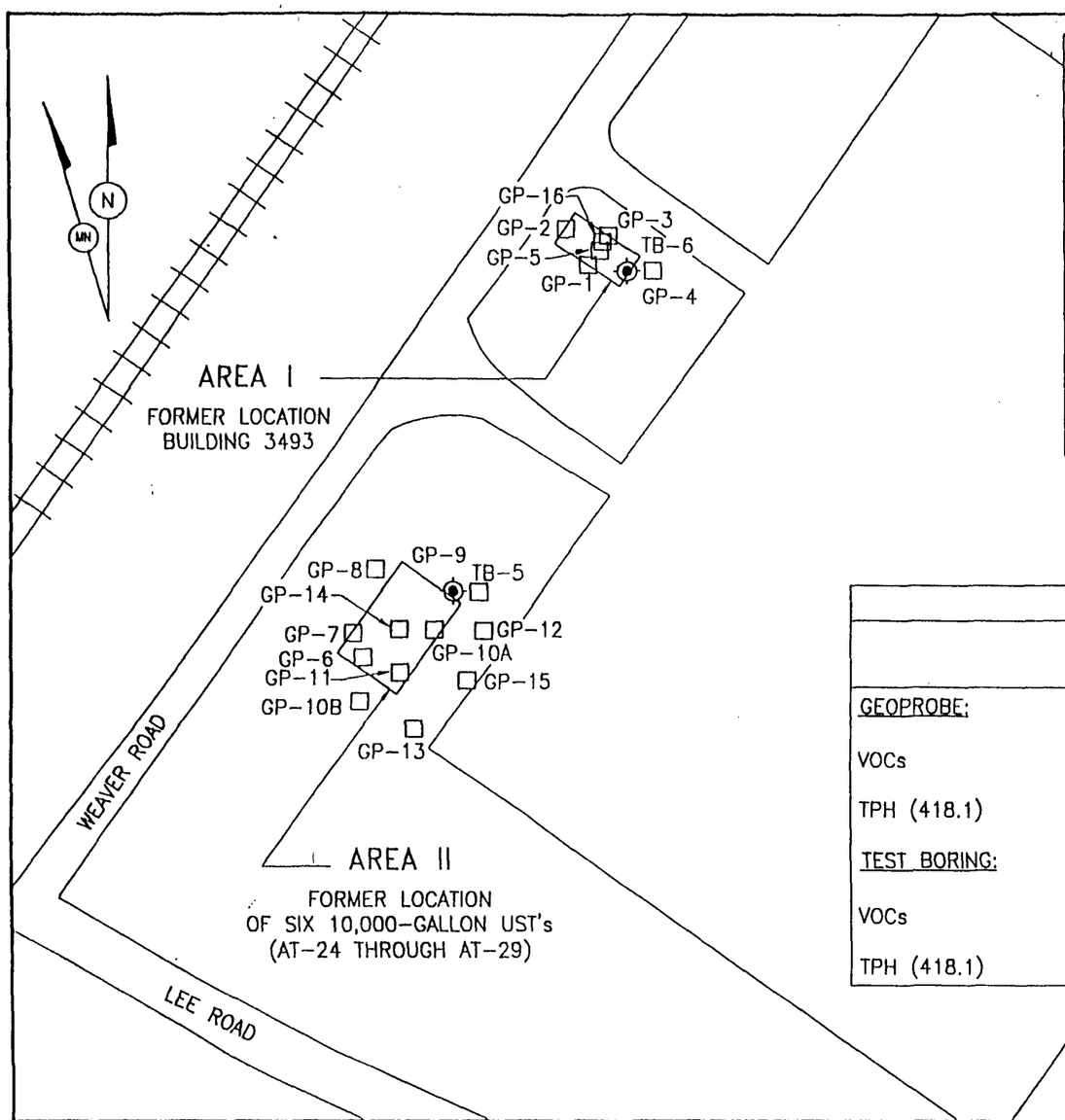
AOC FS-19 REMEDIAL INVESTIGATION

15' - 17' SUBSURFACE SOIL CONTAMINATION MAP

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-15

LAST REVISED: 6-10-04



AREA I

SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-1 (24-25')	GP-2 (24-25')	GP-3 (24-25')	GP-4 (24-25')	GP-5 (24-25')	GP-16 (24-25')
VOCs	ND	ND	ND	ND	NS	ND
TPH (418.1)	31	53	105	240	NS	ND
TEST BORING:	TB-6 (25-27')					
VOCs	ND					
TPH (418.1)	ND					

AREA II

SCREENING DATA
MOBILE LABORATORY

GEOPROBE:	GP-6 (24-25')	GP-7 (24-25')	GP-8 (24-25')	GP-9 (24-25')	GP-10A (24-25')	GP-11 (24-25')	GP-12 (24-25')	GP-13 (24-25')	GP-14 (24-25')	GP-15 (24-25')
VOCs	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND
TPH (418.1)	69	56	128	534	39	37	76	348	15B	ND
TEST BORING:	TB-5 (25-27')									
VOCs	ND									
TPH (418.1)	7.6J									

NOTES:

ALL VOLATILE CONCENTRATIONS REPORTED IN ?g/kg.
ALL TPH CONCENTRATIONS REPORTED IN mg/kg.
VOCs - VOCs ANALYZED BY METHOD 8010/8020.
TPH(8015) - ANALYZED BY MODIFIED METHOD 8015.
TPH(418.1) - TPH ANALYZED BY METHOD 418.1.

KEY

GP-16 □ GEOPROBE LOCATION
TB-6 ⊙ SOIL BORING LOCATION
RAILROAD TRACKS

ND INDICATES COMPOUND NOT DETECTED
NS INDICATES INTERVAL NOT SAMPLED
B,J SEE SECTION 3.6.4 FOR EXPLANATION OF DATA QUALIFIERS.

SCALE
1" = 80'
0 80 160

19_24-27.DWG

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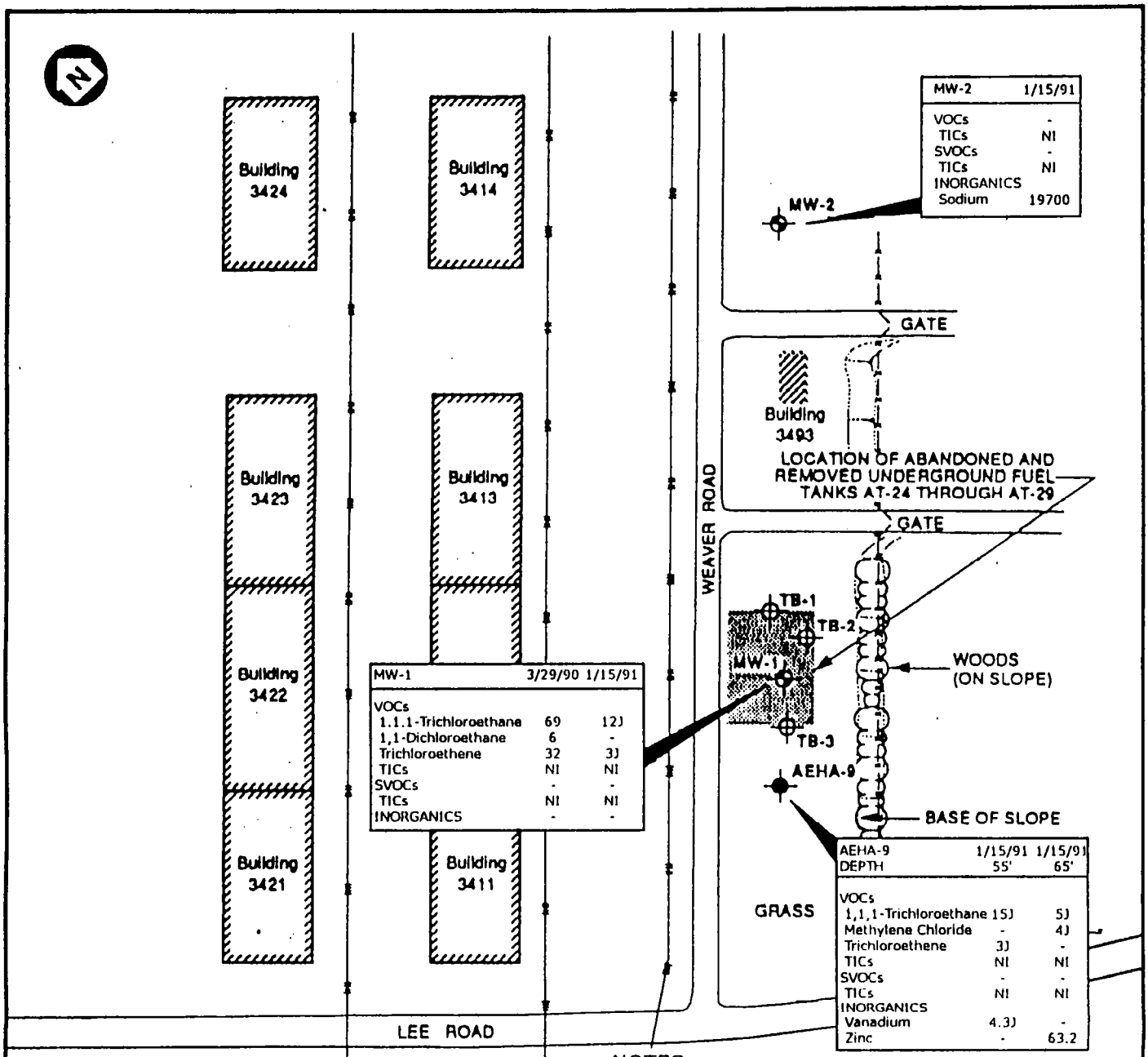
AOC FS-19 REMEDIAL INVESTIGATION

24' - 27' SUBSURFACE SOIL CONTAMINATION MAP

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-16

LAST REVISED: 11-17-95



LEGEND:

- MONITORING WELL LOCATION
- EXISTING MONITORING WELL
- SOIL BORING LOCATION

NOTES:

1. ALL SOIL AND SEDIMENT CONCENTRATIONS IN mg/kg . UNLESS OTHERWISE NOTED, ALL AQUEOUS CONCENTRATIONS IN ug/L.
2. DEPTH, WHERE SHOWN, INDICATES THE TOP OF THE SAMPLE INTERVAL.
3. "-" INDICATES NO TARGETED COMPOUNDS WERE DETECTED.
4. TIC RESULTS INDICATE NUMBER OF COMPOUNDS IDENTIFIED. TOTAL CONCENTRATIONS OF TIC IS SHOWN IN PARENTHESIS.
5. ONLY INORGANIC CONCENTRATIONS ABOVE MMR BACKGROUND ARE SHOWN (SEE SUBSECTION 3.4).
6. FOR DEFINITIONS OF QUALIFIERS, SEE TABLE 3.7.

APPROXIMATE SCALE IN FEET

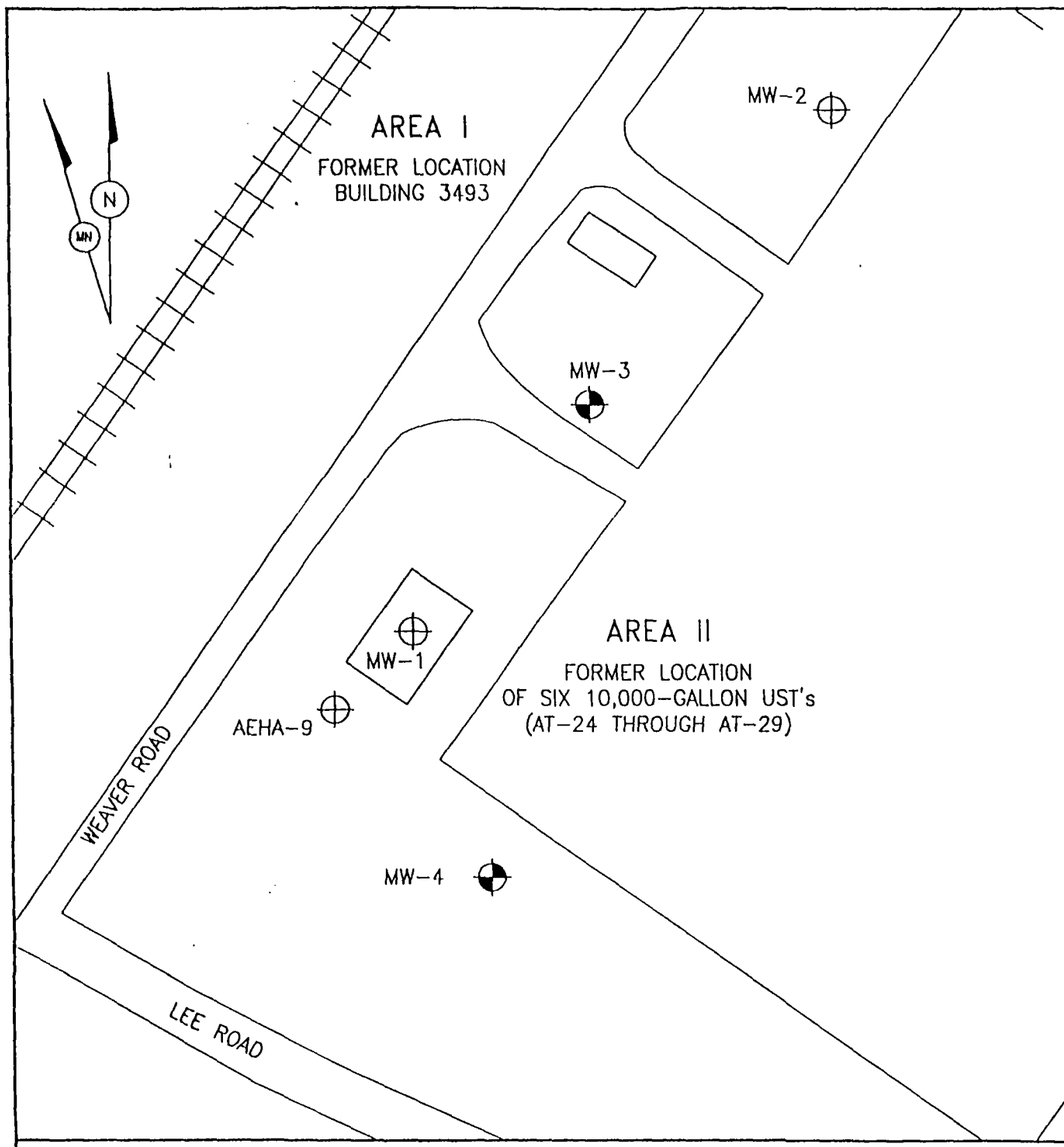
0 100 200

SOURCE: OAFB MASTER PLAN TAB NO. G-7 AND AERIAL SURVEY PHOTO TAKEN IN APRIL, 1990, AND FIELD OBSERVATIONS IN APRIL, 1993.

SUMMARY OF ANALYTES DETECTED IN GROUNDWATER STUDY AREA FS-19

MASSACHUSETTS MILITARY RESERVATION

FIGURE 2-17



METALS IN GROUNDWATER (UNFILTERED)

SAMPLING DATE	1/17/94	1/17/94	1/17/94	1/19/94	1/19/94	1/17/94
PARAMETER/LOCATION	MW-1	MW-1A	MW-2	MW-3	MW-4	AEHA-9
TAL METALS - UNFILTERED						
Aluminum	1,930	15,100	856	5,600	3,300	868
Arsenic	-	4.8 J	-	-	-	-
Barium	-	111	-	136	-	-
Calcium	-	-	-	10,200	-	-
Chromium	-	20.6	-	-	-	-
Cobalt	-	14.1	-	-	-	-
Copper	-	13.7	-	-	-	-
Iron	1,080 J	19,300 J	940 J	5,830 J	3,800 J	986 J
Lead	-	18.5	-	-	-	-
Magnesium	-	8,100	-	5,530	-	-
Manganese	-	465 J	-	204 J	-	-
Nickel	-	22.1	-	-	-	-
Potassium	-	4,180	-	29	2,040	-
Sodium	-	-	-	295	-	-
Vanadium	-	24.4	-	9.2	-	-

METALS IN GROUNDWATER (FILTERED)

SAMPLING DATE	1/17/94	1/17/94	1/17/94	1/19/94	1/19/94	1/17/94
PARAMETER/LOCATION	MW-1	MW-1A	MW-2	MW-3	MW-4	AEHA-9
TAL METALS - UNFILTERED						
Barium	-	-	-	117	-	-
Calcium	-	-	-	10,900	-	-
Sodium	-	-	-	32,500	-	-

GROUNDWATER CLP DATA

SAMPLING DATE	1/17/94	1/17/94	1/17/94	1/19/94	1/19/94	1/17/94
PARAMETER/LOCATION	MW-1	MW-1A	MW-2	MW-3	MW-4	AEHA-9
VOCs (524.2)						
1,1,1 - Trichloroethane	1.3	1.6	ND	ND	ND	ND
Benzene	0.3	0.7	ND	ND	ND	ND
Toluene	4	7.6	1.5	ND	ND	0.4
Ethylbenzene	1.4	2.6	0.6	ND	ND	ND
M,P-Xylene	7.1	12	2.9	ND	ND	ND
O-Xylene	2.9	5.1	1	ND	ND	ND
1,3,5-Trimethylbenzene	0.9	1.2	ND	ND	ND	ND
1,2,4-Trimethylbenzene	2.6	3.8	1.2	ND	ND	ND
TICs	0	1J(1)	0	0	0	0
SVOCs - Low Concentration SOW						
Bis (2-ethylhexyl) phthalate	ND	13	ND	ND	ND	ND
TICs	32J(11)	42J(9)	29J(8)	0	0	32J(8)
Pesticides/PCBs - Low Concentration SOW	ND	ND	ND	ND	ND	ND
TPH (418.1)	ND	ND	ND	ND	ND	ND
EDB (504)	ND	ND	ND	ND	ND	ND

NOTES:

ALL VOLATILE CONCENTRATIONS REPORTED IN ?g/kg.
ALL TPH CONCENTRATIONS REPORTED IN mg/kg.
ALL VOCs, SVOCs, PESTICIDES, PCBs AND EDB CONCENTRATIONS REPORTED IN ?g/l.
VOCs - VOCs ANALYZED BY METHOD 8010/8020.
TPH(8015) - ANALYZED BY MODIFIED METHOD 8015.
TPH(418.1) - TPH ANALYZED BY METHOD 418.1.

KEY

MW-2 — EXISTING MONITORING WELL
MW-3 — NEW MONITORING WELL
ND — INDICATES COMPOUND NOT DETECTED
D,J,B — SEE SECTION 3.6.4 FOR EXPLANATION OF DATA QUALIFIERS.
TICs — TICs FOR VOCs AND SVOCs ARE THE CONCENTRATION FOLLOWED BY THE NUMBER OF TICs IDENTIFIED
RAILROAD TRACKS

SCALE
1" = 80'
0 80 160

19_GWCON.DWG

CDM FEDERAL PROGRAMS CORPORATION
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AOC FS-19 REMEDIAL INVESTIGATION

GROUNDWATER CONTAMINATION MAP

MASSACHUSETTS MILITARY RESERVATION

Figure No. 2-18

APPENDIX B

TABLES

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Table 2-1
Summary of Analytes Detected in Surface Soil
Study Area FS-17

Priority 2 and 3 Areas SI
MASSACHUSETTS MILITARY RESERVATION

ANALYTES / Exploration ID: / Sampled: / Depth:	MW-1 / 22-Nov-89 / 0	TP-3 / 21-Nov-89 / 0	TP-4 / 28-Nov-89 / 1
VOLATILES (mg/kg)	-	-	-
SEMIVOLATILES (mg/kg)			
Bis(2-ethylhexyl)phthalate	0.12J	-	-
PESTICIDES/PCBs (mg/kg)	-	-	N/A
INORGANICS (mg/kg)			
Aluminum	2350	3810	11200
Antimony	17.5	-	-
Arsenic	0.7 J	1J	2.7
Barium	3J	3.7J	16J
Beryllium	-	-	0.94 J
Cadmium	-	-	0.94 J
Calcium	48.8J	43.8J	258J
Chromium	2.5	4	13.4
Cobalt	1.6J	-	3.1J
Copper	2.3J	-	-
Iron	2120	3450	11100
Lead	1.3	1.4J	6.5J
Magnesium	343J	418J	1150
Manganese	24.4	25.6J	53.5
Nickel	-	-	6.8J
Selenium	-	-	0.19J
Silver	-	-	R
Sodium	20.8J	-	-
Vanadium	3J	5.5J	18.1J
Zinc	-	-	20.7
TOTAL PETROLEUM HYDROCARBONS (mg/kg)	-	1370	246

Notes:
- = Not detected
N/A = Not Analyzed
* = Duplicate Sample
Shaded results are below MMR background concentrations.

Table 2-2

Summary of Surface Soil CLP Results

AOC FS-17

MASSACHUSETTS MILITARY RESERVATION

ANALYSIS	SAMPLE LOCATION						MAXIMUM MMR BACKGROUND CONC. [1]
	SS-1A (Dup. of SS-1)	SS-1	SS-2	SS-3	SS-4	SS-5	
TCL VOCs (ug/Kg)							
Methylene Chloride	1.00 J	11.00 U	10.00 U	1.00 J	1.00 J	1,200.00 UJ	NA
Acetone	9.00J	9.00 J	2.0 J	15.0J	11.00 UJ	1,200.00 UJ	NA
Carbon Disulfide	11.00 U	11.00 U	1.00J	11.00 U	11.00 U	1,200.00 U	NA
Chloroform	1.00J	1.00 J	1.00 J	11.00 U	1.00 J	1,200.00 U	NA
Toluene	11.00 U	11.00 U	1.00 J	1.00 J	3.00 J	1,800.00	NA
Ethylbenzene	11.00 U	11.00 U	10.00 U	11.00 U	11.00 U	3,700.00	NA
Total Xylene	11.00 U	11.00 U	2.00 J	11.00 U	5.00 J	25,000.00	NA
TCL SVOCs (ug/Kg)							
Napthalene	720.00 U	720.00 U	350.00 U	350.00 U	1,800.00 U	48,000.00 J	NA
2 - Methylnapthalene	720.00 U	720.00 U	120.00 J	32.00 J	310.00 J	120,000.00	NA
Acenapthylene	95.00 J	96.00 J	14.00 J	27.00 J	220.00 J	52,000.00 U	NA
Dibenzofuran	720.00 U	720.00 U	17.00 J	350.00 U	72.00 J	52,000.00 U	NA
Fluorene	720.00 U	720.00 U	350.00 U	350.00 U	1,800.00 U	10,000.00 J	NA
Phenanthrene	28.0J	27.0J	110J	32.0J	730J	10,000.00 J	NA
Anthracene	23.0J	23.0J	10.0J	11.0J	92.0J	52,000.00 U	NA
Fluoranthene	160J	140J	140J	62.0J	770J	52,000.00 U	NA
Pyrene	200J	190J	110J	55.0J	650J	2,200.00J	NA
Benzo (A) Anthracene	160J	140J	61.0J	35.0J	330J	52,000.00 U	NA
Chrysene	170J	170J	73.0J	46.0J	410J	52,000.00 U	NA
Benzo (B) Fluoranthene	480J	460J	130J	140J	920J	52,000.00 U	NA
Benzo (K) Fluoranthene	480J	460J	130J	140J	920J	52,000.00 U	NA
Benzo (A) Pyrene	180J	180J	36.0J	51.0J	300J	52,000.00 U	NA
Indeno (1,2,3-CD) Pyrene	160J	150J	33.0J	43.0J	330J	52,000.00 U	NA
Dibenzo (A,H) Anthracene	82.0J	81.0J	350.00 U	27.0J	120J	52,000.00 U	NA
Benzo (G,H,I) Perylene	150J	150J	35.0J	46.0J	280J	52,000.00 U	NA
Carbazole	720.00 U	720.00 U	350.00 U	350.00 U	92.00 J	52,000.00 U	NA
Di-n-Butylphthalate	720.00 U	14.00 J	42.00 J	10.00 J	62.00 J	52,000.00 U	NA
TCL Pesticides (ug/Kg)							
4,4 - DDE	3.60 U	3.60 UJ	4.20	1.80 J	23.00 J	3.40 UJ	NA
4,4 - DDD	3.60 U	3.60 UJ	2.20 J	3.50 U	20.00 J	3.40 UJ	NA
4,4 - DDT	4.50	4.90 J	53.00	22.00	350.00 U	6.60 J	NA
Endrin Ketone	3.60 U	3.60 UJ	3.00 J	3.50 U	12.00 J	3.40 UJ	NA
Alpha Chlordane	1.80 U	1.80 UJ	1.80 U	1.80 U	1.20 J	1.80 UJ	NA
Gamma Chlordane	1.80 U	1.80 UJ	0.76 J	1.80 U	4.60 J	1.80 UJ	NA
TCL PCBS (ug/Kg)							
Aroclor-1260	25.00 J	36.00 UJ	43.00	35.00 U	200.00 J	34.00 UJ	NA

Table 2-2 (cont.)

Summary of Surface Soil CLP Results

AOC FS-17

MASSACHUSETTS MILITARY RESERVATION

ANALYSIS	SAMPLE LOCATION						MAXIMUM MMR BACKGROUND CONC. [1]
	SS-1A (Dup. of SS-1)	SS-1	SS-2	SS-3	SS-4	SS-5	
TAL Metals (mg/Kg)							
ALUMINUM	5,170.00	5,680.00	2,410.00	3,050.00	3,000.00	2,370.00	8,930
ANTIMONY	3.40 UJ	3.50 UJ	2.60 UJ	3.20 UJ	3.30 UJ	3.20 UJ	17.5
ARSENIC	2.20	1.90	2.00	1.00	2.60	1.50	3.6
BARIUM	10.50 [2]	10.40	20.90	9.10	56.70	5.80	10.4
BERYLLIUM	0.22	0.23	0.16 U	0.20 U	0.23	0.20 U	0.65
CADMIUM	0.40 U	0.56	0.75	0.40 U	1.30	0.40	1.5
CALCIUM	214.00	306.00	300.00	426.00	525.00	251.00	969
CHROMIUM	10.70	9.90	11.30	3.60	18.80	2.60	6.8
COBALT	1.80	2.60	1.20	2.10	1.90	1.40	4.1
COPPER	9.60	7.60	7.70	5.00	23.00	26.80	5.2
CYANIDE	0.05 UJ	0.05 UJ	0.05 U	0.05 U	0.05 U	0.05 U	0.7
IRON	6,060.00	7,200.00	5,330.00	5,400.00	8,460.00	4,500.00	12,400
LEAD	42.50	74.50	204.00	94.40	769.00	5.20	12.05
MAGNESIUM	650.00	1,040.00	541.00	832.00	630.00	566.00	794.5
MANGANESE	56.40 J	71.80 J	43.90	50.40	124.00	50.10	108
MERCURY	0.11 U	0.11 U	0.10 U	0.11 U	0.11 U	0.10 U	0.06
NICKEL	3.30	3.50	3.10	2.80	4.50	2.90	5.2
POTASSIUM	363.00	377.00	224.00	323.00	302.00	415.00	551
SELENIUM	0.21 UJ	0.20 UJ	0.20 UJ	0.21 UJ	0.21 UJ	0.20 UJ	0.33
SILVER	0.99 U	1.00 U	0.64 U	0.81 U	0.98	0.80 U	1.4
SODIUM	91.50 U	95.90 U	90.40 UJ	93.90 UJ	115.00 UJ	78.00 UJ	386
THALLIUM	0.21 U	0.20 U	0.20 U	0.21 U	0.21 U	0.20 U	0.25
VANADIUM	10.40	12.70	9.60	9.60	13.10	7.70	15.2
ZINC	27.90	29.70	38.90	20.20	155.00	9.40	16
TPH (418.1) (mg/Kg)	460J	460J	210J	230J	890J	37000.00	500 [3]
TPH (8015) as Diesel (mg/Kg)	130D	130D	17.00	85.00	190J	19,000J [4]	500

Legend:

[1] Values referenced from the MMR Risk Assesment Handbook.

[2] Gray shading indicates exceedance of maximum MMR background concentration.

[3] MMR Soil Target Cleanup Level (STCL) for TPH.

[4] TPH Analysis by Method 8015 quantified kerosene at a concentration of 22,000 mg/kg at location SS-5.

Data Validation Qualifiers

J - Indicates an estimated quantity

U - Indicates compound was not detected. Concentration preceeding qualifier is the detection limit

UJ - Indicates compound was not detected and that the detection limit is an estimated value

Table 2-3
Summary of Geoprobe Sscreening and Confirmation Analyses

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

Sample Location	SCREENING RESULTS DEPTH						CONFIRMATIONAL RESULTS DEPTH					
	0 to 1 ft		8 to 9 ft		16 to 17 ft		0 to 1 ft			8 to 9 ft		
	VOCs (8010/8020)	TPH (418.1)	VOCs (8010/8020)	TPH (418.1)	VOCs (8010/8020)	TPH (418.1)	VOCs (8010/8020)	TPH (418.1)	TPH (8015)	VOCs (8010/8020)	TPH (418.1)	TPH (8015)
GP-1	ND [1]	621	ND	180	ND	42	NA [2]	NA	NA	NA	NA	NA
GP-2	ND	525	ND	57	ND	35 [3]	1.82 [4]	1400	81	NA	NA	NA
GP-3	ND	193	ND	137	ND	65	8.20 [5]	570	310 D	NA	NA	NA
GP-4	ND	263	ND	208	ND	81	NA	NA	NA	NA	NA	NA
GP-5	ND	419	ND	490	ND	91	NA	NA	NA	3.8 [6]	110	ND
GP-6	ND	2210 E	ND	103	ND	39	NA	NA	NA	NA	NA	NA
GP-7	ND	7070 E	ND	208	ND	63	NA	NA	NA	NA	NA	NA
GP-8	NA	235	ND	37	ND	71	NA	NA	NA	NA	NA	NA
GP-9	ND	207	ND	77	NA	63	NA	NA	NA	NA	NA	NA
GP-10	ND	208	ND	1250 E	AN	NA	NA	NA	NA	NA	NA	NA
GP-11	ND	ND	ND	ND	ND	ND	6.5 [7]	130 C	22	NA	NA	NA
GP-12	ND	31 B	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA
GP-13	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA	NA	NA

LEGEND: VOCs in units of ug/kg, TPH in units of mg/kg; Refer to Sec. 4.6.4 for definition of data qualifiers.

[1] ND: Target Volatiles (8010/8020) not detected
[2] NA: Parameter not analyzed
[3] Geoprobe could only be advanced to 11ft due to refusal
[4] The confirmation Sample for GP-2 @ 0-1ft contained tetrachlorethylene @ 0.82 ug/kg and 1.0 ug/kg of trichlorethene
[5] The GP-3 Confirmation Sample @ 0-1ft contained 3.8 ug/kg of toluene, 2.60 ug/kg of m,p-wylenes, and 1.80 J ug/kg of o-xylene
[6] The GP-4 Confirmation Sample @ 8-9ft contained 1.80 ug/kg of trichlorethene and 2.0 ug/kg of m,p-xylenes
[7] The GP-11 Confirmation Sample @ 0-1ft contained 1.30 ug/kg of tetrachloroethylene, and 1.8 ug/kg of o-xylenes
Exceedance of mmr STCL for TPH

Table 2-4
Summary of Analytes Detected in Subsurface Soil
Study Area FS-17

PRIORITY 2 AND 3 STUDY AREAS SI
MASSACHUSETTS MILITARY RESERVATION

Exploration ID:	MW-1	MW-2	TP-1	TP-2	TP-5	TP-5	TP-5	TP-7	TP-7
Sampled:	28-Nov-89	30-Nov-89	21-Nov-89	21-Nov-89	28-Nov-89	28-Nov-89	28-Nov-89	16-Nov-90	16-Nov-90
ANALYTES Depth:	80	80	13	13	4	6	4	5	6
VOLATILES (mg/kg)									
4-Methyl-2-Pentanone	-	-	-	-	-	0.012	-	-	-
Acetone	-	0.099 J	-	-	-	-	-	-	-
Methylene Chloride	-	-	-	0.004 J	-	-	-	0.01	-
Styrene	-	-	-	-	-	0.005 J	-	-	-
Tetrachloroethene	-	-	-	-	-	-	-	-	0.055 J
SEMIVOLATILES (mg/kg)									
2-Methylnaphthalene	-	-	-	-	46	0.083 J	46	-	-
Phenanthrene	-	-	-	-	15 J	-	-	-	-
Bis(2-ethylhexyl)phthalate	-	-	-	-	-	0.12 J	-	-	-
INORGANICS (mg/kg)									
Aluminum	599 J	377	1050	1130	11300	N/A	6960	5380	5550
Arsenic	-	-	-	-	6.2	N/A	4	2.4	2.5
Barium	2.9 J	1.4 J	2.4 J	4.1 J	264 J	N/A	212 J	10.6 J	51.2
Beryllium	-	-	-	-	1.1 J	N/A	0.79 J	-	-
Cadmium	-	-	1 J	-	18.5	N/A	15	-	4.5
Calcium	66 J	-	78.9 J	97.2 J	980 J	N/A	816 J	165 J	267 J
Chromium	2.7	2.6 J	2.7	2.8	63.4	N/A	98.4 J	10.9	32.3
Cobalt	-	-	-	-	4.5 J	N/A	3.1 J	2.3 J	1.7 J
Copper	-	-	-	-	324 J	N/A	198 J	8.6	81
Iron	2080 J	991	2180	1720	13900	N/A	9920	5290	4570
Lead	-	0.65 J	8.6 J	14.6 J	1800	N/A	573 J	20.2	183
Magnesium	157 J	-	264 J	222 J	1630	N/A	1180 J	1240	726 J
Manganese	22.7 J	7.2	29.2 J	32.7 J	101 J	N/A	73.5 J	54.9	47.8
Mercury	-	-	-	-	0.32	N/A	0.64	-	-
Nickel	-	-	-	-	15.1	N/A	9.4 J	6.9 J	2.9 J
Potassium	-	-	-	-	705 J	N/A	438 J	412 J	291 J
Selenium	-	-	-	-	0.57 J	N/A	0.24 J	-	-
Silver	R	-	-	-	6.5 J	N/A	2.6 J	-	-
Sodium	-	25.5 J	-	-	158 J	N/A	-	25.8 J	53 J
Thallium	-	0.66 J	-	-	0.11 J	N/A	-	-	-
Vanadium	-	1.3 J	3.6 J	3.2 J	28.1 J	N/A	19.2 J	10.5	11.2
Zinc	9.4	2 J	-	-	426	N/A	517	30.9	190
TPH (mg/kg)	21	-	12	53	18408	39	22421	234	27400

Notes:
- = Not Detected
N/A = Not Analyzed
* = Duplicate Sample
TPH = Total Petroleum Hydrocarbons
Shaded results are below MMR background concentrations

TABLE 2-5

Phase I Sump Removal Action Program
MASSACHUSETTS MILITARY RESERVATION

Parameter	Site: FS-17/CD-1	FS-17/CD-1	FS-17/CD-1	FS-17/CD-1	FS-17/CD-1	FS-17/CD-1	FS-17/CD-1	FS-17/CD-1
	Matr: SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Dpth: 8	12	18	24	8	12	18	8
	ISIS: 23TRX11XX8X1XF	23TRX11X12X1XF	23TRX11X18X1XF	23TRX11X24X1XF	23TRX12XX8X1XF	23TRX12X12X1XF	23TRX12X18X1XF	23TRX13XX8X1XF
	Date: 2-Oct-91	2-Oct-91	2-Oct-91	2-Oct-91	2-Oct-91	2-Oct-91	3-Oct-91	7-Oct-91
PI meter reading (ppm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
VOCx (ug/kg)								
Vinyl chloride	ND	ND	ND	ND	7.8	ND	ND	ND
Benzene	ND	ND	ND	ND	16	12	ND	ND
SVOCs (mg/kg)								
Bis (2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND
Pest/PCBs (ug/kg)								
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
Inorganics (mg/kg)								
Lead	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	200	170	190	ND	160	170	190	230
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
TPH (mg/kg)	230	170	50	60	150	60	50	60

Table 2-5 (cont.)

Phase I Sump Removal Action Program
MASSACHUSETTS MILITARY RESERVATION

Parameter	Site: FS-17/CD-2	FS-17/CD-2	FS-17/CD-2	FS-17/CD-2	FS-17/CD-2	FS-17/CD-2	FS-17/CD-2	FS-17/CD-2
	Matr: SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
	Dpth: 8	12	18	18	24	8	12	18
	ISIS: 23TRX23XX8X1XF	23TRX23X12X1XF	23TRX23X18X1DF	23TRX23X18X1XF	23TRX23X24X1XF	23TRX24XX8X1XF	23TRX24X12X1XF	23TRX24X18X1XF
	Date: 9-Oct-91	9-Oct-91	9-Oct-91	9-Oct-91	9-Oct-91	11-Oct-91	11-Oct-91	11-Oct-91
PI meter reading (ppm)	0.0	1.6	NA	0.0	0.0	0.3	0.0	0.0
VOCx (ug/kg)								
Vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	5.1	15	ND	ND	ND	ND	ND	ND
SVOCs (mg/kg)								
Bis (2-ethylhexyl)phthalate	ND	ND	1.8	2.1	ND	ND	ND	ND
Pest/PCBs (ug/kg)								
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND
Inorganics (mg/kg)								
Lead	ND	ND	ND	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	250	190	270	260	300	140	220	220
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
TPH (mg/kg)	47	58	260	250	110	41	46	59

Table 2-5 (cont.)

Phase I Sump Removal Action Program
MASSACHUSETTS MILITARY RESERVATION

Parameter	Site: FS-17/CD-2 Matr: SOIL Dpth: 24 ISIS: 23TRX24X24X1XF Date: 11-Oct-91	FS-17/CD-2 SOIL 8 23TRX25XX8X1XF 9-Oct-91	FS-17/CD-2 SOIL 12 23TRX25X12X1XF 9-Oct-91	FS-17/CD-2 SOIL 18 23TRX25X18X1XF 9-Oct-91	FS-17/CD-2 SOIL 24 23TRX25X24X1XF 9-Oct-91
PI meter reading (ppm)	0.0	0.3	0.0	0.0	0.0
VOCx (ug/kg)					
Vinyl chloride	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND
SVOCs (mg/kg)					
Bis (2-ethylhexyl)phthalate	ND	ND	ND	ND	ND
Pest/PCBs (ug/kg)					
Chlordane	ND	610	ND	ND	ND
Inorganics (mg/kg)					
Lead	ND	ND	ND	ND	ND
Copper	ND	ND	ND	ND	ND
Zinc	230	240	140	180	200
Arsenic	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND
TPH (mg/kg)	110	110	60	150	29

Table 2-6

Summary of Surface Soil CLP Results

AOC FS-17

MASSACHUSETTS MILITARY RESERVATION

PARAMETER	TB-1 10 - 12	TB-1 45 - 47	TB-1 78 - 80	MW-5 10 - 12	MW-5 20 - 22	MW-5 78 - 80	MW-6 10 - 12	MW-6 20 - 22	MW-6 78 - 80	MW-7 5-7	MW-7 20 - 22	MW-7 30 - 32	MW-7 75 -77	MAXIMUM MMR SUBSURFACE BACKGROUND[a]
TCL Volatiles (ug/Kg)														
2-Butanone	10 U	10 U	11 U	5 J	9 J	4 J	10 U	NA	6 J	NA	4 J	11 U	2 J	N/A
4-Methyl-2Pentanone	10 U	10 U	11 U	6 J	6 J	8 J	10 U	NA	11 J	NA	11 U	11 U	10 U	N/A
Acetone	11 J	10 UJ	19 U	41 J	59 J	31 J	20 J	NA	32 J	NA	170 J	36 UJ	46 UJ	N/A
Benzene	10 U	10 U	11 U	1 J	10 U	11 U	10 U	NA	11 U	NA	11 U	11 U	10 U	N/A
Chloroform	2 J	2 J	2 J	11 J	10 U	11 U	10 U	NA	11 U	NA	11 U	11 U	10 U	N/A
Ethylbenzene	10 U	10 U	11 U	1 J	10 U	11 U	10 U	NA	11 U	NA	11 U	11 U	10 U	N/A
Methylene Chloride	1 J	10 U	11 U	11 UJ	10 UJ	11 UJ	10 UJ	NA	11 UJ	NA	11 U	11 U	10 U	N/A
Tetrachloroethylene	10 U	10 U	11 U	1 J	10 U	11 U	10 U	NA	11 U	NA	11 U	11 U	10 U	N/A
Toluene	10 U	1 J	11 U	10 J	1 J	11 U	10 U	NA	11 U	NA	11 U	11 U	10 U	N/A
Total Xylene	10 U	10 U	11 U	8 J	10 U	11 U	10 U	NA	11 U	NA	11 U	11 U	7 J	N/A
TCL VOC TICs [b]	71 J (3)	0 (0)	28 J (2)	6 J (1)	12 J (1)	0 (0)	13 J (1)	NA	15 J (1)	NA	215 J (3)	0 (0)	125 J (4)	N/A
TCL SVOCs (ug/Kg)														
Phenol	340 U	340 U	14 J	NA	340 U	NA	340 U	350 U	NA	340 U	340 UJ	NA	340 U	N/A
Bis(2-ethylhexyl)phthalate	21 J	37 J	23 J	NA	340 UJ	NA	340 UJ	350 UJ	NA	360 J	340 UJ	NA	340 UJ	N/A
TCL SVOC TICs [b]	5876 J (15)	2577 J (12)	0 (0)	NA	0 (0)	NA	0 (0)	0 (0)	NA	70 J (1)	1440 J (14)	NA	0 (0)	N/A
TCL Pesticides (ug/Kg)	ND	ND	ND	NA	ND	NA	ND	ND	NA	ND	ND	NA	ND	N/A
TCL PCBS (ug/Kg)	ND	ND	ND	NA	ND	NA	ND	ND	NA	ND	ND	NA	ND	N/A
TAL Metals (mg/Kg)														
ALUMINUM	885.00	1330.00	2640.00 [c]	NA	NA	835.00	1330.00	NA	1090.00	NA	707.00	924.00	122.00	1980
ANTIMONY	3.10 U	290.U	3.30 U	NA	NA	3.30 UJ	310.UJ	NA	3.40 UJ	NA	2.50 U	2.70 U	2.70 U	21.7
ARSENIC	0.97	1.60	1.00	NA	0.97	1.20	0.96	NA	1.40	NA	0.58	1.60	1.20	2.3
BARIUM	3.00	5.00	3.60	NA	NA	2.90	3.40	NA	4.20	NA	2.20	4.50	3.60	14.7
BERYLLIUM	0.19 U	0.18 U	0.21 U	NA	NA	0.21 U	0.19 U	NA	0.21 U	NA	0.19 U	0.20 U	0.20 U	0.89
CALCIUM	20.80 J	82.20	23.30 J	NA	NA	44.80 J	98.00	NA	118.00	NA	42.80	73.40	61.90	933
CADMIUM	.039 U	0.36 U	0.42 U	NA	NA	0.41 U	0.52	NA	0.43 U	NA	0.38 U	0.41 U	0.41 U	0.75
CHROMIUM	1.60	2.30	1.70 U	NA	NA	2.20	2.30	NA	9.90	NA	1.30	1.20	2.40	3.9
COBALT	0.58 U	1.10	0.87	NA	NA	0.64	0.98	NA	1.00	NA	0.76 U	0.82 U	1.40	2.8
COPPER	0.89	1.70	0.73	NA	NA	1.40	2.10	NA	4.30	NA	0.94	0.98	0.80	4.3
CYANIDE	0.05 U	0.05 U	0.05 U	NA	NA	0.05 U	0.05 U	NA	0.06 U	NA	0.05 U	0.05 U	0.05 U	0.78
IRON	1850.00	3480.00	9350.00	NA	NA	2460.00	3300.00	NA	4500.00	NA	1340.00	2190.00	3360.00	2800
LEAD	1.20	1.90	1.80	NA	NA	1.80 J	1.80 J	NA	2.40 J	NA	1.80	1.40	1.40	3.7

Table 2-6 (cont.)

Summary of Surface Soil CLP Results

AOC FS-17

MASSACHUSETTS MILITARY RESERVATION

PARAMETER	TB-1			MW-5			MW-6			MW-7				MAXIMUM MMR SUBSURFACE BACKGROUND[a]
	10 - 12	45 - 47	78 - 80	10 - 12	20 - 22	78 - 80	10 - 12	20 - 22	78 - 80	5-7	20 - 22	30 - 32	75 -77	
MAGNESIUM	208.00	391.00	258.00	NA	NA	194.00	422.00	NA	304.00	NA	180.00	232.00	338.00	742
MANGANESE	29.90	33.40	41.80	NA	NA	15.30	48.70	NA	31.30	NA	31.60	27.70	40.70	587
MERCURY	0.10 U	0.10 U	0.10 U	NA	NA	0.11 U	0.10 U	NA	0.11 U	NA	0.08 UJ	0.07 UJ	0.08 UJ	0.06
NICKEL	1.30	1.90	1.20	NA	NA	0.10 U	0.98	NA	2.50	NA	1.10	1.20	1.80	3.9
POTASSIUM	157.00	254.00	96.00	NA	NA	169.00	253.00	NA	300.00	NA	103.00	188.00	192.00	437
SELENIUM	0.19 UJ	1.00 UJ	0.20 UJ	NA	NA	0.20 U	0.20 U	NA	0.22 U	NA	0.20 U	0.22 U	0.20 U	0.62
SILVER	0.78 U	0.73 U	0.83 U	NA	NA	0.82 UJ	0.77 UJ	NA	0.86 UJ	NA	0.38 U	0.45	0.41 U	1.1
SODIUM	139.00 UJ	124.00 UJ	139.00 UJ	NA	NA	151.00 UJ	138.00 UJ	NA	162.00 UJ	NA	150.00	156.00	187.00	339.5
THALLIUM	.019 U	0.19 U	0.20 UJ	NA	NA	0.20 UJ	0.20 UJ	NA	0.22 UJ	NA	0.40 U	0.43 U	0.39 U	1.0
VANADIUM	2.50	4.90	R	NA	NA	4.00	4.70	NA	4.80	NA	2.10	3.80	4.80	5.7
ZINC	4.20	6.70	15.40	NA	NA	3.60	10.60	NA	5.50	NA	3.10	3.80	5.10	16
TPH (mg/Kg)	14 J	NA	10 J	NA	NA	NA	NA	NA	NA	NA	NA	10 UJ	10 UJ	500 [d]

Data Validation Qualifiers

J - Indicates and estimated quanity

U- Indicates compound was not detected. Concentration preceeding qualifier is the detection limit

UJ - Indicates compound was not detected and that the detection limit is an estimated value

R - Indicates analyte was rejected

ND - Non-detect

N/A - Not applicable

NA - Not analyzed

[a] - MMR Final Risk Assessment Handbook. Table E-1. Summary Statisitics for Inorganic Concentrations in Subsurface Soils. Automated Sciences Ground, Inc. September 1994.

[b] - TICs - Represent tentatively identified compounds. Concentrations are estimated (J) and values in parenthesis reflect the number of TICs detected less those found in blanks

[c] - Gray shanding indicates exceedance of maximum MMR Background Concentrations.

[d] - Soil Target Cleanup Level for TPH

Table 2-7
Summary of Analytes Detected in Groundwater
Study Area FS-17

PRIORITY 2 AND 3 STUDY AREAS SI
MASSACHUSETTS MILITARY RESERVATION

ANALYTES / Exploration ID: / Sampled:	MW-1 19-Apr-90	MW-1* 27-Feb-90	MW-1 27-Feb-91	MW-2 19-Apr-90	MW-2 10-Jan-91
VOLATILES (ug/l)					
1.1.2.2 - Tetrachloroethene	1 NJ	-	-	-	-
Chloroform	3 J	-	-	2 J	-
SEMIVOLATILES (ug/l)					
Bis(2-ethylhexyl)phthalate	-	-	-	13	-
INORGANICS (ug/l)					
Aluminum	37.3 J	64.7 J	70 J	16.7 J	-
Barium	13.5 J	12 J	11.4 J	16 J	12.1 J
Calcium	2310 J	2140 J	2280 J	3940 J	3620 J
Cyanide	NR	-	-	3	-
Iron	-	54.3 J	40.4 J	-	-
Magnesium	2060 J	2010 J	2130 J	2970 J	2760 J
Manganese	103 J	11.6 J	13 J	10.2 J	9.8 J
Potassium	-	1450 J	936 J	-	991 J
Sodium	6140	6310	6640	5950	6150

Notes:
- = Not Detected
N/A = Not Analyzed
* = Duplicate Sample
Shaded results are below MMR background concentrations

Table 2-8
Analytical Results for Unfiltered Metals in Groundwater

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

PARAMETERS	MW-1	MW-2	MW-3	MW-4	MW-5A (DUP. OF MW-5)	MW-5	MW-6	MW-7	MAXIMIUM MMR BACKGROUND CONC. [a]	FEDERAL MCL [b]	STATE MMCL [c]
ALUMINUM	937.00 [d]	6,870.00	4,810.00	1,710.00	3,180.00	1,830.00	2,760.00	4,180.00	312	NA	NA
ANTIMONY	2.10 J	3.10 J	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	30.00	6	6
ARSENIC	2.00 U	2.00 U	2.00 U	2.60	2.00 U	2.00 U	2.00 U	1.20	2.00	50	50
BARIUM	19.90	28.20	38.10	34.00	33.20	25.20	25.90	32.90	95.00	2,000	2,000
BERYLLIUM	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.50	4	4
CADMIUM	0.20 U	0.22	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.28	2.50	5	5
CALCIUM	3,050.00	3,890.00	4,840.00	3,760.00	3,420.00	3,090.00	5,150.00	3,640.00	6,770.00	100	100
CHROMIUM	6.00 U	12.70	6.50	6.00 U	15.20	6.00 U	14.00	14.00	17.00	NA	NA
COBALT	4.00 U	4.00 U	9.30	4.00 U	4.00 U	4.00 U	4.00 U	5.10	6.00	NA	NA
COPPER	5.00	40.60	8.60	3.00 U	7.10	3.00	4.30	7.80	12.50	1,300 [e]	1,300
CYANIDE	1.00 UJ	1.00 UJ	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	5.00	200	200
IRON	1,130.00 J	7,320.00 J	11,200.00	3,490.00	5,930.00	3,490.00	5,430.00	8,010.00	471.00	NA	NA
LEAD	1.4	40.00	5.20	2.50	3.80	2.70	4.40	6.30	2.90	15 [f]	15
MAGNESIUM	2,510.00	2,980.00	3,770.00	3,790.00	3,910.00	3,230.00	4,550.00	3,580.00	4,930.00	NA	NA
MANGANESE	51.60 J	86.60 J	311.00	73.80	120.00	84.10	88.40	200.00	109.00	NA	NA
MERCURY	0.20UJ	0.20UJ	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	0.10	2	2
NICKEL	4.00 U	6.00	11.10	5.40	10.40	8.30	9.40	7.60	19.00	100	100
POTASSIUM	1,100.00 J	1,360.00 J	1,950.00	1,550.00	1,610.00	1,400.00	1,710.00	2,090.00	1,975.00	NA	NA
SELENIUM	1.00UJ	1.00UJ	5.00U	5.00U	5.00U	5.00U	5.00U	1.00U	2.00	50	50
SILVER	2.00 UJ	2.00 UJ	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	2.00 U	5.00	NA	NA
SODIUM	8,100.00	5,050.00	7,180.00	10,300.00	7,650.00	7,180.00	8,020.00	8,380.00	22,600.00	NA	NA
THALLIUM	2.00U	2.00U	2.00U	2.00U	2.00U	2.00U	2.00U	2.00U	1.50	2	2
VANADIUM	2.50	14.90	12.80	5.50	8.40	4.00	7.40	8.30	7.50	NA	NA
ZINC	22.70	65.50	28.00	11.30	30.10	20.40	40.50	41.50	68.90	NA	NA

Units in ug/L

[a] Maximum MMR Background concentrations for unfiltered metals in groundwater were obtained from the MMR Background Inorganics Study (HAZWRAP 1994, Background Inorganics Study, Massachusetts Military Reservation, Cape Cod, Massachusetts, January 1994).

[b] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (US EPA 1995, Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C., May 1995).

[c] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values (MDEP, 1994, Massachusetts Department of Environmental Protection, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring 1994).

[d] Gray Shading Indicates An Exceedance Of an ARAR

[e] The Federal Treatment Technology for copper is 1,300 mg/L

[f] The Federal Treatment Technology for lead is 15 mg/L

NA - ARAR does not exist

Data Validation Qualifiers

J - Indicates an estimated quantity

U - Indicates compound was not detected. Concentration preceeding qualifier is the detection limit

UJ - Indicates compound was not detected and that the detection limit is an estimated value

Table 2-8 (Continued)
Analytical Results for Filtered Metals in Groundwater
AOC FS-17
Massachusetts Military Reservation

Parameters	MW-1	MW-2	MW-3	MW-4	MW-5A (Duplicate)	MW-5	MW-6	MW-7	Maximum MMR Background Concentrations [a]	Federal MCL [b]	State MMCL [c]
Aluminum	113.0 U	113.0 U	113.0 U	125.0 J	113.0 U	113.0 U	113.0 U	**666.0[d]**	259	NA	NA
Antimony	6.7 U	8.9 J	5.4J	4.9 J	2.0 U	6.4 J	2.0 U	3	30	6	6
Arsenic	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	1.0 U	2	50	50
Barium	14.7 UJ	12.4 UJ	10.7	18.8	14.4	14	10.6	10.9	100	200	200
Beryllium	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U	5.1	4	4
Cadmium	0.2 UJ	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	2.5	5	5
Calcium	2890	4140	4260	3350	3000	2990	4660	3590	6610	100	100
Chromium	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	**6**	5	NA	NA
Cobalt	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	4.1	6	NA	NA
Copper	3.0 U	6.6	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	12.5	1300[e]	1300
Iron	24.0 U	24.0 U	24.0 U	32.2	28.1	24.0 U	24.0 U	**464**	422	NA	NA
Lead	1.0 U	1.0 U	1.1	1.0 U	1.0 U	1.0 U	1.0 U	1.4	2	15[f]	15
Magnesium	2260	2590	2480	2950	2560	2510	3360	2560	4890	NA	NA
Manganese	14.8	16.1	10.4	19.5	17.6	18.4	9.3	39	103	NA	NA
Mercury	0.2 UJ	0.2 UJ	0.2 U	.02 U	0.2 U	0.2 U	0.2 U	0.2 U	0.1	2	2
Nickel	4.0 U	4.0 U	4.5J	4.5 U	4.0 U	4.0 U	4.0 U	5.7	19	100	100
Potassium	1090	871	1020	1050	869	966	961	1370	1975	NA	NA
Selenium	1.0 UJ	1.0UJ	R	R	R	R	R	1.0 U	2	50	50
Silver	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	5	NA	NA
Sodium	7900	6140	6790	9110	7270	7080	7660	8590	22400	NA	NA
Thallium	2.0 UJ	2.0 UJ	2.0U	2.0U	2.0U	2.0U	2.0U	2.0U	1.5	2	2
Vanadium	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	2.6	7.5	NA	NA
Zinc	5.6 UJ	21.7	7.8 UJ	5.9 UJ	6.4 UJ	11.7	4.4 UJ	13.6	73.5	NA	NA

Units in ug/L

[a] Maximum MMR Background concentrations for unfiltered metals in groundwater were obtained from the 1994 MMR Background Inorganics Study (HAZWRAP 1994)

[b] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C , May 1995).

[c] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values (MADEP, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring 1994)

[d] Gray Shading Indicates An Exceedance Of an ARAR

[e] The Federal Treatment Technology for copper is 1,300 mg/L

[f] The Federal Treatment Technology for lead is 15 mg/L

NA - ARAR does not exist

Data Validation Qualifiers

J - Indicates an estimated quantity

U - Indicates compound was not detected. Concentration preceeding qualifier is the detection limit

UJ - Indicates compound was not detected and that the detection limit is an estimated value

Table 2-8a
FS-17 Groundwater Analytical Results - 1999

TAL METALS	MW-1	MW-3	MW-3 DUPLICATE	MW-5	MW-6	MW-7	MAXIMUM MMR BACKGROUND [b]	FEDERAL MCL [c]	STATE MMCL [d]
Aluminum	ND	ND	ND	ND	ND	ND	312.00	NA	NA
Antimony	ND	ND	ND	ND	ND	ND	30.00	6	6
Arsenic	ND	ND	3.4J	ND	ND	ND	2.00	50	50
Barium	15.4J	14.8J	14J	11.9J	9.6J	10.2J	95.00	2,000	2,000
Beryllium	ND	ND	ND	ND	ND	ND	1.50	4	4
Cadmium	ND	ND	ND	ND	ND	ND	2.50	5	5
Calcium	3250	4200	4030	2520	3490	3810	6770	100	100
Chromium	ND	ND	ND	13.00	ND	ND	17.00	NA	NA
Cobalt	ND	ND	ND	ND	5.40	ND	6.00	NA	NA
Copper	ND	ND	ND	ND	ND	ND	12.50	1,300 TT	1,300
Cyanide	NA	NA	NA	NA	NA	NA	5.00	200	200
Iron	ND	ND	ND	160.00	ND	ND	471.00	NA	NA
Lead	ND	ND	ND	ND	ND	ND	2.90	15 TT	15
Magnesium	2,420	1,780	1,720	1,930	2,360	2,480	4,930	NA	NA
Manganese	6.3J	6.5J	5.9J	14.30	9.2J	4.3J	109.00	NA	NA
Mercury	ND	ND	ND	ND	ND	ND	0.10	2	2
Nickel	ND	ND	ND	18.6J	ND	ND	19.00	100	100
Potassium	ND	867J	722J	ND	ND	ND	1,975.00		NA
Selenium	ND	ND	ND	ND	ND	ND	2.00	50	50
Silver	ND	ND	ND	ND	ND	ND	5.00	NA	NA
Sodium	9,610	8,030	7,720	6,830	10,200	6,800	22,600	NA	NA
Thallium	ND	7.0J (ND)	7.9J	ND	ND	ND	1.50	2	2
Vanadium	ND	ND	ND	ND	ND	ND	7.50	NA	NA
Zinc	ND	ND	ND	ND	ND	ND	66.90	NA	NA

Unit in ug/L

[b] Maximum MMR Background concentrations for unfiltered metals in groundwater were obtained from the MMR Background Inorganics Study (HAZWRAP 1994, Background Inorganics Study, Massachusetts Military Reservation, Cape Cod, Massachusetts, January 1994).
[c] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (US EPA 1995, Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C., December 1995).
[d] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values.
Department of Environmental Protection, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring1994).
[e] The MCL for copper is an action level set at 1,300 ug/L.
[f] The MCL for lead is an action level set at 15 ug/L.
() Sample resutls for the July/August Sampling Event (MW-3 sampled for Thallium only.)
Exceedance of Maximum MMR Background Concentration
Exceedance of Federal Action Limit/State MMCL

J estimated value

Table 2-9
Summary of Analytes Detected in Surface Soil
Study Area FS-19

PRIORITY 2 AND 3 STUDY AREAS SI
MASSACHUSETTS MILITARY RESERVATION

ANALYTES	Exploration ID:	TB-1 *	TB-1	TB-2
	Sampled:	20-Nov-89	20-Nov-89	3-Dec-90
	Depth:	0	0	2
VOLATILES (mg/kg)		-	-	-
SEMIVOLATILES (mg/kg)		-	-	-
INORGANICS (mg/kg)				
Aluminum		1710	1720	N/A
Arsenic		0.7 J	0.91 J	N/A
Barium		4.5 J	4.8 J	N/A
Cadmium		1.2 J	-	N/A
Calcium		206 J	127 J	N/A
Chromium		3.6	4.1	N/A
Copper		2.5 J	2.8 J	N/A
Iron		3150	2870	N/A
Lead		8.5 J	10 J	N/A
Magnesium		450 J	396 J	N/A
Manganese		54.8 J	52.5 J	N/A
Vanadium		4.1 J	3.9 J	N/A
TOTAL PETROLEUM HYDRCARBONS (mg/kg)		64	61	N/A

Notes:

- = Not Detected
N/A = Not Analyzed
* - Duplicate Sample
Shaded result are below MMR background concentrations

Table 2-10
Summary of Surface Soil CLP Results

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

AREA I AND AREA II CLP DATA					MAXIMUM MMR BACKGROUND CONCENTRATION [a]
ANALYSIS/ COMPOUND	SURFACE SOIL SAMPLES SS-1	SS-2	SS-2A	SS-3	
TCL VOCs (ug/kg)					
Methylene Chloride	ND	1 J	1 J	ND	N/A
Acetone	5 J	ND	ND	ND	N/A
Chloroform	ND	1 J	1 J	1 J	N/A
Toluene	ND	1 J	ND	2 J	N/A
Total xylene	ND	3 J	ND	ND	N/A
CLP VOC TICs [a]	82 (3)	73 (2)	76 (2)	24 (3)	N/A
TCL SVOCs (ug/kg)					
Naphthalene	29 J	ND	ND	ND	N/A
2-Methylnaphthalene	38 J	ND	ND	ND	N/A
Acenaphthylene	ND	ND	ND	22 J	N/A
Phenanthrene	35 J	41 J	35 J	110 J	N/A
Anthracene	ND	ND	ND	11 J	N/A
Di-n-butylphthalate	20 J	12 J	ND	ND	N/A
Fluoranthene	38 J	74 J	76 J	170 J	N/A
Pyrene	35 J	65 J	72 J	130 J	N/A
Benzo(a)anthracene	ND	46 J	42 J	64 J	N/A
Chrysene	36 J	51 J	46 J	89 J	N/A
Benzo(b)fluoranthene	46 J	92 J	88 J	160 J	N/A
Benzo(k)fluoranthene	46 J	92 J	88 J	160 J	N/A
Benzo(a)pyrene	17 J	43 J	37 J	64 J	N/A
Indeno(1,2,3-cd)pyrene	24 J	35 J	33 J	49 J	N/A
Dibenzo(a,h)anthracene	ND	ND	ND	29 J	N/A
Benzo(g,h,i)perylene	22 J	30 J	28 J	45 J	N/A
CLP SVOC TICs [a]	7,241 (23)	2,666 (15)	2,117 (11)	12,188 (23)	N/A
TCL Pesticides (ug/kg)					
Dieldrin	70	21	18	120	N/A
4,4'-DDE	110	44	39	11	N/A
4,4'-DDD	19 J	12 J	12 J	ND	N/A
4,4'-DDT	930 J	280 J	380 J	27 J	N/A
Methoxychlor	16 J	31	34	ND	N/A
Endrin Ketone	17	30	32	ND	N/A
alpha Chlordane	ND	ND	1.3 J	ND	N/A
gamma Chlordane	1.9 J	2.6 J	3 J	ND	N/A
TCL PCBs (ug/kg)					
Aroclor-1260	260	420	540	ND	N/A

Table 2-10 (cont.)
Summary of Surface Soil CLP Results

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

AREA I AND AREA II					MAXIMUM MMR BACKGROUND CONCENTRATION
CLP DATA					
ANALYSIS/ COMPOUND	SURFACE SOIL SAMPLES				
	SS-1	SS-2	SS-2A	SS-3	
TAL Inorganics (mg/kg)					
Aluminum	13,800	7,590	7,260	7,650	8,930
Antimony	3.9UJ	3.8UJ	3.6UJ	4UJ	17.5
Arsenic	4.8	2.9	3.2	3.1	3.6
Barium	57.9	15.9	15.7	16.4	10.4
Beryllium	0.39	0.29	0.28	0.24U	0.65
Calcium	1,280	356	404	444	969
Cadmium	0.45	1.1	1	0.47U	1.5
Chromium	11.5	7.1	6.6	7.9	6.8
Cobalt	3.2	3	3	1.5	4.1
Copper	5UJ	23.7UJ	24.4UJ	3.9UJ	5.2
Cyanide	0.06UJ	0.1J	0.05UJ	0.06UJ	0.7
Iron	13,900	9,420	9,340	9,780	12,400
Lead	119	40.8	36.2	29.9	12.05
Magnesium	1,300	1,030	1,000	633	794.5
Manganese	73.4J	92J	81.9J	43.3J	108
Mercury	0.12U	0.11U	0.11U	0.12U	0.06
Nickel	6	5.3	4.8	4	5.2
Potassium	717	490	495	370	551
Selenium	0.23UJ	0.21UJ	0.21UJ	0.21UJ	0.33
Silver	1.1U	1.1U	1.1U	1.2U	1.4
Sodium	105U	102U	97.7U	109U	386
Thallium	0.23U	0.21U	0.21U	0.21U	0.25
Vanadium	22.5	14.8	13.4	18.7	15.2
Zinc	68	38.2	41.6	21.6	16
TPH (418.1) (mg/kg)	93 J	50 J	48 J	ND	500[b]
TPH (8015) (mg/kg)	37	ND	14	16	500 [b]

[a] TICs represent tentatively identified compounds. Concentrations are considered estimated values.

The value in parenthesis is the number of TICs identified

[b] MMR Soil Target Cleanup Level (STCL) for TPH.

ft bgs - Feet below ground surface

ND - Not detected

NA - Not applicable to MMR

N/A - Not Available

U - Indicates analyte was not detected. Concentration preceeding the qualifier is the detection limit

J - Indicates an estimated concentration

UJ - Indicates that analyte was not detected. The detection limit is an estimated value

Indicates that the analyte exceeded the maximum MMR background concentration for surficial soils

Table 2-11
Summary of Analytes Detected in Subsurface Soil
Study Area FS-19

PRIORITY 2 AND 3 STUDY AREAS SI
MASSACHUSETTS MILITARY RESERVATION

ANALYTES	Exploration ID: Sampled: Depth:	TB-12 3-Dec-90 10	TB-2 3-Dec-90 20	MW-1 21-Nov-90 60
VOLATILES (mg/kg)		-	-	-
SEMIVOLATILES (mg/kg)		N/A	-	-
INORGANICS (mg/kg)				
Aluminum		N/A	1010 J	505
Arsenic		N/A	1.4 J	0.73 J
Barium		N/A	4.2 J	2.4 J
Calcium		N/A	137 J	58.1 J
Chromium		N/A	3.4 J	3
Copper		N/A	2.2 J	-
Iron		N/A	2290 J	1620
Lead		N/A	1.4 J	0.74 J
Magnesium		N/A	311 J	104 J
Manganese		N/A	34.9 J	9.1 J
Sodium		N/A	67.8 J	-
Vanadium		N/A	-	3.4 J
Zinc		N/A	5.7 J	-
TOTAL PETROLEUM HYDRCARBONS (mg/kg)		64	N/A	-

Notes:

- = Not Detected
N/A = Not Analyzed
* - Duplicate Sample
Shaded result are below MMR background concentrations

Table 2-12
CLP Results for Test Borings TB-5 AND TB-6

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

AREA I TEST BORING TB-6			
ANALYTE	**DEPTHS (ft bgs)**		
	5 - 7	**10 - 12**	**30 - 32**
TCL VOCs (ug/kg)			
Acetone	ND	97 J	160 J
2 - Butanone	4 J	ND	8 J
Total Xylenes	ND	11	ND
TCL VOC TICs [a]	**194J (2)**	**179J (4)**	**250J (5)**
TCL SVOCs (ug/kg)	ND	ND	ND
TCL SVOCs TICs [a]	0	0	0
TCL Pesticides (ug/kg)			
4,4' - DDT	4.9	6.2	ND
TCL PCBs (ug/kg)	ND	ND	ND
TAL METALS [b] (mg/kg)	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)	NA [c]	NA [c]	NA [c]

Table 2-12 (cont.)
CLP Results for Test Borings TB-5 AND TB-6

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

AREA II TEST BORING TB-5					
ANALYTE	DEPTHS (ft bgs)				MAXIMUM MMR BACKGROUND [b]
	5 - 7	10 - 12	15 - 17	30-32	
TCL VOCs (ug/kg)					
Acetone	ND	ND	NA	150J	N/A
2 - Butanone	ND	ND	NA	5J	N/A
Toluene	3 J	ND	NA	10U	N/A
Total xylene	4 J	ND	NA	10U	N/A
TCL VOC TICs	183J (2)	218J (2)	NA	174J (2)	N/A
TCL SVOCs (ug/kg)	NA	ND	ND	ND	N/A
TCL SVOCs TICs	NA	0	0	176J (2)	N/A
TCL Pesticides (ug/kg)					
Dieldrin	NA	ND	ND	2.9J	N/A
4,4' - DDT	NA	ND	ND	3.4	N/A
TAL Metals (mg/kg)					
Arsenic	NA	0.95	1.2	2.4	2.3
Iron	NA	2,350	2,220	3,030	2,800
Total Petroleum Hydrocarbons (mg/kg)	NA [c]	NA [c]	ND	NA [c]	500 [d]

Units for VOCs, SVOCs, pesticides and PCBa are in units of ug/kg. TAL metals and cyanide in units of mg/kg

[a] TICs - Represent tentatively identified compounds. Concentrations are estimated (J) and values in parenthesis reflect the numbers of TICs detected less those found in blanks.
[b] Only metals exceeding maximum MMR Background Concentrations for subsurface soils are provided in this table.
[c] Refer to Table 5-3 for TPH results obtained as part of the screening program.
[d] MMR Soil Target Cleanup Level (STCL) for TPH is 500 mg/kg
ft bgs - Feet below ground surface
ND - Analyte not detected
NA - Parameter not analyzed
N/A - ARAR or background concentration does not exist
- Metal did not exceed maximum MMR Background concentration
J - Indicates an estimated concentration
Indicates an exceedance of maximum MMR background concentration

Table 2-13
Summary of Analytes Detected in Groundwater
Study Area FS-19

PRIORITY 2 AND 3 STUDY AREAS SI
MASSACHUSETTS MILITARY RESERVATION

ANALYTES / Exploration ID: / Sampled: / Depth:	MW-1 29-Mar-90	MW-1 15-Jan-91	MW-2 15-Jan-91	AEHA-9 15-Jan-91 24-Feb-00	AEHA-9 15-Jan-91 5-Mar-00
VOLATILES (ug/l)					
1.1.1. - Trichlorethane	69	12 J	-	15 J	5 J
1.1 - Dichloroethane	6	-	-	-	-
Methylene Chloride	-	-	-	-	4 J
Trichlorethene	32	3 J	-	3 J	-
SEMIVOLATILES (ug/l)	-	-	-	-	-
INORGANICS (ug/l)					
Barium	13.6 J	17.7 J	15.7 J	10.7 J	10.6 J
Calcium	3340 J	4530 J	5390	3550 J	3470 J
Lead	-	2 J	-	1.1 J	-
Magnesium	1360 J	1830 J	3180 J	2000 J	2180 J
Manganese	4.3 J	-	68.3	7.5 J	12.3 J
Nickel	-	-	-	16 J	14 J
Potassium	-	936 J	1110 J	905 J	1230 J
Sodium	8200	10500	19700	9830	10300
Vanadium	-	-	-	4.3 J	-
Zinc	-	-	-	-	63.2

Notes:
- = Not Detected
N/A = Not Analyzed
* = Duplicate Sample
Shaded results are below MMR background concentrations

Table 2-13A
Analytical Results0for Unfiltered Metals in Groundwater

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

TAL METALS	MW-1	MW-1A [a]	MW-2	MW-3	MW-4	AEHA-9	MAXIMUM MMR BACKGROUND [b]	FEDERAL MCL [c]	STATE MMCL [d]
Aluminum	1,930.00	15,100.00	856.00	5,600.00	3,300.00	968.00	312.00	NA	NA
Antimony	2.00U	2.00U	2.00U	2.00U	2.00U	2.00U	30.00	6	6
Arsenic	2.00U	4.80 J	2.00U	2.00UJ	2.00UJ	2.00U	2.00	50	50
Barium	25.7	111.00	29.30	136.00	42.20	29.20	95.00	2,000	2,000
Beryllium	1.00U	1.2	1.00U	1.00U	1.00U	1.00U	1.50	4	4
Cadmium	0.20U	0.20U	0.20U	0.20U	0.20U	0.20U	2.50	5	5
Calcium	4,110.00	3,810	5,390.00	10,200.00	3,450.00	5,310.00	6,770.00	100	100
Chromium	6.00U	20.60	6.00U	9.10	6.00U	6.00U	17.00	NA	NA
Cobalt	4.00U	14.10	4.00U	4.00U	4.00U	4.00U	6.00	NA	NA
Copper	3.00U	13.70	3.00U	3.00U	4.70	3.00U	12.50	1,300 TT	1,300
Cyanide	1.00UJ	1.00UJ	1.00UJ	1.00U	1.00U	1.00UJ	5.00	200	200
Iron	1,080 J	19,300 J	940.00 J	5,830.00 J	3,900.00 J	986.00 J	471.00	NA	NA
Lead	1.00U	[redacted]	R	1.30	1.00U	1.00U	2.90	15 TT	15
Magnesium	3,040	6,100.00	2,980.00	5,530.00	3,290.00	2,980.00	4,930.00	NA	NA
Manganese	36.90	465 J	30.70J	204.00 J	102.00 J	33.40 J	109.00	NA	NA
Mercury	0.20UJ	0.20UJ	0.20UJ	0.20UJ	0.20UJ	0.20UJ	0.10	2	2
Nickel	4.00U	22.10	4.00U	5.20	4.50	4.00U	19.00	100	100
Potassium	1,530.00	4,180.00	1,370.00J	2,900.00	2,040.00	1,290.00 J	1,975.00	NA	NA
Selenium	1.00UJ	5UJ	1.00UJ	1.00UJ	1.00UJ	1.00UJ	2.00	50	50
Silver	2.00UJ	2.00UJ	2.00UJ	2.00UJ	2.00UJ	2.00UJ	5.00	NA	NA
Sodium	21,200.00	14,300.00	19,800.00	25,500.00	7,040.00	19,600.00	22,600.00	NA	NA
Thallium	2.00U	2.00U	2.00U	2.00U	2.00U	2.00U	1.50	2	2
Vanadium	2.00U	24.40	2.00U	9.20	2.00U	2.00U	7.50	NA	NA
Zinc	8.6UJ	58.9	7.3UJ	31.3	17.4	6.10UJ	66.90	NA	NA

Unit in ug/L

[a] *MW-1A is a duplicate sample of MW-1.*
[b] Maximum MMR Background concentrations for unfiltered metals in groundwater were obtained from the MMR Background Inorganics Study (HAZWRAP 1994, Background Inorganics Study, Massachusetts Military Reservation, Cape Cod, Massachusetts, January 1994).
[c] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (US EPA 1995, Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C., December 1995).
[d] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values. Department of Environmental Protection, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring1994).
[e] The MCL for copper is an action level set at 1,300 ug/L.
[f] The MCL for lead is an action level set at 15 ug/L.
NA - ARAR does not exist
J - Indicates an estimated concentration
U - Indicates compound was not detected. Concentration proceedin the qualifier is the detection limit.
UJ - Indicates compound not detected and the detection limit is an estimated value
R - Indicates that analyte was rejected
Exceedance of Maximum MMR Background Concentration
[redacted] Exceedance of Federal Action Limit/State MMCL

Table 2-13A (cont.)
Analytical Results for Filtered Metals in Groundwater

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

TAL METALS	MW-1	MW-1A [a]	MW-2	MW-3	MW-4	AEHA-9	MAXIMUM MMR BACKGROUND [b]	FEDERAL MCL [c]	STATE MMCL [d]
Aluminum	113 UJ	113 UJ	113 UJ	155	113 UJ	113 UJ	259.00	NA	NA
Antimony	3J	3.7J	2.3J	5J	5.5J	4.9J	30.00	6	6
Arsenic	2U	2U	2U	2U	2U	2U	2.00	50	50
Barium	17.1UJ	11.5UJ	24.3	117	17.0 UJ	23.4	100.00	2,000	2,000
Beryllium	1U	1U	1U	1U	1U	1U	5.10	4	4
Cadmium	0.2UJ	0.2UJ	0.2UJ	0.22	0.2U	0.2UJ	2.50	5	5
Chromium	6U	6U	6U	6U	6U	6U	6,610.00	100	100
Calcium	4,110	3,810	5,400	10,900	3,040	5,310	5.00	NA	NA
Cobalt	4U	4U	4U	4U	4U	4U	6.00	NA	NA
Copper	3U	3U	3U	3U	3U	3U	12.50	1,300 TT	1,300
Iron	24U	24U	24U	24U	24U	24U	422.00	NA	NA
Lead	1U	1U	R	1.3	1U	1U	2.00	15 TT	15
Magnesium	2,440	2,220	2,820	4,310	2,100	2,750	4,890.00	NA	NA
Manganese	16.3	8.6	6.2	40.3	8.4	6.1	103.00	NA	NA
Mercury	0.2UJ	0.2UJ	0.2UJ	0.2UJ	0.2UJ	0.2UJ	0.10	2	2
Nickel	4U	4U	4U	5.2	4U	4U	19.00	100	100
Potassium	1,330	1,090	1,180	1,870	1,410	1,260	1,975.00	NA	NA
Selenium	1UJ	1UJ	1UJ	1UJ	1UJ	1UJ	2.00	50	50
Silver	2U	2U	2U	2U	2U	2U	5.00	NA	NA
Sodium	20,900	13,900	2,820	32,500	6,580	19,600	22,400.00	NA	NA
Thallium	2UJ	2UJ	2UJ	2UJ	2UJ	2UJ	1.50	2	2
Vanadium	2U	2U	2U	2U	2U	2U	7.50	NA	NA
Zinc	6.9UJ	36.2	3.8UJ	11.7	8.2UJ	7UJ	73.50	NA	NA

Units in ug/L
[a] MW-1A is a duplicate sample of MW-1.
[b] Maximum MMR Background concentrations for filtered metals in groundwater were obtained from the MMR Background Inorganics Study (HAZWRAP 1994, Background Inorganics Study, Massachusetts Military Reservation, Cape Cod, Massachusetts, January 1994).
[c] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (US EPA 1995, Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C., May 1995).
[d] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values (MDEP, 1994, Massachusetts Department of Environmental Protection, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring 1994).
NA - ARAR does not exist
TT - Treatment Technology Based
[ ] Indicates exceedance of Maximum MMR (filtered) Background Concentrations

Table 2-13A (cont.)
Summary of Groundwater CLP Results (Organics)

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

PARAMETERS	MW-1	MW-1A	MW-2	MW-3	MW-4	AEHA-9	FEDERAL MCL	STATE MCL
TCL VOCs								
1,1,1-Trichloroethane	1.3	1.6	ND	ND	ND	ND	200	200
Benzene	0.3	0.7	ND	ND	ND	ND	5	5
Toluene	4	7.6	1.5	ND	ND	0.4	1,000	1,000
Ethylbenzene	1.4	2.6	0.6	ND	ND	ND	700	700
O-Xylene	2.9	5.1	1	ND	ND	ND	10,000 [a]	10,000 [a]
M,P-Xylene	7.1	12	2.9	ND	ND	ND	10,000 [a]	10,000 [a]
1,3,5-Trimethylbenzene	0.9	1.2	ND	ND	ND	ND	N/A	N/A
1,2,4-Trimethylbenzene	2.6	3.8	1.2	ND	ND	ND	N/A	N/A
TCL VOC TICs [b]	0	1 J (1)	0	0	0	0	N/A	N/A
TCL SVOCs								
Bis(2-ethylhexyl)phthalate	ND	13	ND	ND	ND	ND	N/A	6
TCL SVOC TICs	32 J (11)	42 J (9)	29 J (8)	0	0	32 J (8)	N/A	N/A
TCL Pesticides	ND	ND	ND	ND	ND	ND	N/A	N/A
TCL PCBs	ND	ND	ND	ND	ND	ND	0.5	0.5
TPH (418.1)	ND	ND	ND	ND	ND	ND	N/A	N/A
EDB	ND	ND	ND	ND	ND	ND	0.05	0.02

[a] ARAR or standard is for total xylenes.
[b] *TICs - Represent tentatively identified compounds. Concentrations are estimated (J) and values in parenthesis* reflect the numbers of TICs detected less those found in blanks.
ND - Compound not detected
N/A - ARAR does not exist
[ ] Exceedance of State MCL

Table 2-13b
FS-19 Groundwater Analytical Results - 1999

TAL METALS	MW-1	MW-2	MW-3	MW-4	AEHA-9	AEHA-9 DUPLICATE	MAXIMUM MMR BACKGROUND [b]	FEDERAL MCL [c]	STATE MMCL [d]
Aluminum	ND	ND	ND	43.3J	ND	ND	312.00	NA	NA
Antimony	ND	ND	ND	ND	ND	ND	30.00	6	6
Arsenic	ND	ND	2.6J	ND	ND	ND	2.00	50	50
Barium	13-1J	17.7J	28.20	24.50	7.9J	7.2J	95.00	2,000	2,000
Beryllium	ND	ND	ND	ND	ND	ND	1.50	4	4
Cadmium	ND	ND	ND	ND	ND	ND	2.50	5	5
Calcium	2830J	4,770	4,190	4,020	2,080	1,980	6,770	100	100
Chromium	ND	ND	ND	0.9J	ND	ND	17.00	NA	NA
Cobalt	ND	ND	7.20	3.0J	ND	ND	6.00	NA	NA
Copper	ND	62.3J	ND	ND	96J	ND	12.50	1,300 TT	1,300
Cyanide	NA	NA	NA	NA	NA	NA	5.00	200	200
Iron	ND	ND	ND	ND	ND	ND	471.00	NA	NA
Lead	ND	ND	ND	ND	ND	ND	2.90	15 TT	15
Magnesium	1,300	2,560	2,340	2,420	1,150	1,080	4,930	NA	NA
Manganese	3.3J	13.80	10.30	11.10	3.9J	3.6J	109.00	NA	NA
Mercury	ND	ND	ND	ND	ND	ND	0.10	2	2
Nickel	ND	ND	ND	2.0J	ND	ND	19.00	100	100
Potassium	ND	744.00	697J	1,150.00	ND	ND	1,975.00	NA	NA
Selenium	ND	ND	ND	ND	ND	ND	2.00	50	50
Silver	ND	ND	ND	ND	ND	ND	5.00	NA	NA
Sodium	17600J	31,100	20,200	9,190	11,600	11,400	22,600	NA	NA
Thallium	ND	ND	13.3 (ND)	ND	ND	ND	1.50	2	2
Vanadium	ND	ND	ND	ND	ND	ND	7.50	NA	NA
Zinc	ND	ND	26.10	ND	ND	14.9J	66.90	NA	NA

Unit in ug/L

[b] Maximum MMR Background concentrations for unfiltered metals in groundwater were obtained from the MMR Background Inorganics Study (HAZWRAP 1994, Background Inorganics Study, Massachusetts Military Reservation, Cape Cod, Massachusetts, January 1994).
[c] MCLs for inorganics were obtained from EPA's Drinking Water Regulations, May 1995 (US EPA 1995, Drinking Water Regulations and Health Advisories; U.S. Environmental Protection Agency, Office of Water, Washington, D.C., December 1995).
[d] Massachusetts Drinking Water MCLs (MMCLs) were obtained from MDEP's Spring 1994 Published values. Department of Environmental Protection, Drinking Water Standards and Guidelines for Chemical in Massachusetts Drinking Water, Spring1994).
[e] The MCL for copper is an action level set at 1,300 ug/L.
[f] The MCL for lead is an action level set at 15 ug/L.
() Sample resutls for the July/August Sampling Event (MW-3 sampled for Thallium only.)
Exceedance of Maximum MMR Background Concentration
Exceedance of Federal Action Limit/State MMCL

J estimated value

Table 2-14
Selection of COCs for Surface Soils - Human Health

AOC FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	MAXIMUM	AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	HQ=0.2 (non-cancer)	COC
Volatile Organics											
Acetone	mg/kg	3	5	0.002	0.015	0.13 *	NA	NA	--	5.49E+03	
Carbon Disulfide	mg/kg	1	5	0.001	0.001	0.12 *	NA	NA	--	--	YES
Chloroform	mg/kg	3	5	0.001	0.001	0.12 *	NA	NA	4.29E-01	5.49E+02	
Ethyl Benzene	mg/kg	1	5	3.7	3.7	0.74	NA	NA	--	1.66E+03	
Methylene Chloride	mg/kg	3	5	0.001	0.001	0.12 *	NA	NA	8.54E+01	9.32E+02	
Toluene	mg/kg	4	5	0.001	1.8	0.36	NA	NA	--	5.93E+02	
Total Xylenes	mg/kg	3	5	0.002	25	5.00	NA	NA	--	1.10E+05	
Semi-Volatile Organics											
2-Methylnaphthalene	mg/kg	4	5	0.032	120	24.00	NA	NA	--	--	YES
Acenaphthylene	mg/kg	4	5	0.014	0.22	5.30 *	NA	NA	--	2.20E+03	
Anthracene	mg/kg	4	5	0.01	0.092	5.20 *	NA	NA	--	1.65E+04	
Benzo(a)anthracene	mg/kg	4	5	0.035	0.33	5.30 *	NA	NA	8.77E-01	--	
Benzo(a)pyrene	mg/kg	4	5	0.036	0.3	5.30 *	NA	NA	8.77E-02	--	YES
Benzo(b)fluoranthene	mg/kg	4	5	0.13	0.92	5.50 *	NA	NA	8.77E-01	--	YES
Benzo(g,h,i)perylene	mg/kg	4	5	0.035	0.28	5.30 *	NA	NA	--	2.20E+03	
Benzo(k)fluoranthene	mg/kg	4	5	0.13	0.92	5.50 *	NA	NA	8.75E+00	--	
Carbazole	mg/kg	1	5	0.092	0.092	5.40 *	NA	NA	3.20E+01	--	
Chrysene	mg/kg	4	5	0.046	0.41	5.30 *	NA	NA	8.77E+01	--	
Dibenzo(a,h)anthracene	mg/kg	3	5	0.027	0.12	5.30 *	NA	NA	8.77E-02	--	YES
Dibenzofuran	mg/kg	2	5	0.017	0.072	5.30 *	NA	NA	--	2.20E+02	
Di-n-butylphthalate	mg/kg	4	5	0.01	0.062	5.20 *	NA	NA	--	5.49E+03	
Fluoranthene	mg/kg	4	5	0.062	0.77	5.40 *	NA	NA	--	2.20E+03	
Fluorene	mg/kg	1	5	10	10	2.30	NA	NA	--	2.20E+03	
Indeno(1,2,3-cd)pyrene	mg/kg	4	5	0.033	0.33	5.30 *	NA	NA	8.77E-01	--	
Naphthalene	mg/kg	4	5	0.021	48	9.74	NA	NA	--	2.20E+03	
Phenanthrene	mg/kg	5	5	0.028	10	2.20	NA	NA	--	2.20E+03	
Pyrene	mg/kg	5	5	0.055	2.2	0.64	NA	NA	--	1.65E+03	

Table 2-14
Selection of COCs for Surface Soils - Human Health

AOC FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	MAXIMUM	AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	HQ=0.2 (non-cancer)	COC
Pesticides/PCBs											
4,4'-DDE	mg/kg	3	5	0.0018	0.023	0.0065	NA	NA	6.28E+00	1.28E+02	
4,4'-DDD	mg/kg	2	5	0.0022	0.02	0.0055	NA	NA	8.89E+00	5.49E+02	
4,4'-DDT	mg/kg	5	5	0.0049	0.35	0.087	NA	NA	6.28E+00	9.15E+01	
alpha-Chlordane	mg/kg	1	5	0.0012	0.0012	0.0001	NA	NA	1.64E+00	1.10E+01	
gamma-Chlordane	mg/kg	2	5	0.00076	0.0046	0.0016	NA	NA	1.64E+00	1.10E+01	
Endrin Ketone	mg/kg	2	5	0.003	0.012	0.0041	NA	NA	--	--	YES
Aroclor-1260	mg/kg	3	5	0.025	0.2	0.061	NA	NA	1.58E-01	--	YES
Inorganic Analytes											
Aluminum	mg/kg	5	5	2370	5680	3302	1146	8930	--	5.49E+04	
Arsenic	mg/kg	5	5	1	2.6	1.9	0.15	3.6	3.66E-01	1.65E+01	YES
Barium	mg/kg	5	5	5.8	56.7	21	2	10.4	--	3.80E+03	
Beryllium	mg/kg	2	5	0.23	0.23	0.15	0.1	0.65	1.49E-01	2.74E+02	YES
Cadmium	mg/kg	4	5	0.4	1.3	0.64	0.4	1.5	--	2.64E+01	
Calcium	mg/kg	5	5	251	525	362	26	989	--	--	**
Chromium	mg/kg	5	5	2.6	18.8	9.4	0.8	6.8	6.57E+02	2.74E+02	
Cobalt	mg/kg	5	5	1.2	2.6	1.8	0.5	4.1	--	--	YES
Copper	mg/kg	5	5	5	26.8	14	0.47	5.2	--	--	YES
Iron	mg/kg	5	5	4500	8460	6178	2050	12400	--	--	**
Lead	mg/kg	5	5	5.2	769	229	1.3	12.05	--	3.00E+02	YES
Magnesium	mg/kg	5	5	541	1040	722	176	794.5	--	--	**
Manganese	mg/kg	5	5	43.9	124	68	16	108	--	2.74E+02	
Nickel	mg/kg	5	5	2.8	4.5	3.4	1.05	5.2	3.21E+04	1.10E+03	
Potassium	mg/kg	5	5	224	415	328	76	551	--	--	**
Silver	mg/kg	1	5	0.98	0.98	0.52	0.33	1.4	--	2.74E+02	
Vanadium	mg/kg	5	5	7.7	13.1	11	1.13	15.2	--	3.84E+02	
Zinc	mg/kg	5	5	9.4	155	51	3.05	16	--	1.65E+04	

NOTES:

1. MMR Final Risk Assessment Handbook. Table E-1. Summary Statistics for Inorganic Concentrations Selected Background Surface Soil Samples. Automated Sciences Group, Inc. September 1994.
2. MMR Final Risk Assessment Handbook. Table F-1. Human Health PRE, Risk/Hazard Equivalent Concentrations for Soils. Automated Sciences Group, Inc. September 1994. Tier 1 - Outside Flightline.

* The average concentration exceeds the maximum concentration due to values of one-half the detection limit for nondetects exceeding the maximum concentration.
-- No risk-based concentration available for this compound.
NA Not Applicable
** Calcium, iron, magnesium, and potassium are considered as essential macronutrients for human health and are excluded as COCs.

TABLE 2-15
SELECTION OF COCS FOR SUBSURFACE SOILS - HUMAN HEALTH

AOC FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	MAXIMUM	AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	HQ=0.2 (noncancer)	COC
Volatile Organics											
Methylene Chloride	mg/kg	1	11	0.001	0.001	0.005 **	NA	NA	8.54E+01	9.32E+02	
Acetone	mg/kg	8	11	0.011	0.17	0.04	NA	NA	--	5.49E+03	
Carbon Disulfide	mg/kg	1	11	0.001	0.001	0.005 **	NA	NA	--	--	YES
Chloroform	mg/kg	3	11	0.002	0.002	0.004 **	NA	NA	4.29E-01	5.49E+02	
2-Butanone	mg/kg	6	11	0.002	0.009	0.005	NA	NA	--	9.26E+02	
Benzene	mg/kg	1	11	0.001	0.001	0.005 **	NA	NA	1.08E+00	--	
4-Methyl-2-Pentanone	mg/kg	4	11	0.008	0.011	0.008	NA	NA	--	--	YES
Toluene	mg/kg	3	11	0.001	0.01	0.005	NA	NA	--	5.93E+02	
Ethylbenzene	mg/kg	1	11	0.001	0.001	0.005 **	NA	NA	--	1.66E+03	
Total Xylenes	mg/kg	2	11	0.007	0.008	0.008	NA	NA	--	1.10E+05	
Semi-Volatile Organics											
Phenol	mg/kg	1	9	0.014	0.014	0.15 **	NA	NA	--	3.29E+04	
Bis(2-Ethylhexyl)phthalate	mg/kg	4	9	0.021	0.36	0.12	NA	NA	4.57E+01	1.10E+03	
Pesticides/PCBs											
None											
Inorganic Analytes											
Aluminum	mg/kg	9	9	707	2640	1200	203.5	1980	--	5.49E+04	
Arsenic	mg/kg	9	9	0.58	1.6	1.2	0.23	2.3	3.66E-01	1.65E+01	YES
Barium	mg/kg	9	9	2.2	5	3.6	0.95	14.7	--	3.80E+03	
Cadmium	mg/kg	1	9	0.52	0.52	0.24	0.21	0.75	--	2.64E+01	
Calcium	mg/kg	9	9	20.8	118	63	22.8	933	--	--	***
Chromium	mg/kg	8	9	1.2	9.9	2.7	0.95	3.9	6.57E+02	2.74E+02	
Cobalt	mg/kg	6	9	0.64	1.4	0.79	0.5	2.6	--	--	YES
Copper	mg/kg	9	9	0.73	4.3	1.5	0.3	4.3	--	--	YES
Iron	mg/kg	9	9	1340	9350	3500	672	2600	--	--	***
Lead	mg/kg	9	9	1.2	2.8	1.8	0.12	3.7	--	3.00E+02	
Magnesium	mg/kg	9	9	180	442	283	34	742	--	--	***
Manganese	mg/kg	9	9	15.3	48.7	33	4.55	587	--	2.74E+02	
Nickel	mg/kg	8	9	0.98	2.5	1.3	0.75	3.9	3.21E+04	1.10E+03	
Potassium	mg/kg	9	9	96	300	190	96.5	437	--	--	***
Silver	mg/kg	1	9	0.45	0.45	0.36	0.3	1.1	--	2.74E+02	
Sodium	mg/kg	3	9	150	187	100	10.15	339.5	--	--	***
Vanadium	mg/kg	8	8*	2.1	4.9	4	0.6	5.7	--	3.84E+02	
Zinc	mg/kg	9	9	3.1	15.4	6.4	1.9	16	--	1.65E+04	

NOTES:

1 MMR Final Risk Assessment Handbook. Table E-2. Summary Statistics for Inorganic Concentrations Selected Background Subsurface Soil Samples. Automated Sciences Group, Inc. September 1994.
2. MMR Final Risk Assessment Handbook. Table F-1. Human Health PRE, Risk/Hazard Equivalent Concentrations for Soils. Automated Sciences Group, Inc. September 1994. Tier I - Outside Flightline.
* The data for vanadium for sample 23BS0010078F was rejected.
** The average concentration exceeds the maximum concentration due to values of one-half the detection limit exceeding the maximum concentration.
*** Calcium, iron, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.
NA Not Applicable

Table 2-16
Selection of COCs for Groundwater - Human Health
Total and Dissolved Inorganics Concentrations
AOC FS-17 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	DETECTED CONCENTRATION MAXIMUM	DETECTED CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (2) HQ=0.2 (non-cancer)	COC
Volatile Organics											
Acetone	mg/l	2	7	0.0031	0.0038	0.0020	NA	NA	--	7.29E-01	
Benzene	mg/l	1	7	0.0002	0.0002	0.00007	NA	NA	6.12E-04	--	
Chloroform	mg/l	7	7	0.0015	0.003	0.0022	NA	NA	2.75E-04	7.03E-02	YES
Dichlorodifluoromethane	mg/l	3	7	0.0007	0.0011	0.00049	NA	NA	--	--	YES
Tetrachloroethene	mg/l	5	7	0.0004	0.0005	0.00036	NA	NA	--	6.38E-02	
SVOCs											
Bis(2-ethylhexyl)phthalate	mg/l	1	7	0.001	0.001	0.0023*	NA	NA	5.11E-03	1.23E-01	
Pesticides/PCBs											
4,4'-DDT	mg/l	1	7	0.00002	0.00002	0.0000114	NA	NA	2.10E-04	3.06E-03	
Inorganics (Total Concentrations)											
Aluminum	mg/l	7	7	0.937	6.87	3.5	0.067	0.312	--	7.30E+00	
Antimony	mg/l	2	7	0.0021	0.0031	0.0015	0.026	0.03	--	2.92E-03	YES
Arsenic	mg/l	2	7	0.0012	0.0026	0.0013	0.0015	0.002	4.87E-05	2.19E-03	YES
Barium	mg/l	7	7	0.0199	0.0381	0.03	0.0025	0.095	--	5.11E-01	
Cadmium	mg/l	2	7	0.00022	0.00028	0.00014	0.0025	0.0025	--	3.65E-03	
Calcium	mg/l	7	7	3.05	5.15	4.0	1.38	6.77	--	--	**
Chromium	mg/l	6	7	0.0065	0.0152	0.0094	0.003	0.017	--	3.65E-02	
Cobalt	mg/l	2	7	0.0051	0.0093	0.0035	0.0045	0.006	--	--	YES
Copper	mg/l	6	7	0.0043	0.0406	0.011	0.002	0.013	--	--	YES
Iron	mg/l	7	7	1.13	11.2	6.1	0.017	0.471	--	--	YES (3)
Lead	mg/l	7	7	0.0014	0.04	0.0091	0.001	0.0029	--	1.50E-02	YES
Magnesium	mg/l	7	7	2.51	4.55	3.6	1.06	4.93	--	--	**
Manganese	mg/l	7	7	0.0516	0.311	0.13	0.001	0.109	--	3.65E-02	YES
Nickel	mg/l	6	7	0.0054	0.0111	0.0074	0.0055	0.019	--	1.46E-01	
Potassium	mg/l	7	7	1.1	2.09	1.6	0.68	1.975	--	--	**
Sodium	mg/l	7	7	5.05	10.3	7.8	2.9	22.6	--	--	**
Vanadium	mg/l	7	7	0.0025	0.0149	0.0085	0.002	0.0075	--	5.11E-02	
Zinc	mg/l	7	7	0.0113	0.0655	0.034	0.0032	0.0669	--	2.19E+00	

Table 2-16
Selection of COCs for Groundwater - Human Health
Total and Dissolved Inorganics Concentrations
AOC FS-17 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	DETECTED CONCENTRATION MAXIMUM	DETECTED CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (2) HQ=0.2 (non-cancer)	COC
Inorganics (Dissolved Concentrations)											
Aluminum	mg/l	2	7	0.125	0.666	0.15	0.07	0.259	--	7.30E+00	
Antimony	mg/l	6	7	0.003	0.0089	0.0052	0.026	0.03	--	2.92E-03	YES
Barium	mg/l	5	7	0.0106	0.0188	0.011	0.0015	0.1	--	5.11E-01	
Calcium	mg/l	7	7	2.89	4.66	3.8	1.21	6.61	--	--	**
Chromium	mg/l	1	7	0.006	0.006	0.0034	0.003	0.005	--	3.65E-02	
Cobalt	mg/l	1	7	0.0041	0.0041	0.0023	0.0045	0.006	--	--	YES
Copper	mg/l	1	7	0.0066	0.0066	0.0022	0.002	0.0125	--	--	YES
Iron	mg/l	3	7	0.0281	0.464	0.082	0.0126	0.422	--	--	YES (3)
Lead	mg/l	2	7	0.0011	0.0014	0.00071	0.001	0.002	--	1.50E-02	
Magnesium	mg/l	7	7	2.26	3.36	2.7	1.13	4.89	--	--	**
Manganese	mg/l	7	7	0.0093	0.039	0.018	0.001	0.103	--	3.65E-02	YES
Nickel	mg/l	2	7	0.0045	0.0057	0.0029	0.0055	0.019	--	1.46E-01	
Potassium	mg/l	7	7	0.871	1.37	1.05	0.68	1.975	--	--	**
Sodium	mg/l	7	7	6.14	9.11	7.6	2.96	22.4	--	--	**
Vanadium	mg/l	1	7	0.0026	0.0026	0.0012	0.002	0.0075	--	5.11E-02	
Zinc	mg/l	3	7	0.0117	0.0217	0.0084	0.0034	0.0735	--	2.19E+00	

Notes:
1. MMR Background Inorganics Study. HAZWRAP. Final January 1994. Table 1-Unfiltered Background Inorganic Concentrations and Table 2-Filtered Background Inorganic Concentrations.
2. MMR Final Risk Assessment Handbook. Table F-3. Human Health PRE, Risk/Hazard Equivalent Concentrations for Groundwater. Automated Sciences Group, Inc. September 1994. Tier 1 - Offsite.
3. Iron was selected as a COC based on exceedance of MMR background.

* The average concentration exceeds the maximum concentration due to values of one-half the detection limit for nondetects exceeding the maximum concentration.
** Calcium, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.
--- No risk-based concentration available for this compound.
NA Not Applicable

Table 2-17
Identification of COPCs for Surface Water - Human Health
Based on Groundwater Concentrations
AOC FS-17 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	MAXIMUM	AVERAGE	MMR RISK CONCENTRATION (1) 1.0E-06 (cancer)	HQ=0.2 (non-cancer)	COPC
Volatile Orgainics									
Acetone	mg/l	2	7	0.0031	0.0038	0.0020	--	3.20E+01	
Benzene	mg/l	1	7	0.0002	0.0002	0.00007	1.26E-02	--	
Chloroform	mg/l	7	7	0.0015	0.003	0.0022	7.44E-02	1.66E-01	
Dichlorodifluoromethane	mg/l	3	7	0.0007	0.0011	0.00049	--	--	YES
Tetrachloroethene	mg/l	5	7	0.0004	0.0005	0.00036	--	2.64E-02	
SVOCs									
Bis(2-ethylhexyl)phthalate	mg/l	1	7	0.001	0.001	0.0023*	1.33E-02	3.20E-05	YES
Pesticides/PCBs									
4,4'-DDT	mg/l	1	7	0.00002	0.00002	0.0000114	5.38E-04	1.95E-08	YES
Inorganics (Total Concentrations)									
Aluminum	mg/l	7	7	0.937	6.87	3.5	--	1.72E+01	
Antimony	mg/l	2	7	0.0021	0.0031	0.0015	--	7.43E-02	
Arsenic	mg/l	2	7	0.0012	0.0026	0.0013	3.74E-02	1.85E-04	YES
Barium	mg/l	7	7	0.0199	0.0381	0.03	--	3.00E+00	
Cadmium	mg/l	2	7	0.00022	0.00028	0.00014	--	1.16E-05	YES
Calcium	mg/l	7	7	3.05	5.15	4.0	--	--	**
Chromium	mg/l	6	7	0.0065	0.0152	0.0094	--	4.32E-03	YES
Cobalt	mg/l	2	7	0.0051	0.0093	0.0035	--	--	YES
Copper	mg/l	6	7	0.0043	0.0406	0.011	--	--	YES
Iron	mg/l	7	7	1.13	11.2	6.1	--	--	YES (2)
Lead	mg/l	7	7	0.0014	0.04	0.0091	--	--	YES
Magnesium	mg/l	7	7	2.51	4.55	3.6	--	--	**
Manganese	mg/l	7	7	0.0516	0.311	0.13	--	2.47E-06	YES
Nickel	mg/l	6	7	0.0054	0.0111	0.0074	--	3.26E-02	
Potassium	mg/l	7	7	1.1	2.09	1.6	--	--	**
Sodium	mg/l	7	7	5.05	10.3	7.8	--	--	**
Vanadium	mg/l	7	7	0.0025	0.0149	0.0085	--	1.21E-01	
Zinc	mg/l	7	7	0.0113	0.0655	0.034	--	5.38E-02	YES

Table 2-17
Identification of COPCs for Surface Water - Human Health
Based on Groundwater Concentrations
AOC FS-17 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	DETECTED CONCENTRATION MINIMUM	MAXIMUM	AVERAGE	MMR RISK CONCENTRATION (1) 1.0E-06 (cancer)	HQ=0.2 (non-cancer)	COPC
Inorganics (Dissolved Concentrations)									
Aluminum	mg/l	2	7	0.125	0.666	0.15	--	1.72E+01	
Antimony	mg/l	6	7	0.003	0.0089	0.0052	--	7.43E-02	
Barium	mg/l	5	7	0.0106	0.0188	0.011	--	3.00E+00	
Calcium	mg/l	7	7	2.89	4.66	3.8	--	--	**
Chromium	mg/l	1	7	0.006	0.006	0.0034	--	4.32E-03	YES
Cobalt	mg/l	1	7	0.0041	0.0041	0.0023	--	--	YES
Copper	mg/l	1	7	0.0066	0.0066	0.0022	--	--	YES
Iron	mg/l	3	7	0.0281	0.464	0.082	--	--	YES
Lead	mg/l	2	7	0.0011	0.0014	0.00071	--	--	
Magnesium	mg/l	7	7	2.26	3.36	2.7	--	--	**
Manganese	mg/l	7	7	0.0093	0.039	0.018	--	2.47E-06	YES
Nickel	mg/l	2	7	0.0045	0.0057	0.0029	--	3.26E-02	
Potassium	mg/l	7	7	0.871	1.37	1.05	--	--	**
Sodium	mg/l	7	7	6.14	9.11	7.6	--	--	**
Vanadium	mg/l	1	7	0.0026	0.0026	0.0012	--	1.12E-01	
Zinc	mg/l	3	7	0.0117	0.0217	0.0084	--	5.38E-02	

Notes:
1. MMR Final Risk Assessment Handbook. Table F-4. Human Health and Ecological PRE, Summary for Surface Water, Risk/Hazard Equivalent Concentrations. Automated Sciences Group, Inc. September 1994. Tier 1.
2. Iron (total concentration) was selected as a COC based on a high detected concentration
* The average concentration exceeds the maximum concentration due to values of one-half the detection limit exceeding the maximum concentration.
** Calcium, magnesium, potassium, and sodium are considered as essentials macronutrients for human health and are excluded as COCs.
--- No risk-based concentration available for this compound.

Table 2-18
Exposure Scenarios, Exposure Equations, and Exposure Assumptions Used to Estimate Human Health Risks

AOC FS-17
Massachusetts Military Reservation

Exposure Scenarios Evaluated for AOC FS-17

Land Use	Exposure Scenario	Media Evaluated
Current	Utility Worker	Soil
	Child Trespasser	Soil
Future	Utility Worker	Soil
	Child Trespasser	Soil
	Adult Resident	Soil & Groundwater
	Child Resident	Soil & Groundwater

Soil Dose/Risk Equation: Ingestion; Inhalation; Dermal Contact

$$\text{Risk/HQ} = \frac{C \times ED \times ((TFo \times 1E\text{-}06kg/mg \times IRsoil \times ABSing \times EF)+(TF1 \times IRair \times EF \times (1/VF + 1/PEF))+(TFo \times 1E\text{-}06kg/mg \times SA \times AF \times ABSderm \times EF))}{BW \times AT \times 365\ d/yr}$$

Groundwater Dose/Risk Equations: Ingestion; Inhalation; Dermal Contact

$$\text{Risk/HQ} = \frac{C \times ED \times ((EF \times TF1 \times VF \times IRair)+(EFs \times TFo \times SA \times PC \times CF1 \times CF2) + (TFo \times EF \times IRw)}{BW \times AT \times 365\ d/yr}$$

Exposure Assumptions and Parameters

			Current and Future Use		Futue Use	
					Residential	
Parameters	Definition	Units	Utility Worker	Child Trespasser	Child	Adult
C	Concentration (mean or maximum as appropriate)	Soil = mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ED	Exposure duration	years	1	6	6	24
EF	Exposure frequency	days/year	42 (Current land use) 183 (Future land use)	52 (Current and future land use)	350	350
TFo	Ingestion slope factor or RfD	$(mg/kg\text{-}d)^{-1}$ o	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
TF1	Inhalation slope factor or RfD	$(mg/kg\text{-}d)^{-1}$	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
IRsoil	Intake rate for soil	mg/d	480	100	200	100
IRair	Inhalation rate	m^3/day	20	20	20	20
ABSing	Ingestion absorption factor	Unitless	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ABSderm	Dermal absorption factor	Unitless	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
VF	Volatilization Factor	m^3/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
PEF	Particulate Emission Factor	m^3/kg	4.63E-09	4.63E-09	4.63E-09	4.63E-09
SA	Skin surface area	cm^2	3120	1000	1000	1000
AF	adherance factor	mg/cm^2	1	1	1	1
PC	Dermal permiability	cm/h	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
CF1	Conversion factor	L/cm^3	na	na	na	0.001
CF2	Conversion factor	h/d	na	na	na	24
IRw	Intake rate of water	L/d				2
BW	Body weight	kg	70	36.2	15	70
AT	Averaging time	years	70	70	70	70

TABLE 2-19
Reference Doses (RfDs) and Cancer Slope Factors (CSFs)
for Site Contaminants of Concern

AOC FS-17 RI Study Area
Massachusetts Military Reservation

CONTAMINANT	INGESTION CSF (mg/kg/day)-1	RFD (mg/kg/day)	INHALATION CSF (mg/kg/day)-1	RFD (mg/kg/day)
Carbon Disulfide	NA	1.00E-01 (1,5)	NA	2.86E-03 (2,5)
Chloroform	6.10E-03 (1)	1.00E-02 (1,5)	8.05E-02 (1)	NA
Dichlorodifluoromethane	NA	2.00E-01 (1,5)	NA	5.71E-02 (4)
4-Methyl-2-pentanone	NA	8.00E-02 (2,5)	NA	2.29E-02 (4)
Benzo(b)fluoranthene	7.30E-01 (3)	NA	NA	NA
Benzo(a)pyrene	7.30E+00 (1)	NA	3.10E+00 (3)	NA
Dibenzo(a,h)anthracene	7.30E+00 (3)	NA	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA
Aroclor-1260	7.70E+00 (1)	NA	NA	NA
Endrin ketone	NA	NA	NA	NA
Antimony	NA	4.00E-04 (1,5)	NA	NA
Arsenic	1.50E+00 (1)	3.00E-04 (1,5)	1.51E+01 (1)	NA
Beryllium	4.30E+00 (1)	5.00E-03 (1,5)	8.40E+00 (1)	NA
Cobalt	NA	NA	NA	NA
Copper	NA	NA	NA	NA
Iron	NA	NA	NA	NA
Lead	NA	NA	NA	NA
Manganese	NA	5.00E-03 (water) (1,5) 1.40E-01(food) (1,5)	NA	1.43E-05 (1,5)

NOTES:
1 - Integrated Risk Information System, on line 1995.
2 - Health Effects Assessment Summary Tables, U.S. Environmental Protection Agency, Annual Update, March 1994.
3 - Interim RFD or CSF. EPA Environmental Criteria and Assessment Office (ECAO).
4 - HEAST alternate.
5 - The chronic oral/inhalation RfD was adopted as the subchronic oral/inhalation RfD.
NA Not Available.

Table 2-20
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Current Use
Maximum Soil Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: $(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)$; Inhalation: $(TF1 \times IRair \times EF \times [1/VF + 1/PEF])$; Dermal: $(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)$)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001	70	70	1	480	42	3120	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.9E-09	2.5E-12	0.0E+00	7.9E-09
SVOCs																									
2-METHYLNAPHTHALENE	120	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92	70	70	1	480	42	3120	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	7.6E-09	0.0E+00	0.0E+00	7.6E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3	70	70	1	480	42	3120	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	2.5E-08	1.4E-13	0.0E+00	2.5E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZO(A,H)ANTHRACENE	0.12	70	70	1	480	42	3120	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	9.9E-09	0.0E+00	0.0E+00	9.9E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.2	70	70	1	480	42	3120	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	5.2E-09	0.0E+00	6.8E-09	1.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.012	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	2.6	70	70	1	480	42	3120	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.4E-08	5.8E-12	0.0E+00	4.4E-08	6.8E-03	0.0E+00	0.0E+00	6.8E-03
BERYLLIUM	0.23	70	70	1	480	42	3120	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.1E-08	2.9E-13	0.0E+00	1.1E-08	3.6E-05	0.0E+00	0.0E+00	3.6E-05
COBALT	2.6	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	26.8	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	769	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration - days of year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor
IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = soil-to-air particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	1.0E-07	6.3E-12	6.8E-09	1.1E-07	6.9E-03	2.5E-12	0.0E+00	6.9E-03

Table 2-21
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Future Use
Maximum Soil Concentrations
FS-17 RI Study Area

Ingestion Inhalation Dermal

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001	70	70	1	480	183	3120	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-08	1.1E-11	0.0E+00	3.4E-08
SVOCs																									
2-METHYLNAPHTHALENE	120	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92	70	70	1	480	183	3120	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.3E-08	0.0E+00	0.0E+00	3.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3	70	70	1	480	183	3120	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.1E-07	6.0E-13	0.0E+00	1.1E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZO(A,H)ANTHRACENE	0.12	70	70	1	480	183	3120	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.3E-08	0.0E+00	0.0E+00	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.2	70	70	1	480	183	3120	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	2.3E-08	0.0E+00	2.9E-08	5.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.012	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	2.6	70	70	1	480	183	3120	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.9E-07	2.5E-11	0.0E+00	1.9E-07	3.0E-02	0.0E+00	0.0E+00	3.0E-02
BERYLLIUM	0.23	70	70	1	480	183	3120	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.9E-08	1.2E-12	0.0E+00	4.9E-08	1.6E-04	0.0E+00	0.0E+00	1.6E-04
COBALT	2.6	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	26.8	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	769	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	4.5E-07	2.7E-11	2.9E-08	4.8E-07	3.0E-02	1.1E-11	0.0E+00	3.0E-02

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration - days of year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = soil-to-air particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-22
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Current Use
Mean Soil Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: $(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)$; Inhalation: $(TF1 \times IRair \times EF \times [1/VF + 1/PEF])$; Dermal: $(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)$)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001 *	70	70	1	480	42	3120	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.9E-09	2.5E-12	0.0E+00	7.9E-09
SVOCs																									
2-METHYLNAPHTHALENE	24	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92 *	70	70	1	480	42	3120	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	7.6E-09	0.0E+00	0.0E+00	7.6E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3 *	70	70	1	480	42	3120	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	2.5E-08	1.4E-13	0.0E+00	2.5E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12 *	70	70	1	480	42	3120	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	9.9E-09	0.0E+00	0.0E+00	9.9E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.061	70	70	1	480	42	3120	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	1.6E-09	0.0E+00	2.1E-09	3.7E-09	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.0041	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	1.9	70	70	1	480	42	3120	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.2E-08	4.3E-12	0.0E+00	3.2E-08	5.0E-03	0.0E+00	0.0E+00	5.0E-03
BERYLLIUM	0.15	70	70	1	480	42	3120	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	7.3E-09	1.9E-13	0.0E+00	7.3E-09	2.4E-05	0.0E+00	0.0E+00	2.4E-05
COBALT	1.8	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	14	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	229	70	70	1	480	42*	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Total Risk																		Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
																		8.3E-08	4.6E-12	2.1E-09	8.5E-08	5.0E-03	2.5E-12	0.0E+00	5.0E-03

* = Maximum detected concentration was used because calculated mean exceeded the maximum

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration - days of the year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-23
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Future Use
Mean Soil Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{\overbrace{C \times ED \times ((TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times (1/VF + 1/PEF))}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF))}^{\text{Dermal}}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001 *	70	70	1	480	183	3120	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-08	1.1E-11	0.0E+00	3.4E-08
SVOCs																									
2-METHYLNAPHTHALENE	24	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92 *	70	70	1	480	183	3120	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.3E-08	0.0E+00	0.0E+00	3.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3 *	70	70	1	480	183	3120	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.1E-07	6.0E-13	0.0E+00	1.1E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12 *	70	70	1	480	183	3120	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.3E-08	0.0E+00	0.0E+00	4.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.061	70	70	1	480	183	3120	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	6.9E-09	0.0E+00	9.0E-09	1.6E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.0041	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	1.9	70	70	1	480	183	3120	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.4E-07	1.9E-11	0.0E+00	1.4E-07	2.2E-02	0.0E+00	0.0E+00	2.2E-02
BERYLLIUM	0.15	70	70	1	480	183	3120	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.2E-08	8.1E-13	0.0E+00	3.2E-08	1.0E-04	0.0E+00	0.0E+00	1.0E-04
COBALT	1.8	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	14	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	229	70	70	1	480	183	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
		3.6E-07	2.0E-11	9.0E-09	3.7E-07	2.2E-02	1.1E-11	0.0E+00	2.2E-02

* = Maximum detected concentration was used because calculated mean exceeded the maximum

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration days of the year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = absorption factor
ABSing = ingestion absorption factor
IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-24
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation, and Dermal Pathways
Child Trespasser, Current and Future Use
Maximum Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{\overbrace{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times [1/VF + 1/PEF])}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)}^{\text{Dermal}}\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001	36.2	70	6	100	52	1000	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-09	5.9E-12	0.0E+00	3.9E-09
SVOCs																									
2-METHYLNAPHTHALENE	120	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92	36.2	70	6	100	52	1000	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	2.3E-08	0.0E+00	0.0E+00	2.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3	36.2	70	6	100	52	1000	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4630000000	7.4E-08	2.0E-12	0.0E+00	7.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12	36.2	70	6	100	52	1000	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	3.0E-08	0.0E+00	0.0E+00	3.0E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.2	36.2	70	6	100	52	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4630000000	1.6E-08	0.0E+00	3.1E-08	4.7E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.012	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	2.8	36.2	70	6	100	52	1000	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4630000000	1.3E-07	8.4E-11	0.0E+00	1.3E-07	3.4E-03	0.0E+00	0.0E+00	3.4E-03
BERYLLIUM	0.23	36.2	70	6	100	52	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4630000000	3.3E-08	4.1E-12	0.0E+00	3.3E-08	1.8E-05	0.0E+00	0.0E+00	1.8E-05
COBALT	2.6	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	26.8	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	769	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
		3.1E-07	9.0E-11	3.1E-08	3.4E-07	3.4E-03	5.9E-12	0.0E+00	3.4E-03

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (equal to ED for noncarcinogens)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area available for contact

TFO = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
AF = soil to skin adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption rate
IRair = inhalation rate

VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-25
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation, and Dermal Pathways
Child Trespasser, Current and Future Use
Mean Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{\overbrace{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times [1/VF + 1/PEF])}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)}^{\text{Dermal}}\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001 *	36.2	70	6	100	52	1000	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-09	5.9E-12	0.0E+00	3.9E-09
SVOCs																									
2-METHYLNAPHTHALENE	24	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92 B	36.2	70	6	100	52	1000	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	2.3E-08	0.0E+00	0.0E+00	2.3E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3 *	36.2	70	6	100	52	1000	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4630000000	7.4E-08	2.0E-12	0.0E+00	7.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12 B	36.2	70	6	100	52	1000	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	3.0E-08	0.0E+00	0.0E+00	3.0E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.061	36.2	70	6	100	52	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4630000000	4.8E-09	0.0E+00	9.5E-09	1.4E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.0041	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	1.9	36.2	70	6	100	52	1000	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4630000000	9.6E-08	6.1E-11	0.0E+00	9.6E-08	2.5E-03	0.0E+00	0.0E+00	2.5E-03
BERYLLIUM	0.15	36.2	70	6	100	52	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4630000000	2.2E-08	2.7E-12	0.0E+00	2.2E-08	1.2E-05	0.0E+00	0.0E+00	1.2E-05
COBALT	1.8	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	14	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	229	36.2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4630000000	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	2.5E-07	6.6E-11	9.5E-09	2.6E-07	2.5E-03	5.9E-12	0.0E+00	2.5E-03

* = Maximum detected concentration was used because calculated mean exceeded the maximum
COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (equal to ED for noncarcinogens)
ED =exposure duration
IRsoil =soil ingestion rate
EF = exposure frequency
SA = skin surface area available for contact
TFO = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = soil to skin adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption rate
IRair = inhalation rate
VF = soil to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-26
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Dermal and Inhalation Pathways
Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone)
Maximum Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: TFo, IRsoil, ABSing; Inhalation: TF1, IRair, VF, PEF; Dermal: TFo, SA, AF, ABSderm)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001	15	70	6	200	350	1000	NA	1.00E+01	NA	3.50E-02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-07	9.7E-11	0.0E+00	1.3E-07
SVOCs																									
2-METHYLNAPHTHALENE	120	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92	15	70	6	200	350	1000	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	7.4E-07	0.0E+00	0.0E+00	7.4E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3	15	70	6	200	350	1000	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	2.4E-06	3.2E-11	0.0E+00	2.4E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12	15	70	6	200	350	1000	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	9.6E-07	0.0E+00	0.0E+00	9.6E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR 1260	0.2	15	70	6	200	350	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	5.1E-07	0.0E+00	5.1E-07	1.0E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.012	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	2.6	15	70	6	200	350	1000	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.3E-06	1.4E-09	0.0E+00	4.3E-06	1.1E-01	0.0E+00	0.0E+00	1.1E-01
BERYLLIUM	0.23	15	70	6	200	350	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.1E-06	6.7E-11	0.0E+00	1.1E-06	5.9E-04	0.0E+00	0.0E+00	5.9E-04
COBALT	2.6	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	26.8	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	769	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
MANGANESE	124	15	70	6	200	350	1000	NA	2.00E+02	NA	6.99E+04	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.2E-01	3.5E-03	0.0E+00	3.2E-01
																	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
																		1.0E-05	1.5E-09	5.1E-07	1.0E-05	4.3E-01	3.5E-03	0.0E+00	4.3E-01

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-27
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Dermal and Inhalation Pathways
Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone)
Mean Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{\overbrace{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times [1/VF + 1/PEF])}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)}^{\text{Dermal}}\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0 001 *	15	70	6	200	350	1000	NA	1 00E+01	NA	3 50E+02	1 0	0	1	20	NA	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	1 3E-07	9 7E-11	0 0E+00	1 3E-07
SVOCs																									
2-METHYLNAPHTHALENE	24	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00
BENZO(B)FLUORANTHENE	0 92 *	15	70	6	200	350	1000	7 30E-01	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	7 4E-07	0 0E+00	0 0E+00	7 4E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00
BENZO(A)PYRENE	0 3 *	15	70	6	200	350	1000	7 30E+00	NA	3 10E+00	NA	1 0	0	1	20	1 00E+10	4 63E+09	2 4E-06	3 2E-11	0 0E+00	2 4E-06	0 0E+00	0 0E+00	0 0E+00	0 0E+00
DIBENZ(A H)ANTHRACENE	0 12 *	15	70	6	200	350	1000	7 30E+00	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	9 6E-07	0 0E+00	0 0E+00	9 6E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0 061	15	70	6	200	350	1000	7 70E+00	NA	NA	NA	1 0	0 06	0 3	20	1 00E+10	4 63E+09	1 5E-07	0 0E+00	1 5E-07	3 1E-07	0 0E+00	0 0E+00	0 0E+00	0 0E+00
ENDRIN KETONE	0 0041	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00
INORGANICS																									
ARSENIC	1 9	15	70	6	200	350	1000	1 50E+00	3 33E+03	1 51E+01	NA	1 0	0	1	20	1 00E+10	4 63E+09	3 1E-06	9 9E-10	0 0E+00	3 1E-06	8 1E-02	0 0E+00	0 0E+00	8 1E-02
BERYLLIUM	0 15	15	70	6	200	350	1000	4 30E+00	2 00E+02	8 40E+00	NA	1 0	0	1	20	1 00E+10	4 63E+09	7 1E-07	4 4E-11	0 0E+00	7 1E-07	3 8E-04	0 0E+00	0 0E+00	3 8E-04
COBALT	1 8	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00
COPPER	14	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00
LEAD	229	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00	0 0E+00

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	8 1E-06	1 1E-09	1 5E-07	8 2E-06	8 1E-02	9 7E-11	0 0E+00	8 1E-02

* = Maximum detected concentration was used because calculated mean exceeded the maximum

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-28
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Residential (7 yrs.- Adult), Future Use, Onsite (Outside Security Zone)
Maximum Soil Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: $(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)$; Inhalation: $(TF1 \times IRair \times EF \times [1/VF + 1/PEF])$; Dermal: $(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)$)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001	70	70	24	100	350	1000	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-08	2.1E-11	0.0E+00	1.4E-08
SVOCs																									
2-METHYLNAPHTHALENE	120	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B)FLUORANTHENE	0.92	70	70	24	100	350	1000	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.2E-07	0.0E+00	0.0E+00	3.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3	70	70	24	100	350	1000	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.0E-06	2.8E-11	0.0E+00	1.0E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.12	70	70	24	100	350	1000	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.1E-07	0.0E+00	0.0E+00	4.1E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.2	70	70	24	100	350	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	2.2E-07	0.0E+00	4.3E-07	6.5E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.012	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	2.6	70	70	24	100	350	1000	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.8E-06	1.2E-09	0.0E+00	1.8E-06	1.2E-02	0.0E+00	0.0E+00	1.2E-02
BERYLLIUM	0.23	70	70	24	100	350	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.6E-07	5.7E-11	0.0E+00	4.6E-07	6.3E-05	0.0E+00	0.0E+00	6.3E-05
COBALT	2.6	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	26.8	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	769	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	4.3E-06	1.3E-09	4.3E-07	4.7E-06	1.2E-02	2.1E-11	0.0E+00	1.2E-02

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor
IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-29
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Residential (7 yrs.- Adult), Future Use, Onsite (Outside Security Zone)
Mean Soil Concentrations
FS-17 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{\overbrace{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times [1/VF + 1/PEF])}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)}^{\text{Dermal}}\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
VOCs																									
CARBON DISULFIDE	0.001 *	70	70	24	100	350	1000	NA	1.00E+01	NA	3.50E+02	1.0	0	1	20	NA	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-08	2.1E-11	0.0E+00	1.4E-08
SVOCs																									
2-METHYLNAPHTHALENE	24	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(B) FLUORANTHENE	0.92 *	70	70	24	100	350	1000	7.30E-01	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.2E-07	0.0E+00	0.0E+00	3.2E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BENZO(A)PYRENE	0.3 *	70	70	24	100	350	1000	7.30E+00	NA	3.10E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.0E-06	2.8E-11	0.0E+00	1.0E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00
DIBENZ(A,H)ANTHRACENE	0.012 *	70	70	24	100	350	1000	7.30E+00	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	4.1E-08	0.0E+00	0.0E+00	4.1E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PESTICIDES/PCBs																									
AROCLOR-1260	0.061	70	70	24	100	350	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	6.6E-08	0.0E+00	1.3E-07	2.0E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENDRIN KETONE	0.0041	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
INORGANICS																									
ARSENIC	1.9	70	70	24	100	350	1000	1.50E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.3E-06	8.5E-10	0.0E+00	1.3E-06	8.7E-03	0.0E+00	0.0E+00	8.7E-03
BERYLLIUM	0.15	70	70	24	100	350	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.0E-07	3.7E-11	0.0E+00	3.0E-07	4.1E-05	0.0E+00	0.0E+00	4.1E-05
COBALT	1.8	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
COPPER	14	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
LEAD	229	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
																	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
																		3.1E-06	8.2E-10	1.3E-07	3.2E-06	8.7E-03	2.1E-11	0.0E+00	8.7E-03

** = Maximum detected concentration was used because calculated mean exceeded the maximum*

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor
IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

TABLE 2-30
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Maximum Groundwater Concentrations - Organics - Total Inorganics

FS-17 RI Study Area
Massachusetts Military Reservation

$$\text{RISK/HQ} = \frac{C \times ED \times [\overbrace{(EF \times TF1 \times K \times IRair)}^{\text{Inhalation}} + \overbrace{(EFs \times TFo \times SA \times PC \times CF1 \times CF2)}^{\text{Dermal}} + \overbrace{(TFo \times EF \times IRw)}^{\text{Ingestion}}]}{BW \times AT \times 365\ \text{days/yr}}$$

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Chloroform	0.003	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	8.05E-02	NA	6.10E-03	1.00E+02	2.00E-02	1.1E-05	8.3E-09	2.1E-07	1.1E-05	0.0E+00	2.3E-06	8.2E-03	8.2E-03
Dichlorodifluoromethane	0.0011	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	1.75E+01	NA	5.00E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-03	0.0E+00	1.5E-04	2.1E-03
INORGANICS																									
Antimony	0.0031	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E-01	2.1E-01
Arsenic	0.0026	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	1.51E+01	NA	1.50E+00	3.33E+03	0.00E+00	0.0E+00	0.0E+00	4.6E-05	4.6E-05	0.0E+00	0.0E+00	2.4E-01	2.4E-01
Cobalt	0.0093	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0406	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Iron	11.2	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.04	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.311	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	6.99E+04	NA	2.00E+02	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.7E+00	1.7E+00
																	Total Risk	**Cancer Inhalation**	**Cancer Dermal**	**Cancer Ingestion**	**Cancer Risk**	**HI Inhalation**	**HI Dermal**	**HI Ingestion**	**HI Total**
																		1.1E-05	**8.3E-09**	**4.6E-05**	**5.7E-05**	**2.0E-03**	**2.3E-06**	**2.2E+00**	**2.2E+00**

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair=daily indoor inhalation rate
K=volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
NA = Not Applicable

EF = exposure frequency
EFs=showering frequency
SA = skin surface area exposed
TF1=inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI= hazard index

TABLE 2-31
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Maximum Gorundwater Concentrations - Organics - Dissolved Inorganics

FS-17 RI Study Area
Massachusetts Military Reservation

$$\text{RISK/HQ} = \frac{C \times ED \times [\overbrace{(EF \times TF1 \times K \times IR_dair)}^{\text{Inhalation}} + \overbrace{(EFs \times TFo \times SA \times PC \times CF1 \times CF2)}^{\text{Dermal}} + \overbrace{(TFo \times EF \times IRw)}^{\text{Ingestion}}]}{BW \times AT \times 365\ \text{days/yr}}$$

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Chloroform	0.003	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	8.05E-02	NA	6.10E-03	1.00E+02	2.00E-02	1.1E-05	8.3E-09	2.1E-07	1.1E-05	0.0E+00	2.3E-06	8.2E-03	8.2E-03
Dichlorodifluoromethane	0.0011	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	1.75E+01	NA	5.00E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-03	0.0E+00	1.5E-04	2.1E-03
INORGANICS																									
Antimony	0.0089	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.1E-01	6.1E-01
Cobalt	0.0041	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0066	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Iron	0.464	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.039	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	6.99E+04	NA	2.00E+02	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E-01	2.1E-01

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	1.1E-05	8.3E-09	2.1E-07	1.1E-05	2.0E-03	2.3E-06	8.3E-01	8.3E-01

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens equal to ED)
ED = exposure duration
IRair = daily indoor inhalation rate
K = volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
NA = Not Applicable

EF = exposure frequency
EFs = showering frequency
SA = skin surface area exposed
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI = hazard index

TABLE 2-32
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Aadult Resident, Future Use, Onsite/Offsite
Mean Groundwater Concentrations - Organics - Total Inorganics

FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$\text{RISK/HQ} = \frac{C \times ED \times [\overbrace{(EF \times TF1 \times K \times IRair)}^{\text{Inhalation}} + \overbrace{(EFs \times TFo \times SA \times PC \times CF1 \times CF2)}^{\text{Dermal}} + \overbrace{(TFo \times EF \times IRw)}^{\text{Ingestion}}]}{BW \times AT \times 365\ \text{days/yr}}$$

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Chloroform	0.0022	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	8.05E-02	NA	6.10E-03	1.00E+02	2.00E-02	7.8E-06	6.1E-09	1.6E-07	8.0E-06	0.0E+00	1.7E-06	6.0E-03	6.0E-03
Dichlorodifluoromethane	0.00049	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	1.75E+01	NA	5.00E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.8E-04	0.0E+00	6.7E-05	9.5E-04
INORGANICS																									
Antimony	0.0015	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-01	1.0E-01
Arsenic	0.0013	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	1.51E+01	NA	1.50E+00	3.33E+03	0.00E+00	0.0E+00	0.0E+00	2.3E-05	2.3E-05	0.0E+00	0.0E+00	1.2E-01	1.2E-01
Cobalt	0.0035	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.011	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Iron	6.1	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Lead	0.0091	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.13	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	6.99E+04	NA	2.00E+02	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.1E-01	7.1E-01
																	Total Risk	**Cancer Inhalation**	**Cancer Dermal**	**Cancer Ingestion**	**Cancer Risk**	**HI Inhalation**	**HI Dermal**	**HI Ingestion**	**HI Total**
																		7.8E-06	**6.1E-09**	**2.3E-05**	**3.1E-05**	**8.8E-04**	**1.7E-06**	**9.4E-01**	**9.4E-01**

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair = daily indoor inhalation rate
K = volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
NA = not applicable

EF = exposure frequency
EFs = showering frequency
SA = skin surface area exposed
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI = hazard index

TABLE 2-33
EQUATION FOR DERIVING RISK/HAZARD QUOTIENT
FOR GROUNDWATER FOR HUMAN HEALTH
INGESTION, INHALATION, AND DERMAL PATHWAYS
ADULT RESIDENT, FUTURE USE, ONSITE/OFFSITE
MEAN GROUNDWATER CONCENTRATIONS - ORGANICS - DISSOLVED INORGANICS

FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$RISK/HQ = \frac{C \times ED \times [(EF \times TF1 \times K \times IR\,air) + (EFs \times TFo \times SA \times PC \times CF1 \times CF2) + (TFo \times EF \times IRw)]}{BW \times AT \times 365\ days/yr}$$

(Inhalation: $EF \times TF1 \times K \times IR\,air$; Dermal: $EFs \times TFo \times SA \times PC \times CF1 \times CF2$; Ingestion: $TFo \times EF \times IRw$)

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 mg/kg/d - cars	TF1 (mg/kg/d) noncarcin	TFo mg/kg/d - cars	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Chloroform	0.0072	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	8.05E-02	NA	4.10E-03	1.00E+02	2.00E-02	7.8E-06	6.1E-09	1.6E-07	8.0E-06	0.0E+00	1.7E-06	6.0E-03	6.0E-03
Dichlorodifluoromethane	0.00049	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	1.75E+01	NA	5.00E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.8E-04	0.0E+00	6.7E-05	9.5E-04
INORGANICS																									
Antimony	0.0052	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E-03	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.6E-01	3.6E-01
Cobalt	0.0023	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Copper	0.0022	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Iron	0.082	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Manganese	0.018	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	6.99E-04	NA	2.00E-02	0.00E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.9E-02	9.9E-02

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	7.8E-06	6.1E-09	1.6E-07	8.0E-06	8.8E-04	1.7E-06	4.6E-01	4.6E-01

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens equal to ED)
ED = exposure duration
IRair = daily indoor inhalation rate
K = volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
NA = not applicable

EF = exposure frequency
EFs = showering frequency
SA = skin surface area exposed
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI = hazard index

Table 2-33a
Summary of Risks and Hazard Quotients

AOC FS-17 STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

CURRENT USE	Maximum	Mean
	Utility Worker (Soil)	
Total Cancer Risk	1.1E-07	8.5E-08
Total HI	6.9E-03	5.0E-03
	Child Trepasser (Soil)	
Total Cancer Risk	3.4E-07	2.6E-07
Total HI	3.4E-03	2.5E-03

FUTURE USE	Maximum	Mean
	Utility Worker (Soil)	
Total Cancer Risk	4.8E-07	3.7E-07
Total HI	3.0E-02	2.2E-02
	Child Resident (Soil)	
Total Cancer Risk	1.0E-05	8.2E-06
Total HI	1.1E-01	8.1E-02
	Adult Resident (Soil and Groundwater)	
Total Cancer Risk	6.2E-05(1.6E-05*)	3.4E-05(1.1E-05)
Soil	4.7E-06	3.2E-06
Groundwater	5.7E-05 (1.1E-05*)	3.1E-05(8.0E-06*)
Total HI		
Soil	1.2E-02	8.7E-03
Groundwater	2.2E+00(8.3E-01*)	9.4E-01(4.6E-01*)
Total Lifetime Resident Cancer Risk (Child + Adult)	7.2E-05(2.6E-05)	4.2E-05(1.9E-05)

* Values in parentheses based on dissolved inorganics concentrations for groundwater.

Table 2-34
Selection of Contaminants of Ecological Concern for Surface Soils

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Max conc. * in Surface soil mg/kg	MMR Site-Specific Background Maximum (mg/kg)	Mouse	Vole	Shrew	Fox	Upland Sandpiper	Grasshopper Sparrow	Northern Harrier	Short-eared Owl	Cardinal
			From Attachment F - Hazard Equivalent Concentrations For Ecological PRE (mg/kg)								
Volatile Organics											
Acetone	0.015	NA	5.69E+01	9.08E+01	6.75E+01	2.04E+04	6.25E+00	1.98E+01	5.39E+02	5.36E+02	1.17E+01
Carbon Disulfide	0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloroform	0.001	NA	5.53E+01	8.60E+01	2.00E+02	8.37E+03	1.87E+01	5.83E+01	9.15E+01	9.15E+01	1.15E+01
Ethyl Benzene	3.7	NA	6.69E+01	1.20E+02	3.19E+01	1.61E+03	2.95E+00	9.36E+00	1.78E+01	1.78E+01	1.27E+01
Methylene Chloride	0.001	NA	1.23E+01	1.87E+01	4.05E+01	2.15E+03	3.75E+00	1.19E+01	2.23E+01	2.24E+01	2.60E+00
Toluene	1.8	NA	1.72E+01	2.85E+01	1.33E+01	6.16E+02	1.23E+00	3.90E+00	6.67E+00	6.67E+00	3.42E+00
Total Xylenes	25	NA	7.94E+02	1.46E+03	3.37E+02	1.75E+04	1.17E+01	3.70E+01	7.35E+01	7.36E+01	5.61E+01
Semi-volatile Organics											
2-Methylnaphthalene	120	NA	1.67E+03	4.16E+03	3.40E+02	2.50E+04	3.12E+01	9.96E+01	2.83E+02	2.83E+02	2.61E+02
Acenaphthylene	0.22	NA	4.14E+01	1.24E+02	6.80E+00	5.85E+02	6.25E-01	1.99E+00	6.81E+00	6.82E+00	6.09E+00
Anthracene	0.092	NA	5.53E+03	2.52E+04	6.78E+02	7.97E+04	6.24E+01	1.98E+02	1.03E+03	1.03E+03	7.44E+02
Benzo(a)anthracene	0.33	NA	7.67E+01	1.69E+03	6.80E+00	3.03E+03	6.25E-01	1.99E+00	8.60E+01	8.61E+01	8.86E+00
Benzo(a)pyrene	0.3	NA	7.13E+01	7.97E+02	6.80E+00	6.37E+02	6.25E-01	1.99E+00	8.13E+00	8.15E+00	8.52E+00
Benzo(b)fluoranthene	0.92	NA	7.73E+01	1.91E+03	6.80E+00	3.83E+03	6.25E-01	1.99E+00	1.91E+02	1.91E+02	8.90E+00
Benzo(g,h,i)perylene	0.28	NA	7.75E+01	2.01E+03	6.80E+00	4.58E+03	6.25E-01	1.99E+00	7.18E+02	7.12E+02	8.91E+00
Benzo(k)fluoranthene	0.92	NA	7.73E+01	1.91E+03	6.80E+00	3.83E+03	6.25E-01	1.99E+00	1.91E+02	1.91E+02	8.90E+00
Carbazole	0.092	NA	3.88E+02	1.02E+04	3.40E+01	2.45E+04	3.12E+00	9.96E+00	3.98E+04	3.59E+04	4.46E+01
Chrysene	0.41	NA	7.67E+01	1.69E+03	6.80E+00	3.03E+03	6.25E-01	1.99E+00	8.60E+01	8.61E+01	8.86E+00
Dibenz(a,h)anthracene	0.12	NA	7.75E+01	2.01E+03	6.80E+00	4.57E+03	6.25E-01	1.99E+00	6.99E+02	6.93E+02	8.91E+00
Dibenzofuran	0.072	NA	5.43E+02	1.71E+03	8.50E+01	7.63E+03	7.81E+00	2.49E+01	8.95E+01	8.96E+01	7.87E+01
Di-n-butylphthalate	0.062	NA	4.62E+02	6.74E+03	4.25E+01	1.63E+04	3.90E+00	1.24E+01	6.18E+03	6.10E+03	5.43E+01
Fluoranthene	0.77	NA	8.67E+02	8.23E+03	8.50E+01	1.70E+04	7.81E+00	2.49E+01	2.49E+02	2.49E+02	1.05E+02
Fluorene	10	NA	5.72E+02	1.91E+03	8.49E+01	7.98E+03	7.81E+00	2.49E+01	9.50E+01	9.51E+01	8.16E+01
Indeno(1,2,3-cd)pyrene	0.33	NA	7.75E+01	2.01E+03	6.80E+00	4.58E+03	6.25E-01	1.99E+00	7.18E+02	7.12E+02	8.91E+00
Naphthalene	48	NA	7.33E+01	1.55E+02	1.79E+01	1.12E+03	1.64E+00	5.24E+00	1.23E+01	1.23E+01	1.24E+01
Phenanthrene	10	NA	5.68E+01	2.73E+02	6.80E+00	8.39E+02	6.25E-01	1.99E+00	1.05E+01	1.06E+01	7.47E+00
Pyrene	2.2	NA	5.62E+02	9.44E+03	5.10E+01	1.64E+04	4.69E+00	1.49E+01	3.17E+02	3.17E+02	6.57E+01

Table 2-34
Selection of Contaminants of Ecological Concern for Surface Soils

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Max conc. * in Surface soil mg/kg	MMR Site-Specific Background Maximum (mg/kg)	Mouse	Vole	Shrew	Fox	Upland Sandpiper	Grasshopper Sparrow	Northern Harrier	Short-eared Owl	Cardinal
			From Attachment F - Hazard Equivalent Concentrations For Ecological PRE (mg/kg)								
Pesticides/PBCs											
4,4'-DDE	0.023	NA	1.28E+02	1.04E+03	1.29E+01	1.29E+02	3.75E-01	1.19E+00	2.27E-01	2.27E-01	4.95E+00
4,4'-DDD	0.02	NA	9.35E+01	2.31E+03	8.22E+00	3.58E+03	2.41E+00	7.69E+00	1.46E+02	1.46E+02	3.44E+01
4,4'-DDT	0.35	NA	7.58E+02	1.44E+04	6.80E+00	7.10E+02	2.50E-01	7.97E-01	4.38E+00	4.38E+00	3.52E+00
alpha-Chlordane	0.0012	NA	2.55E+00	4.87E+01	2.28E-01	7.20E+01	8.75E-02	2.79E-01	1.09E+01	1.10E+01	1.23E+00
gamma-Chlordane	0.0046	NA	2.55E+00	4.87E+01	2.28E-01	7.20E+01	8.75E-02	2.79E-01	1.09E+01	1.10E+01	1.23E+00
Endrin Ketone	0.012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1260	0.2	NA	1.78E+01	3.16E+02	1.60E+00	2.99E+01	1.25E+00	3.98E+00	1.34E+00	1.34E+00	1.76E+01
Inorganics											
Aluminum	5680	8930	2.64E+04	4.28E+04	4.00E+04	3.17E+05	4.94E+08	2.70E+08	4.80E+08	4.53E+08	3.35E+05
Arsenic	2.6	3.6	2.57E+01	1.11E+03	3.12E-01	7.62E+02	2.37E+00	7.55E+00	2.41E+07	2.39E+07	3.37E+01
Barium	56.7	10.4	1.39E+04	6.00E+03	9.20E+03	7.30E+04	9.41E+07	5.14E+07	5.85E+07	5.64E+07	1.05E+04
Beryllium	0.23	0.65	4.14E+04	5.87E+04	1.92E+04	1.52E+05	8.17E+04	4.47E+04	1.08E+05	1.00E+05	2.37E+05
Cadmium	1.3	1.5	1.39E+00	1.35E+01	9.08E-02	3.97E+02	2.09E-01	6.68E-01	7.75E+05	7.58E+05	2.93E+00
Calcium	525	989.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	18.8	6.8	7.28E+00	7.16E+01	7.00E-01	1.85E+02	5.04E+01	1.61E+02	9.97E+07	9.87E+07	7.12E+02
Cobalt	2.6	4.1	5.95E+02	7.72E+02	3.33E+02	2.64E+03	2.17E+05	1.18E+05	1.26E+05	1.22E+05	8.19E+02
Copper	26.8	5.2	7.74E+01	7.66E+01	5.87E+02	4.61E+03	1.13E+06	6.16E+05	3.85E+04	3.85E+04	1.93E+01
Iron	8460	12400.0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	769	12.05	1.73E+02	5.18E+03	3.67E+01	6.61E+04	1.58E+01	5.04E+01	1.13E+07	1.05E+07	2.25E+02
Magnesium	1040	794.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	124	108	7.87E+02	3.64E+02	1.67E+03	1.32E+04	3.81E+08	2.08E+08	4.45E+06	4.46E+06	2.98E+02
Nickel	4.5	5.2	2.72E+03	4.32E+03	1.67E+04	1.32E+05	9.41E+07	5.14E+07	1.13E+07	1.13E+07	9.55E+02
Potassium	415	551	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver	0.98	1.4	6.93E+01	3.28E+01	1.20E+02	9.50E+02	NA	NA	2.69E+04	2.70E+04	2.06E+01
Vanadium	13.1	15.2	2.75E+01	4.53E+01	1.40E+01	1.11E+02	5.53E+07	3.02E+07	2.73E+05	2.74E+05	8.03E+01
Zinc	155	16	4.02E+01	1.03E+02	5.13E+00	7.72E+03	3.98E+00	1.27E+01	2.03E+04	2.04E+04	4.50E+01

ations in surface soil were less than MMR background concentrations for soils.

* Italicized numbers indicate that maximum concentra

HI - Hazard Index
ND - Not Derived
NA - Not Available
NE - Not Evaluated. Calcium, iron, sodium, potassium, and magnesium were not evaluated because they are nutritional requirements and have low toxicity.

Table 2-34
Selection of Contaminants of Ecological Concern for Surficial Soils

AOC FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Mouse HI	Vole HI	Shrew HI	Fox HI	Upland Sandpiper HI	Grasshopper Sparrow HI	Northern Harrier HI	Short-eared Owl HI	Cardinal HI	Contaminant of Ecological Concern
Volatile Organics										
Acetone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Carbon Disulfide	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Chloroform	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Ethyl Benzene	0.1	0.0	0.1	0.0	1.3	0.4	0.2	0.2	0.3	YES
Methylene Chloride	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Toluene	0.1	0.1	0.1	0.0	1.5	0.5	0.3	0.3	0.5	YES
Total Xylenes	0.0	0.0	0.1	0.0	2.1	0.7	0.3	0.3	0.4	YES
Semi-volatile Organics										
2-Methylnaphthalene	0.1	0.0	0.4	0.0	3.8	1.2	0.4	0.4	0.5	YES
Acenaphthylene	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	NO
Anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Benzo(a)anthracene	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	NO
Benzo(a)pyrene	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	NO
Benzo(b)fluoranthene	0.0	0.0	0.1	0.0	1.5	0.5	0.0	0.0	0.1	YES
Benzo(g,h,i)perylene	0.0	0.0	0.0	0.0	0.4	0.1	0.0	0.0	0.0	NO
Benzo(k)fluoranthene	0.0	0.0	0.1	0.0	1.5	0.5	0.0	0.0	0.1	YES
Carbazole	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Chrysene	0.0	0.0	0.1	0.0	0.7	0.2	0.0	0.0	0.0	NO
Dibenz(a,h)anthracene	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	NO
Dibenzofuran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Di-n-butylphthalate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Fluoranthene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	NO
Fluorene	0.0	0.0	0.1	0.0	1.3	0.4	0.1	0.1	0.1	YES
Indeno(1,2,3-cd)pyrene	0.0	0.0	0.0	0.0	0.5	0.2	0.0	0.0	0.0	NO
Naphthalene	0.7	0.3	2.7	0.0	29.3	9.2	3.9	3.9	3.9	YES
Phenanthrene	0.2	0.0	1.5	0.0	16.0	5.0	1.0	0.9	1.3	YES
Pyrene	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.0	0.0	NO

Table 2-34
SELECTION OF CONTAMINANTS OF ECOLOGICAL CONCERN FOR SURFICIAL SOILS

AOC FS-17 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Mouse HI	Vole HI	Shrew HI	Fox HI	Upland Sandpiper HI	Grasshopper Sparrow HI	Northern Harrier HI	Short-eared Owl HI	Cardinal HI	Contaminant of Ecological Concern
Pesticides/PBCs										
4,4'-DDE	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	NO
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
4,4'-DDT	0.0	0.0	0.1	0.0	1.4	0.4	0.1	0.1	0.1	YES
alpha-Chlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
gamma-Chlordane	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	NO
Endrin Ketone	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Aroclor-1260	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.1	0.0	NO
Inorganics										
Aluminum	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	NO
Arsenic	0.1	0.0	8.3	0.0	1.1	0.3	0.0	0.0	0.1	YES
Barium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Beryllium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Cadmium	0.9	0.1	14.3	0.0	6.2	1.9	0.0	0.0	0.4	YES
Calcium	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Chromium	2.6	0.3	26.9	0.1	0.4	0.1	0.0	0.0	0.0	YES
Cobalt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Copper	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.4	YES
Iron	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Lead	4.4	0.1	21.0	0.0	48.7	15.3	0.0	0.0	3.4	YES
Magnesium	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Manganese	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.4	NO
Nickel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO
Potassium	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Silver	0.0	0.0	0.0	0.0	NE	NE	0.0	0.0	0.0	NO
Vanadium	0.5	0.3	0.9	0.1	0.0	0.0	0.0	0.0	0.2	NO
Zinc	3.9	1.5	30.2	0.0	38.9	12.2	0.0	0.0	3.4	YES

ations in surface soil were less than MMR background concentrations for soils.
HI - Hazard Index
ND - Not Derived
NA - Not Available
NE - Not Evaluated. Calcium, iron, sodium, potassium, and magnesium were not evaluated because they are nutritional requirements and have low toxicity.

Table 2-35
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
White-footed Mouse

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAFinv	Max IC (mg/g)	PInv	PP	PS	IR(a) (g/d)	IT (g/d)	PI (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS																	
ETHYL BENZENE	2.99E+00	3.70E-03	1.11E-02	0.31 (1)	1.15E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.60E-01
TOLUENE	5.32E+00	1.60E-03	9.58E-03	0.31 (1)	5.58E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.53E-01
TOTAL XYLENES	2.54E+00	2.50E-02	6.35E-02	1.8 (2)	4.50E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.16E+00
SEMI-VOLATILE ORGANICS																	
2-METHYLNAPHTHALENE	9.07E-01	1.20E-01	1.09E-01	0.2 (2)	2.40E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.86E+00
BENZO(B)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.21 (2)	1.93E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.22E-03
BENZO(K)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.21 (2)	1.93E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.22E-03
FLUORENE	4.71E-01	1.00E-02	4.71E-03	0.2 (2)	2.00E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	8.66E-02
NAPHTHALENE	1.48E+00	4.80E-02	7.10E-02	0.21 (2)	1.01E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.18E+00
PHENANTHRENE	2.49E-01	1.00E-02	2.49E-03	0.28 (2)	2.80E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	5.44E-02
PESTICIDES/PCBs																	
4,4' DDT	1.56E-02	3.50E-04	5.53E-06	3 (4)	1.05E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.80E-03
INORGANICS																	
ARSENIC	6.00E-03	2.60E-03	1.56E-05	0.24 (3)	6.24E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.86E-03
CADMIUM	1.50E-01	1.30E-03	1.95E-04	14 (3)	1.82E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	8.46E-02
CHROMIUM	4.50E-03	1.88E-02	8.46E-05	0.3 (3)	5.64E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.12E-02
COPPER	2.50E-01	2.68E-02	6.70E-03	0.515 (3)	1.38E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.67E-01
LEAD	9.00E-03	7.69E-01	6.92E-03	0.27 (3)	2.08E-01	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.25E+00
ZINC	9.00E-01	1.55E-01	1.40E-01	3.78 (3)	5.66E-01	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	4.24E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1996
(4) MMR RAH

(a) EPA 1993

Table 2-36
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
White-footed Mouse

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAFinv	Mean IC (mg/g)	PInv	PP	PS	IR(a) (g/d)	IT (g/d)	PI (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS																	
ETHYL BENZENE	2.99E+00	7.44E-04	2.23E-03	0.31 (1)	2.31E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.62E-02
TOLUENE	5.32E+00	3.62E-04	1.93E-03	0.31 (1)	1.12E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.06E-02
TOTAL XYLENES	2.54E+00	5.00E-03	1.27E-02	1.8 (2)	9.00E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	2.32E-01
SEMI-VOLATILE ORGANICS																	
2-METHYLNAPHTHALENE	9.07E-01	2.42E-02	2.19E-02	0.2 (2)	4.83E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.75E-01
BENZO(B)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.21 (2)	8.77E-05	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	5.54E-04
BENZO(K)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.21 (2)	8.77E-05	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	5.54E-04
FLUORENE	4.71E-01	2.26E-03	1.06E-03	0.2 (2)	4.52E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.96E-02
NAPHTHALENE	1.48E+00	9.74E-03	1.44E-02	0.21 (2)	2.05E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	2.39E-01
PHENANTHRENE	2.49E-01	2.18E-03	5.43E-04	0.28 (2)	6.10E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.18E-02
PESTICIDES/PCBs																	
4,4' DDT	1.58E-02	8.73E-05	1.38E-06	3 (4)	2.62E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	9.47E-04
INORGANICS																	
ARSENIC	6.00E-03	1.86E-03	1.12E-05	0.24 (3)	4.46E-04	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	2.76E-03
CADMIUM	1.50E-01	6.42E-04	9.63E-05	14 (3)	8.99E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.19E-02
CHROMIUM	4.50E-03	9.40E-03	4.23E-05	0.3 (3)	2.82E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.56E-02
COPPER	2.50E-01	1.44E-02	3.60E-03	0.515 (3)	7.42E-03	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	8.98E-02
LEAD	9.00E-03	2.29E-01	2.06E-03	0.27 (3)	6.18E-02	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	3.74E-01
ZINC	9.00E-01	5.06E-02	4.55E-02	3.78 (3)	1.91E-01	0.17	0.8	0.03	0.864	0.147	0.69	0.026	0	0.0355	0.5	0.022	1.38E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1996
(4) MMR RAH

(a) EPA 1993

Table 2-37
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Meadow Vole

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Max SC (mg/g)	Max PC (mg/g)	PP	PS	IR(a) (g/d)	PI (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	3.70E-03	1.11E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	5.42E-01
TOLUENE	5.32E+00	1.80E-03	9.58E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	4.67E-01
TOTAL XYLENES	2.54E+00	2.50E-02	6.35E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.12E+00
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	1.20E-01	1.09E-01	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	5.46E+00
BENZO(B)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.49E-03
BENZO(K)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.49E-03
FLUORENE	4.71E-01	1.00E-02	4.71E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.44E-01
NAPHTHALENE	1.48E+00	4.80E-02	7.10E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.52E+00
PHENANTHRENE	2.49E-01	1.00E-02	2.49E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.36E-01
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	3.50E-04	5.53E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	7.94E-04
INORGANICS													
ARSENIC	4.00E-02	2.60E-03	1.04E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	8.95E-03
CADMIUM	5.50E-01	1.30E-03	7.15E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.66E-02
CHROMIUM	7.50E-03	1.88E-02	1.41E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.51E-02
COPPER	4.00E-01	2.68E-02	1.07E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	5.60E-01
LEAD	4.50E-02	7.69E-01	3.46E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.83E+00
ZINC	1.50E+00	1.55E-01	2.33E-01	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.15E+01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFInv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(a) EPA 1993

Table 2-38
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Meadow Vole

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	PP	PS	IR(a) (g/d)	PI (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	7.44E-04	2.23E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.09E-01
TOLUENE	5.32E+00	3.62E-04	1.93E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	9.40E-02
TOTAL XYLENES	2.54E+00	5.00E-03	1.27E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	6.24E-01
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	2.42E-02	2.19E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.10E+00
BENZO(B)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	6.75E-04
BENZO(K)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	6.75E-04
FLUORENE	4.71E-01	2.26E-03	1.06E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	5.50E-02
NAPHTHALENE	1.48E+00	9.74E-03	1.44E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	7.14E-01
PHENANTHRENE	2.49E-01	2.18E-03	5.43E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.96E-02
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	8.73E-05	1.38E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.98E-04
INORGANICS													
ARSENIC	4.00E-02	1.86E-03	7.44E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	6.40E-03
CADMIUM	5.50E-01	6.42E-04	3.53E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.81E-02
CHROMIUM	7.50E-03	9.40E-03	7.05E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.75E-02
COPPER	4.00E-01	1.44E-02	5.76E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.01E-01
LEAD	4.50E-02	2.29E-01	1.03E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	8.44E-01
ZINC	1.50E+00	5.06E-02	7.59E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.76E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(a) EPA 1993

Table 2-39
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max SC (mg/g)	BAFinv	Max IC (mg/g)	PInv	PS	IR(a) (g/d)	IT (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	3.70E-03	0.31 (1)	1.15E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	5.19E-02
TOLUENE	1.80E-03	0.31 (1)	5.58E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.52E-02
TOTAL XYLENE	2.50E-02	1.8 (2)	4.50E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	1.88E+00
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	1.20E-01	0.2 (2)	2.40E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	1.14E+00
BENZO(B)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	9.12E-03
BENZO(K)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	9.12E-03
FLUORENE	1.00E-02	0.2 (2)	2.00E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	9.50E-02
NAPHTHALENE	4.80E-02	0.21 (2)	1.01E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	4.76E-01
PHENANTHRENE	1.00E-02	0.28 (2)	2.80E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	1.28E-01
PESTICIDES/PCBs													
4,4' DDT	3.50E-04	3 (4)	1.05E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	4.36E-02
INORGANICS													
ARSENIC	2.60E-03	0.24 (3)	6.24E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.90E-02
CADMIUM	1.30E-03	14 (3)	1.82E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	7.50E-01
CHROMIUM	1.88E-02	0.3 (3)	5.64E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.56E-01
COPPER	2.68E-02	0.515 (3)	1.38E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	6.02E-01
LEAD	7.69E-01	0.27 (3)	2.08E-01	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	9.52E+00
ZINC	1.55E-01	3.78 (3)	5.86E-01	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.43E+01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

IC = invertebrate concentration
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-40
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean SC (mg/g)	BAFinv	Mean IC (mg/g)	PInv	PS	IR(a) (g/d)	IT (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	7.44E-04	0.31 (1)	2.31E-04	0.97	0.03	1.27	1.23	0.04	0		0.5	0.015	1.04E-02
TOLUENE	3.62E-04	0.31 (1)	1.12E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	5.08E-03
TOTAL XYLENE	5.00E-03	1.8 (2)	9.00E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	3.77E-01
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	2.42E-02	0.2 (2)	4.83E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.29E-01
BENZO(B)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	4.14E-03
BENZO(K)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	4.14E-03
FLUORENE	2.26E-03	0.2 (2)	4.52E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.15E-02
NAPHTHALENE	9.74E-03	0.21 (2)	2.05E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	9.65E-02
PHENANTHRENE	2.18E-03	0.28 (2)	6.10E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.79E-02
PESTICIDES/PCBs													
4,4' DDT	8.73E-05	3 (4)	2.62E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	1.09E-02
INORGANICS													
ARSENIC	1.86E-03	0.24 (3)	4.46E-04	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.07E-02
CADMIUM	6.42E-04	14 (3)	8.99E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	3.70E-01
CHROMIUM	9.40E-03	0.3 (3)	2.82E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	1.28E-01
COPPER	1.44E-02	0.515 (3)	7.42E-03	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	3.23E-01
LEAD	2.29E-01	0.27 (3)	6.18E-02	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	2.83E+00
ZINC	5.06E-02	3.78 (3)	1.91E-01	0.97	0.03	1.27	1.23	0.04	0	0.0125	0.5	0.015	7.93E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

IC = invertebrate concentration
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-41
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Red Fox

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max SC (mg/g)	SCFs (kg dry soil)/ (kg dry plant)	Max PC	BAF kg diet kg bird	BAF kg diet kg mammal	Max Cb (mg/g)	Max Cm (mg/g)	IR(b) (g/d)	PS	PM	PB	SI (g/d)	BI (g/d)	MI (g/d)	HRF	BW(b) (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS																	
ETHYL BENZENE	3.70E-03	2.99E+00	1.11E-02	2.84E-02	9.37E-03	3.14E-04	1.04E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	3.39E-03
TOLUENE	1.80E-03	5.32E+00	9.58E-03	1.72E-02	5.86E-03	3.10E-05	1.05E-05	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	3.44E-04
TOTAL XYLENE	2.50E-02	2.54E+00	6.35E-02	3.24E-02	1.06E-02	8.10E-04	2.65E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	8.76E-03
SEMI-VOLATILE ORGANICS																	
2-METHYLNAPHTHALENE	1.20E-01	9.07E-01	1.09E-01	6.83E-02	2.07E-02	7.98E-03	2.48E-03	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	8.38E-02
BENZO(B)FLUORANTHENE	9.20E-04	2.41E-03	2.22E-06	8.51E-01	2.24E-01	7.83E-04	2.06E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	7.60E-03
BENZO(K)FLUORANTHENE	9.20E-04	2.41E-03	2.22E-06	8.51E-01	2.24E-01	7.83E-04	2.06E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	7.60E-03
FLUORENE	1.00E-02	4.71E-01	4.71E-03	9.71E-02	2.95E-02	9.71E-04	2.95E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	1.01E-02
NAPHTHALENE	4.80E-02	1.48E+00	7.10E-02	4.80E-02	1.53E-02	2.30E-03	7.34E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	2.45E-02
PHENANTHRENE	1.00E-02	2.49E-01	2.49E-03	1.36E-01	4.03E-02	1.36E-03	4.03E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	1.39E-02
PESTICIDES/PCBs																	
4,4' DDT	3.50E-04	1.58E-02	5.53E-06	3.08E+00	6.13E-01	1.08E-03	2.15E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	9.36E-03
INORGANICS																	
ARSENIC	2.60E-03	4.00E-02	1.04E-04	1.18E+00	2.50E-03 (a)	3.07E-03	6.50E-06	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	1.70E-02
CADMIUM	1.30E-03	5.50E-01	7.15E-04	3.25E-01	3.33E-01 (a)	4.23E-04	4.33E-04	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	9.22E-03
CHROMIUM	1.88E-02	7.50E-03	1.41E-04	3.25E+00	8.46E-02 (a)	6.11E-02	1.59E-03	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	3.63E-01
COPPER	2.68E-02	4.00E-01	1.07E-02	5.90E+00	1.96E-01 (a)	1.58E-01	5.26E-03	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	9.58E-01
LEAD	7.69E-01	4.50E-02	3.46E-02	1.77E-01	1.05E-01 (a)	1.36E-01	8.11E-02	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	2.04E+00
ZINC	1.55E-01	1.50E+00	2.33E-01	5.90E+01	7.72E-01 (a)	9.15E+00	1.20E-01	115.90	0.03	0.72	0.25	3.48	28.98	83.45	0.0048	5.25	5.24E+01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
WC = water concentration
BI = bird ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg bird = bioaccumulation rate (dry weight)
BAF kg diet/kg mammal = bioaccumulation rate (dry weight)
Cb = concentration in bird
IR = ingestion rate by species of concern (dry weight)
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

Cm = concentration in mammal
PM = percentage mammal ingestion (dry weight)
MI = mammal ingestion rate (dry weight)
BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)
(b) EPA 1993

Table 2-42
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Red Fox

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean SC (mg/g)	SCFs (mg/g dry soil) (mg/g dry plant)	Mean PC	BAF kg diet kg bird	BAF kg diet kg mammal	Mean Cb (mg/g)	Mean Cm (mg/g)	IR(b) (g/d)	PS	PM	PB	SI (g/d)	BI (g/d)	MI (g/d)	HRF	BW(b) (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS																	
ETHYL BENZENE	7.44E-04	2.99E+00	2.23E-03	2.84E-02	9.37E-03	6.32E-05	2.09E-05	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	6.83E-04
TOLUENE	3.62E-04	5.32E+00	1.93E-03	1.72E-02	5.66E-03	3.31E-05	1.13E-05	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	3.63E-04
TOTAL XYLENE	5.00E-03	2.54E+00	1.27E-02	3.24E-02	1.06E-02	4.11E-04	1.35E-04	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	4.43E-03
SEMI-VOLATILE ORGANICS																	
2-METHYLNAPHTHALENE	2.42E-02	9.07E-01	2.19E-02	6.63E-02	2.07E-02	1.45E-03	4.54E-04	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	1.53E-02
BENZO(B)FLUORANTHENE	4.18E-04	2.41E-03	1.01E-06	8.51E-01	2.24E-01	8.56E-07	2.25E-07	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	9.64E-06
BENZO(K)FLUORANTHENE	4.18E-04	2.41E-03	1.01E-06	8.51E-01	2.24E-01	8.56E-07	2.25E-07	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	9.64E-06
FLUORENE	2.26E-03	4.71E-01	1.06E-03	9.71E-02	2.95E-02	1.03E-04	3.14E-05	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	1.06E-03
NAPHTHALENE	9.74E-03	1.48E+00	1.44E-02	4.80E-02	1.53E-02	6.92E-04	2.21E-04	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	7.36E-03
PHENANTHRENE	2.18E-03	2.49E-01	5.43E-04	1.36E-01	4.03E-02	7.38E-05	2.19E-05	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	7.62E-04
PESTICIDES/PCBs																	
4,4' DDT	8.73E-05	1.58E-02	1.38E-06	3.08E+00	6.13E-01	4.25E-06	8.46E-07	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	3.72E-05
INORGANICS																	
ARSENIC	1.86E-03	4.00E-02	7.44E-05	1.18E+00	2.50E-03 (a)	8.78E-05	1.86E-07	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	4.93E-04
CADMIUM	6.42E-04	5.50E-01	3.53E-04	3.25E-01	3.33E-01 (a)	1.15E-04	1.18E-04	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	2.51E-03
CHROMIUM	9.40E-03	7.50E-03	7.05E-05	3.25E+00	8.46E-02 (a)	2.29E-04	5.96E-06	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	1.39E-03
COPPER	1.44E-02	4.00E-01	5.76E-03	5.90E+00	1.96E-01 (a)	3.40E-02	1.13E-03	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	2.06E-01
LEAD	2.29E-01	4.50E-02	1.03E-02	1.77E-01	1.05E-01 (a)	1.82E-03	1.09E-03	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	2.81E-02
ZINC	5.06E-02	1.50E+00	7.59E-02	5.90E+01	7.72E-01 (a)	4.48E+00	5.86E-02	115.90	0.03	0.72	0.25	3.48E+00	2.90E+01	8.35E+01	0.0048	5.25	2.56E+01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
WC = water concentration
BI = bird ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg bird = bioaccumulation rate (dry weight)
BAF kg diet/kg mammal = bioaccumulation rate (dry weight)
Cb = concentration in bird
IR = ingestion rate by species of concern (dry weight)
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

Cm = concentration in mammal
PM = percentage mammal ingestion (dry weight)
MI = mammal ingestion rate (dry weight)
BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)
(b) EPA 1993

Table 2-43
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Upland Sandpiper

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max SC (mg/g)	BAFinv	Max IC (mg/g)	IT(a) (g/d)	HRF	ED (d/d)	BW (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS								
ETHYL BENZENE	3.70E-03	0.31 (1)	1.15E-03	2.87	0.5	0.25	0.164	2.51E-03
TOLUENE	1.80E-03	0.31 (1)	5.58E-04	2.87	0.5	0.25	0.164	1.22E-03
TOTAL XYLENE	2.50E-02	1.8 (2)	4.50E-02	2.87	0.5	0.25	0.164	9.83E-02
SEMI-VOLATILE ORGANICS								
2-METHYLNAPHTHALENE	1.20E-01	0.2 (2)	2.40E-02	2.87	0.5	0.25	0.164	5.24E-02
BENZO(B)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	2.87	0.5	0.25	0.164	4.22E-04
BENZO(K)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	2.87	0.5	0.25	0.164	4.22E-04
FLUORENE	1.00E-02	0.2 (2)	2.00E-03	2.87	0.5	0.25	0.164	4.37E-03
NAPHTHALENE	4.80E-02	0.21 (2)	1.01E-02	2.87	0.5	0.25	0.164	2.20E-02
PHENANTHRENE	1.00E-02	0.28 (2)	2.80E-03	2.87	0.5	0.25	0.164	6.12E-03
PESTICIDES/PCBs								
4,4' DDT	3.50E-04	3 (4)	1.05E-03	2.87	0.5	0.25	0.164	2.29E-03
INORGANICS								
ARSENIC	2.60E-03	0.24 (3)	6.24E-04	2.87	0.5	0.25	0.164	1.36E-03
CADMIUM	1.30E-03	14 (3)	1.82E-02	2.87	0.5	0.25	0.164	3.98E-02
CHROMIUM	1.88E-02	0.3 (3)	5.64E-03	2.87	0.5	0.25	0.164	1.23E-02
COPPER	2.68E-02	0.515 (3)	1.38E-02	2.87	0.5	0.25	0.164	3.02E-02
LEAD	7.69E-01	0.27 (3)	2.08E-01	2.87	0.5	0.25	0.164	4.54E-01
ZINC	1.55E-01	3.78 (3)	5.86E-01	2.87	0.5	0.25	0.164	1.28E+00

COC = contaminant of concern
SC = soil concentration
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration rate (dry weight)
Water Ingestion rate not available for this species.

IT = invertebrate ingestion rate (dry weight)
HRF = home range factor
BW = body weight
D = exposure dose
ED = exposure duration (ingestion) = 180 days/ 365 days

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-44
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Upland Sandpiper

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean SC (mg/g)	BAFinv	Mean IC (mg/g)	IT(a) (g/d)	HRF	ED (d/d)	BW (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS								
ETHYL BENZENE	7.44E-04	0.31 (1)	2.31E-04	2.87	0.5	0.25	0.164	5.04E-04
TOLUENE	3.62E-04	0.31 (1)	1.12E-04	2.87	0.5	0.25	0.164	2.45E-04
TOTAL XYLENE	5.00E-03	1.8 (2)	9.00E-03	2.87	0.5	0.25	0.164	1.97E-02
SEMI-VOLATILE ORGANICS								
2-METHYLNAPHTHALENE	2.42E-02	0.2 (2)	4.83E-03	2.87	0.5	0.25	0.164	1.06E-02
BENZO(B)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	2.87	0.5	0.25	0.164	1.92E-04
BENZO(K)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	2.87	0.5	0.25	0.164	1.92E-04
FLUORENE	2.26E-03	0.2 (2)	4.52E-04	2.87	0.5	0.25	0.164	9.88E-04
NAPHTHALENE	9.74E-03	0.21 (2)	2.05E-03	2.87	0.5	0.25	0.164	4.47E-03
PHENANTHRENE	2.18E-03	0.28 (2)	6.10E-04	2.87	0.5	0.25	0.164	1.33E-03
PESTICIDES/PCBs								
4,4' DDT	8.73E-05	3 (4)	2.62E-04	2.87	0.5	0.25	0.164	5.72E-04
INORGANICS								
ARSENIC	1.86E-03	0.24 (3)	4.46E-04	2.87	0.5	0.25	0.164	9.76E-04
CADMIUM	6.42E-04	14 (3)	8.99E-03	2.87	0.5	0.25	0.164	1.96E-02
CHROMIUM	9.40E-03	0.3 (3)	2.82E-03	2.87	0.5	0.25	0.164	6.16E-03
COPPER	1.44E-02	0.515 (3)	7.42E-03	2.87	0.5	0.25	0.164	1.62E-02
LEAD	2.29E-01	0.27 (3)	6.18E-02	2.87	0.5	0.25	0.164	1.35E-01
ZINC	5.06E-02	3.78 (3)	1.91E-01	2.87	0.5	0.25	0.164	4.18E-01

COC = contaminant of concern
SC = soil concentration
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration rate (dry weight)
Water Ingestion rate not available for this species.

IT = invertebrate ingestion rate (dry weight)
HRF = home range factor
BW = body weight
D = exposure dose
ED = exposure duration (ingestion) = 180 days/ 365 days

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-45
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max SC (mg/g)	BAFinv	Max IC (mg/g)	IT(a) (g/d)	HRF	ED (d/d)	BW (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS								
ETHYL BENZENE	3.70E-03	0.31 (1)	1.15E-03	0.0064	0.5	0.5	0.0139	1.32E-04
TOLUENE	1.80E-03	0.31 (1)	5.58E-04	0.0064	0.5	0.5	0.0139	6.42E-05
TOTAL XYLENES	2.50E-02	1.8 (2)	4.50E-02	0.0064	0.5	0.5	0.0139	5.18E-03
SEMI-VOLATILE ORGANICS								
2-METHYNAPHTHALENE	1.20E-01	0.2 (2)	2.40E-02	0.0064	0.5	0.5	0.0139	2.76E-03
BENZO(B)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	0.0064	0.5	0.5	0.0139	2.22E-05
BENZO(K)FLUORANTHENE	9.20E-04	0.21 (2)	1.93E-04	0.0064	0.5	0.5	0.0139	2.22E-05
FLUORENE	1.00E-02	0.2 (2)	2.00E-03	0.0064	0.5	0.5	0.0139	2.30E-04
NAPHTHALENE	4.80E-02	0.21 (2)	1.01E-02	0.0064	0.5	0.5	0.0139	1.16E-03
PHENANTHRENE	1.00E-02	0.28 (2)	2.80E-03	0.0064	0.5	0.5	0.0139	3.22E-04
PESTICIDES/PCBs								
4,4' DDT	3.50E-04	3 (4)	1.05E-03	0.0064	0.5	0.5	0.0139	1.21E-04
INORGANICS								
ARSENIC	2.60E-03	0.24 (3)	6.24E-04	0.0064	0.5	0.5	0.0139	7.18E-05
CADMIUM	1.30E-03	14 (3)	1.82E-02	0.0064	0.5	0.5	0.0139	2.09E-03
CHROMIUM	1.88E-02	0.3 (3)	5.64E-03	0.0064	0.5	0.5	0.0139	6.49E-04
COPPER	2.68E-02	0.515 (3)	1.38E-02	0.0064	0.5	0.5	0.0139	1.59E-03
LEAD	7.69E-01	0.27 (3)	2.08E-01	0.0064	0.5	0.5	0.0139	2.39E-02
ZINC	1.55E-01	3.78 (3)	5.86E-01	0.0064	0.5	0.5	0.0139	6.74E-02

COC = contaminant of concern
SC = soil concentration
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration (dry weight)
Water Ingestion rate not available for this species.

IT = invertebrate ingestion rate (dry weight)
HRF = home range factor
BW = body weight
D = exposure dose
ED = exposure duration (ingestion) = 180 days/ 365 days

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-46
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean SC (mg/g)	BAFinv	Mean IC (mg/g)	IT(a) (g/d)	HRF	ED (d/d)	BW (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS								
ETHYL BENZENE	7.44E-04	0.31 (1)	2.31E-04	0.0064	0.5	0.5	0.0139	2.66E-05
TOLUENE	3.62E-04	0.31 (1)	1.12E-04	0.0064	0.5	0.5	0.0139	1.29E-05
TOTAL XYLENES	5.00E-03	1.8 (2)	9.00E-03	0.0064	0.5	0.5	0.0139	1.04E-03
SEMI-VOLATILE ORGANICS								
2-METHYNAPHTHALENE	2.42E-02	0.2 (2)	4.83E-03	0.0064	0.5	0.5	0.0139	5.56E-04
BENZO(B)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	0.0064	0.5	0.5	0.0139	1.01E-05
BENZO(K)FLUORANTHENE	4.18E-04	0.21 (2)	8.77E-05	0.0064	0.5	0.5	0.0139	1.01E-05
FLUORENE	2.26E-03	0.2 (2)	4.52E-04	0.0064	0.5	0.5	0.0139	5.20E-05
NAPHTHALENE	9.74E-03	0.21 (2)	2.05E-03	0.0064	0.5	0.5	0.0139	2.35E-04
PHENANTHRENE	2.18E-03	0.28 (2)	6.10E-04	0.0064	0.5	0.5	0.0139	7.03E-05
PESTICIDES/PCBs								
4,4' DDT	8.73E-05	3 (4)	2.62E-04	0.0064	0.5	0.5	0.0139	3.01E-05
INORGANICS								
ARSENIC	1.86E-03	0.24 (3)	4.46E-04	0.0064	0.5	0.5	0.0139	5.14E-05
CADMIUM	6.42E-04	14 (3)	8.99E-03	0.0064	0.5	0.5	0.0139	1.03E-03
CHROMIUM	9.40E-03	0.3 (3)	2.82E-03	0.0064	0.5	0.5	0.0139	3.25E-04
COPPER	1.44E-02	0.515 (3)	7.42E-03	0.0064	0.5	0.5	0.0139	8.54E-04
LEAD	2.29E-01	0.27 (3)	6.18E-02	0.0064	0.5	0.5	0.0139	7.12E-03
ZINC	5.06E-02	3.78 (3)	1.91E-01	0.0064	0.5	0.5	0.0139	2.20E-02

COC = contaminant of concern
SC = soil concentration
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration (dry weight)
Water Ingestion rate not available for this species.

IT = invertebrate ingestion rate (dry weight)
HRF = home range factor
BW = body weight
D = exposure dose
ED = exposure duration (ingestion) = 180 days/ 365 days

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-47
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Harrier

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAF kg diet kg rodent	Max Cb (mg/g)	IR (g/d)	PS	PB	SI (g/d)	BI (g/d)	HRF	BW (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	3.70E-03	1.11E-02	9.37E-03	1.04E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	8.45E-05
TOLUENE	5.32E+00	1.80E-03	9.58E-03	5.86E-03	5.61E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	4.57E-05
TOTAL XYLENE	2.54E+00	2.50E-02	6.35E-02	1.06E-02	6.73E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	5.49E-04
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	1.20E-01	1.09E-01	2.07E-02	2.25E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.84E-03
BENZO(B)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	2.24E-01	4.97E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	4.05E-07
BENZO(K)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	2.24E-01	4.97E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	4.05E-07
FLUORENE	4.71E-01	1.00E-02	4.71E-03	2.95E-02	1.39E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.13E-04
NAPHTHALENE	1.48E+00	4.80E-02	7.10E-02	1.53E-02	1.09E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	8.86E-04
PHENANTHRENE	2.49E-01	1.00E-02	2.49E-03	4.03E-02	1.00E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	8.18E-05
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	3.50E-04	5.53E-06	6.13E-01	3.39E-06	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	2.76E-06
INORGANICS													
ARSENIC	4.00E-02	2.60E-03	1.04E-04	2.50E-03 (a)	2.60E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	2.12E-07
CADMIUM	5.50E-01	1.30E-03	7.15E-04	3.33E-01 (a)	2.38E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.94E-04
CHROMIUM	7.50E-03	1.88E-02	1.41E-04	8.46E-02 (a)	1.19E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	9.72E-06
COPPER	4.00E-01	2.68E-02	1.07E-02	1.96E-01 (a)	2.10E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.72E-03
LEAD	4.50E-02	7.69E-01	3.46E-02	1.05E-01 (a)	3.65E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	2.97E-03
ZINC	1.50E+00	1.55E-01	2.33E-01	7.72E-01 (a)	1.79E-01	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.46E-01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird/mammal ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
BI = rodent ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg rodent = bioaccumulation rate
Cb = concentration in bird/mammal
IR = ingestion rate by species of concern (dry weight)
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)

Table 2-48
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Harrier

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAF kg diet kg rodent	Mean Cb (mg/g)	IR (g/d)	PS	PB	SI (g/d)	BI (g/d)	HRF	BW (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	7.44E-04	2.23E-03	9.37E-03	2.09E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.70E-05
TOLUENE	5.32E+00	3.62E-04	1.93E-03	5.86E-03	1.13E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	9.20E-06
TOTAL XYLENE	2.54E+00	5.00E-03	1.27E-02	1.06E-02	1.35E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.10E-04
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	2.42E-02	2.19E-02	2.07E-02	4.54E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	3.70E-04
BENZO(B)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	2.24E-01	2.25E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.84E-07
BENZO(K)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	2.24E-01	2.25E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.84E-07
FLUORENE	4.71E-01	2.26E-03	1.06E-03	2.95E-02	3.14E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	2.56E-05
NAPHTHALENE	1.48E+00	9.74E-03	1.44E-02	1.53E-02	2.21E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.80E-04
PHENANTHRENE	2.49E-01	2.18E-03	5.43E-04	4.03E-02	2.19E-05	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.78E-05
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	8.73E-05	1.38E-06	6.13E-01	8.46E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	6.89E-07
INORGANICS													
ARSENIC	4.00E-02	1.86E-03	7.44E-05	2.50E-03 (a	1.86E-07	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	1.52E-07
CADMIUM	5.50E-01	6.42E-04	3.53E-04	3.33E-01 (a	1.18E-04	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	9.59E-05
CHROMIUM	7.50E-03	9.40E-03	7.05E-05	8.46E-02 (a	5.96E-06	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	4.86E-06
COPPER	4.00E-01	1.44E-02	5.76E-03	1.96E-01 (a	1.13E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	9.22E-04
LEAD	4.50E-02	2.29E-01	1.03E-02	1.05E-01 (a	1.09E-03	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	8.85E-04
ZINC	1.50E+00	5.06E-02	7.59E-02	7.72E-01 (a	5.86E-02	160	0.00	1.00	0.00E+00	1.60E+02	0.0027	0.530	4.77E-02

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird/mammal ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
BI = rodent ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg rodent = bioaccumulation rate
Cb = concentration in bird/mammal
IR = ingestion rate by species of concern (dry weight)
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)

Table 2-49
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Short-eared Owl

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAF kg diet/ kg rodent	Max Cb (mg/g)	IR (g/d)	PS	PB	SI (g/d)	BI (g/d)	HRF	BW (kg)	Max D (mg/kg/d)
VOLATILE ORAGINCS													
ETHYL BENZENE	2.99E+00	3.70E-03	1.11E-02	9.37E-03	1.04E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.25E-04
TOLUENE	5.32E+00	1.80E-03	9.58E-03	5.86E-03	5.61E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	3.38E-04
TOTAL XYLENES	2.54E+00	2.50E-02	6.35E-02	1.06E-02	6.73E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	4.06E-03
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	1.20E-01	1.09E-01	2.07E-02	2.25E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.36E-02
BENZO(B)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	2.24E-01	4.97E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	2.99E-06
BENZO(K)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	2.24E-01	4.97E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	2.99E-06
FLUORENE	4.71E-01	1.00E-02	4.71E-03	2.95E-02	1.39E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	8.37E-04
NAPHTHALENE	1.48E+00	4.80E-02	7.10E-02	1.53E-02	1.09E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.55E-03
PHENANTHRENE	2.49E-01	1.00E-02	2.49E-03	4.03E-02	1.00E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.05E-04
PESTICIDES/PCBs													
4, 4' DDT	1.58E-02	3.50E-04	5.53E-06	6.13E-01	3.39E-06	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	2.04E-05
INORGANICS													
ARSENIC	4.00E-02	2.60E-03	1.04E-04	2.50E-03 (a)	2.60E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.57E-06
CADMIUM	5.50E-01	1.30E-03	7.15E-04	3.33E-01 (a)	2.38E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.44E-03
CHROMIUM	7.50E-03	1.88E-02	1.41E-04	8.46E-02 (a)	1.19E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	7.19E-05
COPPER	4.00E-01	2.68E-02	1.07E-02	1.96E-01 (a)	2.10E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.27E-02
LEAD	4.50E-02	7.69E-01	3.46E-02	1.05E-01 (a)	3.65E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	2.20E-02
ZINC	1.50E+00	1.55E-01	2.33E-01	7.72E-01 (a)	1.79E-01	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.08E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird/mammal ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
BI = rodent ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg rodent = bioaccumulation rate
Cb = concentration in bird/mammal
IR = ingestion rate by species of concern
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)

Table 2-50
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Short-eared Owl

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAF kg diet/ kg rodent	Mean Cb (mg/g)	IR (g/d)	PS	PB	SI (g/d)	BI (g/d)	HRF	BW (kg)	Mean D (mg/kg/d)
VOLATILE ORAGINCS													
ETHYL BENZENE	2.99E+00	7.44E-04	2.23E-03	9.37E-03	2.09E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.26E-04
TOLUENE	5.32E+00	3.62E-04	1.93E-03	5.86E-03	1.13E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.80E-05
TOTAL XYLENES	2.54E+00	5.00E-03	1.27E-02	1.06E-02	1.35E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	8.11E-04
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	2.42E-02	2.19E-02	2.07E-02	4.54E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	2.73E-03
BENZO(B)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	2.24E-01	2.25E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.36E-06
BENZO(K)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	2.24E-01	2.25E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.36E-06
FLUORENE	4.71E-01	2.26E-03	1.06E-03	2.95E-02	3.14E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.89E-04
NAPHTHALENE	1.48E+00	9.74E-03	1.44E-02	1.53E-02	2.21E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.33E-03
PHENANTHRENE	2.49E-01	2.18E-03	5.43E-04	4.03E-02	2.19E-05	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.32E-04
PESTICIDES/PCBs													
4, 4' DDT	1.58E-02	8.73E-05	1.38E-06	6.13E-01	8.46E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	5.10E-06
INORGANICS													
ARSENIC	4.00E-02	1.86E-03	7.44E-05	2.50E-03 (a)	1.86E-07	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	1.12E-06
CADMIUM	5.50E-01	6.42E-04	3.53E-04	3.33E-01 (a)	1.18E-04	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	7.09E-04
CHROMIUM	7.50E-03	9.40E-03	7.05E-05	8.46E-02 (a)	5.96E-06	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	3.59E-05
COPPER	4.00E-01	1.44E-02	5.76E-03	1.96E-01 (a)	1.13E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.82E-03
LEAD	4.50E-02	2.29E-01	1.03E-02	1.05E-01 (a)	1.09E-03	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	6.55E-03
ZINC	1.50E+00	5.06E-02	7.59E-02	7.72E-01 (a)	5.86E-02	113.92	0.00	1.00	0.00E+00	1.14E+02	0.02	0.378	3.53E-01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
PS = percentage of soil ingestion
PB = percentage of bird/mammal ingestion
BAFinv = bioaccumulation factor for invertebrates
IC = invertebrate concentration
BI = rodent ingestion rate (dry weight)

SI = soil ingestion rate (dry weight)
Water ingestion rate not available for this species.
BAF kg diet/kg rodent = bioaccumulation rate
Cb = concentration in bird/mammal
IR = ingestion rate by species of concern
HRF = home range factor
BW = body weight
D = exposure dosage
NA = not available

BAF[bird or mammal] = bioaccumulation factor for herbivorous bird/mammal

(a) Sample et al. 1998 (RAH is current for all others)

Table 2-51
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Cardinal

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAFinv	Max IC (mg/g)	PInv	PP	IR (g/d)	IT (g/d)	PI (g/d)	HRF	BW (kg)	Max D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	3.70E-03	1.11E-02	0.31 (1)	1.15E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.05E-02
TOLUENE	5.32E+00	1.80E-03	9.58E-03	0.31 (1)	5.58E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	7.69E-02
TOTAL XYLENES	2.54E+00	2.50E-02	6.35E-02	1.8 (2)	4.50E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	6.48E-01
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	1.20E-01	1.09E-01	0.2 (2)	2.40E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.33E-01
BENZO(B)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.21 (2)	1.93E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	6.66E-04
BENZO(K)FLUORANTHENE	2.41E-03	9.20E-04	2.22E-06	0.21 (2)	1.93E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	6.66E-04
FLUORENE	4.71E-01	1.00E-02	4.71E-03	0.2 (2)	2.00E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	4.36E-02
NAPHTHALENE	1.48E+00	4.80E-02	7.10E-02	0.21 (2)	1.01E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	5.90E-01
PHENANTHRENE	2.49E-01	1.00E-02	2.49E-03	0.28 (2)	2.80E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	2.89E-02
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	3.50E-04	5.53E-06	3 (4)	1.05E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	3.57E-03
INORGANICS													
ARSENIC	6.00E-03	2.60E-03	1.56E-05	0.24 (3)	6.24E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	2.22E-03
CADMIUM	1.50E-01	1.30E-03	1.95E-04	14 (3)	1.82E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	6.26E-02
CHROMIUM	4.50E-03	1.88E-02	8.46E-05	0.3 (3)	5.64E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.96E-02
COPPER	2.50E-01	2.68E-02	6.70E-03	0.515 (3)	1.38E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.88E-02
LEAD	9.00E-03	7.69E-01	6.92E-03	0.27 (3)	2.08E-01	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	7.51E-01
ZINC	9.00E-01	1.55E-01	1.40E-01	3.78 (3)	5.86E-01	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	3.06E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PP = percent plant ingestion
HRF = home range factor
BW = body weight
WC = water concentration
Water ingestion rate not available for this species.

D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

Table 2-52
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Cardinal

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAFinv	Mean IC (mg/g)	PInv	PP	IR (g/d)	IT (g/d)	PI (g/d)	HRF	BW (kg)	Mean D (mg/kg/d)
VOLATILE ORGANICS													
ETHYL BENZENE	2.99E+00	7.44E-04	2.23E-03	0.31 (1)	2.31E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.82E-02
TOLUENE	5.32E+00	3.62E-04	1.93E-03	0.31 (1)	1.12E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.55E-02
TOTAL XYLENES	2.54E+00	5.00E-03	1.27E-02	1.8 (2)	9.00E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.30E-01
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	9.07E-01	2.42E-02	2.19E-02	0.2 (2)	4.83E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.88E-01
BENZO(B)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.21 (2)	8.77E-05	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	3.02E-04
BENZO(K)FLUORANTHENE	2.41E-03	4.18E-04	1.01E-06	0.21 (2)	8.77E-05	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	3.02E-04
FLUORENE	4.71E-01	2.26E-03	1.06E-03	0.2 (2)	4.52E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.85E-03
NAPHTHALENE	1.48E+00	9.74E-03	1.44E-02	0.21 (2)	2.05E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.20E-01
PHENANTHRENE	2.49E-01	2.18E-03	5.43E-04	0.28 (2)	6.10E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	6.30E-03
PESTICIDES/PCBs													
4,4' DDT	1.58E-02	8.73E-05	1.38E-06	3 (4)	2.62E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	1.39E-02	2.82E-03
INORGANICS													
ARSENIC	6.00E-03	1.86E-03	1.12E-05	0.24 (3)	4.46E-04	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	1.59E-03
CADMIUM	1.50E-01	6.42E-04	9.63E-05	14 (3)	8.99E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	3.09E-02
CHROMIUM	4.50E-03	9.40E-03	4.23E-05	0.3 (3)	2.82E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.80E-03
COPPER	2.50E-01	1.44E-02	3.60E-03	0.515 (3)	7.42E-03	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	5.31E-02
LEAD	9.00E-03	2.29E-01	2.06E-03	0.27 (3)	6.18E-02	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	2.24E-01
ZINC	9.00E-01	5.06E-02	4.55E-02	3.78 (3)	1.91E-01	0.3	0.70	0.985	2.95E-01	6.89E-01	0.5	4.40E-02	9.99E-01

COC - contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PP = percent plant ingestion
HRF = home range factor
BW = body weight
WC = water concentration
Water ingestion rate not available for this species.

D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

Table 2-53
Terrestrial Vegetation Risk Characterization
Maximum Surface Soil Concentrations

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Maximum Detected Concentration (mg/kg)	Benchmark	Critical Soil Concentration (mg/kg)	HQ
Volatile Organics				
Acetone	0.015	PV	318.35	4.7E-05
Carbon Disulfide	0.001	PV	NA	NE
Chloroform	0.001	PV	73.43	1.4E-05
Ethylbenzene	3.7	PV	10.2	3.6E-01
Methylene chloride	0.001	PV	138.4	7.2E-06
Toluene	1.8	PV	33.6	3.0E-05
Total Xylenes	25	PV	1.68	1.1E+00
	VOC HI	**1.4E+00**		
Semi-Volatile Organics				
2-Methylnaphthalene	120	PV	8.6	1.4E+01
Acenaphthylene	0.22	PV	5.77	3.8E-02
Anthracene	0.092	PV	6.59	1.4E-02
Benzo(a)anthracene	0.33	PV	7.82	4.2E-02
Benzo(a)pyrene	0.3	PV	8.48	3.5E-02
Benzo(b)fluoranthene	0.92	PV	8.46	1.1E-01
Benzo(g,h,i)perylene	0.28	PV	8.96	3.1E-02
Benzo(k)fluoranthene	0.92	PV	8.46	1.1E-01
Carbazole	0.092	PV	NA	NE
Chrysene	0.41	PV	7.82	5.2E-02
Dibenz(a,h)anthracene	0.12	PV	9	1.3E-02
Dibenzofuran	0.072	PV	6.21	1.2E-02
Di-n-butylphthalate	0.062	PV	38.7	1.6E-03
Fluoranthene	0.77	PV	7.26	1.1E-01
Fluorene	10	PV	6.26	1.6E+00
Indeno(1,2,3-cd)pyrene	0.33	PV	8.96	3.7E-02
Naphthalene	48	PV	10	4.8E+00
Phenanthrene	10	PV	4.16	2.4E+00
Pyrene	2.2	PV	7.08	3.1E-01
	SVOC HI	**2.4E+01**		
Pesticides/PCBs				
4,4'-DDE	0.023	PV	50	4.6E-04
4,4'-DDD	0.02	PV	50	4.0E-04
4,4'-DDT	0.35	PV	50	7.0E-03
alpha-Chlordane	0.0012	PV	NA	NE
gamma-Chlordane	0.0046	PV	38.95	1.2E-04
Endrin Ketone	0.012	PV	NA	NE
Aroclor-1260	0.2	PV	10	2.0E-02
	Pesticide/PCB HI	**2.8E-02**		
Inorganic Analytes				
Aluminum	5680	PV	NA	NE
Arsenic*	2.6	PV	5.0	5.2E-01
Barium	56.7	PV	NA	NE
Beryllium	0.23	PV	NA	NE
Cadmium*	1.3	PV	5.0	2.6E-01
Calcium	525	PV	NA	NE
Chromium*	18.8	PV	5.0	3.8E+00
Cobalt *	2.6	PV	15.0	1.7E-01
Copper*	26.8	PV	20.0	1.3E+00
Iron	8460	PV	NA	NE
Lead*	769	PV	30.0	2.6E+01
Magnesium	1040	PV	NA	NE
Manganese*	124	PV	300.0	4.1E-01
Nickel*	4.5	PV	10.0	4.5E-01
Potassium	415	PV	NA	NE
Silver	0.98	PV	NA	NE
Vanadium	13.1	PV	NA	NE
Zinc*	155	PV	100.0	1.6E+00
	Inorganic HI	**3.4E+01**		

Total HI = 5.9E+01

HI = Hazard Index
HQ = Hazard Quotient
NA = Not Available
NE = Not Evaluated
PV = Phytotoxicity Value. MMR Risk Assessment Handbook, Volume I Table O-3 and Table O-4.
* Phytotoxicity value given as a range: HQ calculated using lowest value

Table 2-54
Terrestrial Vegetation Risk Characterization
Mean Surface Soil Concentrations

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Detected Concentration (mg/kg)	Benchmark	Critical Soil Concentration (mg/kg)	HQ
Volatile Organics				
Acetone	0.0079	PV	318.35	2.5E-05
Carbon Disulfide	0.0044	PV	NA	NE
Chloroform	0.0021	PV	73.43	2.9E-05
Ethylbenzene	0.74	PV	10.2	7.3E-02
Methylene chloride	0.002	PV	138.4	1.4E-05
Toluene	0.36	PV	33.6	6.0E-05
Total Xylenes	5	PV	1.68	2.2E-01
	VOC HI	**2.9E-01**		
Semi-Volatile Organics				
2-Methylnaphthalene	24	PV	8.6	2.8E+00
Acenaphthylene	0.089	PV	5.77	1.5E-02
Anthracene	0.034	PV	6.59	5.2E-03
Benzo(a)anthracene	0.15	PV	7.82	1.9E-02
Benzo(a)pyrene	0.14	PV	8.48	1.7E-02
Benzo(b)fluoranthene	0.42	PV	8.46	5.0E-02
Benzo(g,h,i)perylene	0.13	PV	8.96	1.4E-02
Benzo(k)fluoranthene	0.42	PV	8.46	4.9E-02
Carbazole	0.20	PV	NA	NE
Chrysene	0.18	PV	7.82	2.3E-02
Dibenz(a,h)anthracene	0.10	PV	9	1.1E-02
Dibenzofuran	0.16	PV	6.21	2.6E-02
Di-n-butylphthalate	0.032	PV	38.7	8.3E-04
Fluoranthene	0.28	PV	7.26	3.9E-02
Fluorene	2.3	PV	6.26	3.6E-01
Indeno(1,2,3-cd)pyrene	0.14	PV	8.98	1.6E-02
Naphthalene	9.7	PV	10	9.7E-01
Phenanthrene	2.2	PV	4.16	5.2E-01
Pyrene	0.64	PV	7.06	9.1E-02
	SVOC HI	**5.0E+00**		
Pesticides/PCBs				
4,4'-DDE	0.0065	PV	50	1.3E-04
4,4'-DDD	0.0055	PV	50	1.1E-04
4,4'-DDT	0.087	PV	50	1.7E-03
alpha-Chlordane	0.00096	PV	NA	NE
gamma-Chlordane	0.0016	PV	38.95	4.1E-05
Endrin Ketone	0.0041	PV	NA	NE
Aroclor-1260	0.061	PV	10	6.1E-03
	Pesticide/PCB HI	**8.1E-03**		
Inorganic Analytes				
Aluminum	3302	PV	NA	NE
Arsenic*	1.9	PV	5.0	3.7E-01
Barium	21	PV	NA	NE
Beryllium	0.15	PV	NA	NE
Cadmium*	0.64	PV	5.0	1.3E-01
Calcium	362	PV	NA	NE
Chromium*	9.4	PV	5.0	1.9E+00
Cobalt *	1.8	PV	15.0	1.2E-01
Copper*	14	PV	20.0	7.2E-01
Iron	6178	PV	NA	NE
Lead*	229	PV	30.0	7.6E+00
Magnesium	722	PV	NA	NE
Manganese*	68	PV	300.0	2.3E-01
Nickel*	3.4	PV	10.0	3.4E-01
Potassium	328	PV	NA	NE
Silver	0.52	PV	NA	NE
Vanadium	11	PV	NA	NE
Zinc*	51	PV	100.0	5.1E-01
	Inorganic HI	**1.2E+01**		

Total HI = 1.7E+01

HI = Hazard Index
HQ = Hazard Quotient
NA = Not Available
NE = Not Evaluated
PV = Phytotoxicity Value. *MMR Risk Assessment Handbook, Volume I* Table O-3 and Table O-4.
* Phytotoxicity value given as a range: HQ calculated using lowest value

Table 2-55
Aquatic Risk Characterization - Maximum Concentrations

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Maximum Detected Concentrations Total (ug/L)	Maximum Detected Concentrations Dissolved (ug/L)	Aquatic Benchmark Value (a) (ug/L)	HQ Total	HQ Dissolved
PESTICIDES/PCBs					
4,4'-DDT	0.02	ND	0.001	2.0E+01	NE
			Pesticide/PCB HI =	**2.0E+01**	**NE**
INORGANICS					
Aluminum	6870	666	87	7.9E+01	7.7E+00
Cadmium	0.28	ND	0.24	1.2E+00	NE
Chromium	15.2	6	11	1.4E+00	5.5E-01
Copper	40.6	6.6	2.2	1.8E+01	3.0E+00
Iron	11200	464	1000	1.1E+01	4.6E-01
Lead	40	1.4	0.26	1.5E+02	5.4E+00
Zinc	65.5	21.7	47.00	1.4E+00	4.6E-01
			Inorganic HI =	**2.7E+02**	**1.8E+01**
			Total HI=	2.9E+02	1.8E+01

Notes:

(a) All values obtained from MMR Ecological Assessment Guidence,Table O-2, with the exception of aluminum. Values for aluminum are from federal Ambient Water Quality Criteria (AWQC) and Guidelines (USEPA, 1992). Aluminum is pH dependant criterion, a pH of 7.8 was assumed. Cadmium, copper, lead, nickel, and zinc assumed water hardness value of 14 mg CaCO3/L and used AWQC hardness equation to derive the benchmark value. Value for iron is based on asthetics in surface water. Value for chromium VI was used.

COC = contaminant of concern
HI = Hazard Index
HQ = Hazard Quotient
ND = Not Detected/Not Determined
NE = Not Evaluated

Table 2-56
Aquatic Risk Characterization - Mean Concentrations

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Detected Concentrations Total (ug/L)	Mean Detected Concentrations Dissolved (ug/L)	Aquatic Benchmark Value (a) (ug/L)	HQ Total	HQ Dissolved
PESTICIDES/PCBs					
4,4'-DDT	0.0114	ND	0.001	1.1E+01	NE
			Pesticide/PCB HI	**1.1E+01**	**NE**
INORGANICS					
Aluminum	3500	0.15	87	4.0E+01	1.7E-03
Cadmium	0.14	ND	0.24	5.8E-01	NE
Chromium	9.386	3.429	11	8.5E-01	3.1E-01
Copper	10.7	2.229	2.2	4.9E+00	1.0E+00
Iron	6073	81.757	1000	6.1E+00	8.2E-02
Lead	9.1	0.7143	0.26	3.5E+01	2.7E+00
Zinc	34	8.4	47.00	7.2E-01	1.8E-01
			Inorganic HI	**8.8E+01**	**4.3E+00**
			Total HI=	1.0E+02	4.3E+00

Notes:

(a) All values obtained from MMR Ecological Assessment Guidence,Table O-2, with the exception of aluminum. Values for aluminum are from federal Ambient Water Quality Criteria (AWQC) and Guidelines (USEPA, 1992). Aluminum is pH dependant criterion, a pH of 7.8 was assumed. Cadmium, copper, lead, nickel, and zinc assumed water hardness value of 14 mg CaCO3/L and used AWQC hardness equation to derive the benchmark value. Value for iron is based on asthetics in surface water. Value for chromium VI was used.

COC = contaminant of concern
HI = Hazard Index
HQ = Hazard Quotient
ND = Not Detected/Not Determined
NE = Not Evaluated

Table 2-57
Adjusted Benchmarks
Terrestrial Model Receptors
Mammals

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Test Species	Test Species NOAEL (mg/kg/d)	Test Species Body Weight (kg)	Endpoint Assessed	Reference Study	Target Species BW (kg)				Adjusted Oral Benchmark (mg/kg-d) N. Short-tailed Shrew	Adjusted Oral Benchmark (mg/kg-d) Meadow Vole	Adjusted Oral Benchmark (mg/kg-d) White-footed Mouse	Adjusted Oral Benchmark (mg/kg-d) Red Fox
						N. Short-tailed Shrew	Meadow Vole	White-footed Mouse	Red Fox				
VOLATILE ORGANICS													
ETHYL BENZENE	rat	47300*	na	Mortality	Wolf et al. 1956	na	na	na	na	4.73			
TOLUENE	mouse	26	0.03	Reproduction	Nawrot et al. 1979.	0.015	0.044	0.022	4.5	30.9	23.6	28.1	7.4
TOTAL XYLENES	mouse	2.1	0.03	Reproduction	Marks et al. 1982.	0.015	0.044	0.022	4.5	2.5	1.908	2.269	0.6
SEMI-VOLATILE ORGANICS													
2-METHYLNAPHTHALENE	rat	5000*	na	Mortality	Sac, N. I. 1984.	0.015	0.044	0.022	4.5	50	50	50	50
BENZO(B)FLUORANTHENE	na	na	na	na	na	na	na	na	na	1	1	1	1
BENZO(K)FLUORANTHENE	na	na	na	na	na	na	na	na	na	1	1	1	1
FLUORENE	mouse	125	na	Systemic Effects	USEPA 1989.	na	na	na	na	12.5	12.5	12.5	12.5
NAPHTHALENE	mouse	0.05*	na	Reproductive Effects	Plasterer et al. 1985.	na	na	na	na	3	3	3	3
PHENANTHRENE	na	na	na	na	na	na	na	na	na	1	1	1	1
PESTICIDES/PCBs													
4, 4' DDT	rat	0.8	0.35	Reproduction	Fitzhugh, O. G. 1948.	0.015	0.044	0.022	4.5	1.76	1.34	1.6	0.42
INORGANICS													
ARSENIC	mouse	0.126	0.03	Reproduction	Schroeder and Mitchner 1971	0.015	0.044	0.022	4.5	0.15	0.114	0.136	0.036
CADMIUM	rat	1.0	0.303	Reproduction	Sutou et al. 1980b	0.015	0.044	0.022	4.5	2.12	1.62	1.926	0.509
CHROMIUM	rat	3.28	0.35	Body Weight/Food Consumption	MacKenzie et al. 1958	0.015	0.044	0.022	4.5	7.21	5.51	6.55	1.73
COPPER	mink	11.7	1	Reproduction	Aulerich et al. 1982	0.015	0.044	0.022	4.5	33.4	25.5	30.4	8.03
LEAD	rat	8	0.35	Reproduction	Azar et al. 1973	0.015	0.044	0.022	4.5	17.56	13.44	15.98	4.22
ZINC	rat	160	0.35	Reproduction	Schlicker and Cox 1968	0.015	0.044	0.022	4.5	351.7	268.7	319.5	84.5

* Only LD50 available
* Only a LOAEL available

Table 2-58
Adjusted Benchmarks
Terrestial Model Receptors
Birds

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Test Species	Endpoint Assessed	Basis	Reference Study	Adjusted Oral Avian Benchmark (mg/kg-d) All Species
VOLATILE ORGANICS					
ETHYL BENZENE	Rat	Mortality	LD50	Smyth et al. 1962	0.47
TOLUENE	Mouse	Neurological	NOAEL	Kostas and Hotchin. 1981	0.2
TOTAL XYLENES	Quail	Mortality	LD50	Hill and Camardese. 1986	1.87
SEMI-VOLATILE ORGANICS					
2-METHYLNAPHTHALENE	Rat	Mortality	LOAEL	Sax 1984	5
BENZO(B)FLUORANTHENE	na	na	na	No toxicological data available	0.1
BENZO(K)FLUORANTHENE	na	na	na	No toxicological data available	0.1
FLUORENE	Mouse	Systemic	NOAEL	USEPA 1989	1.25
NAPHTHALENE	Dog	Systemic	LOAEL	Zoulzar and Apt 1949	0.26
PHENANTHRENE	na	na	na	No toxicological data available	0.1
PESTICIDES/PCBs					
4, 4' DDT	Brown Pelican	Reproduction	NOAEL	Anderson et al 1985	0.003
INORGANICS					
ARSENIC	Brown-headed Cowbird	Mortality	NOAEL	USFWS 1969	2.5
CADMIUM	Mallard Duck	Reproduction	NOAEL	White and Finley 1978	1.45
CHROMIUM	Black Duck	Reproduction	NOAEL	Haseltine et al unpublished data	1
COPPER	1-day old chicks	Mortality	NOAEL	Mehring et al 1960	47
LEAD	Japanese Quail	Reproduction	NOAEL	Edens et al 1976	1.13
ZINC	White Leghorn Hens	Reproduction	NOAEL	Stahl et al 1990	14.5

Table 2-59
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
White-footed Mouse

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.80E-01	4.728	(b)	3.80E-02
TOLUENE	1.53E-01	28.1	(a)	5.46E-03
TOTAL XYLENES	1.16E+00	2.269	(a)	5.12E-01
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.86E+00	50	(b)	3.72E-02
BENZO(B)FLUORANTHENE	1.22E-03	1	(b)	1.22E-03
BENZO(K)FLUORANTHENE	1.22E-03	1	(b)	1.22E-03
FLUORENE	8.66E-02	12.5	(b)	6.92E-03
NAPHTHALENE	1.18E+00	3	(b)	3.93E-01
PHENANTHRENE	5.44E-02	1	(b)	5.44E-02
PESTICIDES/PCBs				
4, 4' DDT	3.80E-03	1.6	(a)	2.37E-03
INORGANICS				
ARSENIC	3.86E-03	0.136	(a)	2.84E-02
CADMIUM	6.46E-02	1.926	(a)	3.35E-02
CHROMIUM	3.12E-02	6.55	(a)	4.77E-03
COPPER	1.67E-01	30.4	(a)	5.50E-03
LEAD	1.25E+00	15.98	(a)	7.85E-02
ZINC	4.24E+00	319.5	(a)	1.33E-02
		HI =		1.2

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-60
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
White-footed Mouse

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	3.62E-02	4.728	(b)	7.65E-03
TOLUENE	3.08E-02	28.1	(a)	1.10E-03
TOTAL XYLENES	2.32E-01	2.269	(a)	1.02E-01
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	3.75E-01	50	(b)	7.49E-03
BENZO(B)FLUORANTHENE	5.54E-04	1	(b)	5.54E-04
BENZO(K)FLUORANTHENE	5.54E-04	1	(b)	5.54E-04
FLUORENE	1.96E-02	12.5	(b)	1.56E-03
NAPHTHALENE	2.39E-01	3	(b)	7.97E-02
PHENANTHRENE	1.18E-02	1	(b)	1.18E-02
PESTICIDES/PCBs				
4, 4' DDT	9.47E-04	1.6	(a)	5.92E-04
INORGANICS				
ARSENIC	2.76E-03	0.136	(a)	2.03E-02
CADMIUM	3.19E-02	1.926	(a)	1.66E-02
CHROMIUM	1.56E-02	6.55	(a)	2.38E-03
COPPER	8.98E-02	30.4	(a)	2.95E-03
LEAD	3.74E-01	15.98	(a)	2.34E-02
ZINC	1.38E+00	319.5	(a)	4.33E-03
		HI =		0.3

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-61
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Meadow Vole

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day	Hazard Quotient
VOLATILE ORGANICS			
ETHYL BENZENE	5.42E-01	4.728 (b)	1.15E-01
TOLUENE	4.67E-01	23.6 (a)	1.98E-02
TOTAL XYLENES	3.12E+00	1.908 (a)	1.63E+00
SEMI-VOLATILE ORGANICS			
2-METHYLNAPHTHALENE	5.46E+00	50 (b)	1.09E-01
BENZO(B)FLUORANTHENE	1.49E-03	1 (b)	1.49E-03
BENZO(K)FLUORANTHENE	1.49E-03	1 (b)	1.49E-03
FLUORENE	2.44E-01	12.5 (b)	1.95E-02
NAPHTHALENE	3.52E+00	3 (b)	1.17E+00
PHENANTHRENE	1.36E-01	1 (b)	1.36E-01
PESTICIDES/PCBs			
4, 4' DDT	7.94E-04	1.34 (a)	5.92E-04
INORGANICS			
ARSENIC	8.95E-03	0.114 (a)	7.85E-02
CADMIUM	3.66E-02	1.62 (a)	2.26E-02
CHROMIUM	3.51E-02	5.51 (a)	6.36E-03
COPPER	5.60E-01	25.5 (a)	2.20E-02
LEAD	2.83E+00	13.44 (a)	2.11E-01
ZINC	1.15E+01	268.7 (a)	4.29E-02
		HI =	3.6

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-62
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Meadow Vole

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day	Hazard Quotient
VOLATILE ORGANICS			
ETHYL BENZENE	1.09E-01	4.728 (b)	2.31E-02
TOLUENE	9.40E-02	23.6 (a)	3.98E-03
TOTAL XYLENES	6.24E-01	1.908 (a)	3.27E-01
SEMI-VOLATILE ORGANICS			
2-METHYLNAPHTHALENE	1.10E+00	50 (b)	2.20E-02
BENZO(B)FLUORANTHENE	6.75E-04	1 (b)	6.75E-04
BENZO(K)FLUORANTHENE	6.75E-04	1 (b)	6.75E-04
FLUORENE	5.50E-02	12.5 (b)	4.40E-03
NAPHTHALENE	7.14E-01	3 (b)	2.38E-01
PHENANTHRENE	2.96E-02	1 (b)	2.96E-02
PESTICIDES/PCBs			
4, 4' DDT	1.98E-04	1.34 (a)	1.48E-04
INORGANICS			
ARSENIC	6.40E-03	0.114 (a)	5.62E-02
CADMIUM	1.81E-02	1.62 (a)	1.12E-02
CHROMIUM	1.75E-02	5.51 (a)	3.18E-03
COPPER	3.01E-01	25.5 (a)	1.18E-02
LEAD	8.44E-01	13.44 (a)	6.28E-02
ZINC	3.76E+00	268.7 (a)	1.40E-02
		HI =	0.8

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-63
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	5.19E-02	4.728	(b)	1.10E-02
TOLUENE	2.52E-02	30.9	(a)	8.17E-04
TOTAL XYLENES	1.88E+00	2.497	(a)	7.54E-01
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.14E+00	50	(b)	2.28E-02
BENZO(B)FLUORANTHENE	9.12E-03	1	(b)	9.12E-03
BENZO(K)FLUORANTHENE	9.12E-03	1	(b)	9.12E-03
FLUORENE	9.50E-02	12.5	(b)	7.60E-03
NAPHTHALENE	4.76E-01	2.63	(b)	1.81E-01
PHENANTHRENE	1.28E-01	1	(b)	1.28E-01
PESTICIDES/PCBs				
4, 4' DDT	4.36E-02	1.76	(a)	2.48E-02
INORGANICS				
ARSENIC	2.90E-02	0.15	(a)	1.93E-01
CADMIUM	7.50E-01	2.12	(a)	3.54E-01
CHROMIUM	2.56E-01	7.21	(a)	3.55E-02
COPPER	6.02E-01	33.4	(a)	1.80E-02
LEAD	9.52E+00	17.58	(a)	5.41E-01
ZINC	2.43E+01	351.7	(a)	6.91E-02
		HI =		2.4

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-64
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.04E-02	4.728	(b)	2.21E-03
TOLUENE	5.08E-03	30.9	(a)	1.64E-04
TOTAL XYLENES	3.77E-01	2.497	(a)	1.51E-01
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	2.29E-01	50	(b)	4.59E-03
BENZO(B)FLUORANTHENE	4.14E-03	1	(b)	4.14E-03
BENZO(K)FLUORANTHENE	4.14E-03	1	(b)	4.14E-03
FLUORENE	2.15E-02	12.5	(b)	1.72E-03
NAPHTHALENE	9.65E-02	2.63	(b)	3.67E-02
PHENANTHRENE	2.79E-02	1	(b)	2.79E-02
PESTICIDES/PCBs				
4, 4' DDT	1.09E-02	1.76	(a)	6.18E-03
INORGANICS				
ARSENIC	2.07E-02	0.15	(a)	1.38E-01
CADMIUM	3.70E-01	2.12	(a)	1.75E-01
CHROMIUM	1.28E-01	7.21	(a)	1.77E-02
COPPER	3.23E-01	33.4	(a)	9.68E-03
LEAD	2.83E+00	17.58	(a)	1.61E-01
ZINC	7.93E+00	351.7	(a)	2.25E-02
		HI =		0.8

(a) values obtained from Suter et al. 1996
(b) values obtained from Table 0-1A of the RAH.

Table 2-65
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Red Fox

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	3.39E-03	4.728	(b)	7.18E-04
TOLUENE	3.44E-04	7.4	(a)	4.65E-05
TOTAL XYLENES	8.76E-03	0.6	(a)	1.46E-02
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	8.38E-02	50	(b)	1.68E-03
BENZO(B)FLUORANTHENE	7.60E-03	1	(b)	7.60E-03
BENZO(K)FLUORANTHENE	7.60E-03	1	(b)	7.60E-03
FLUORENE	1.01E-02	12.5	(b)	8.06E-04
NAPHTHALENE	2.45E-02	2.63	(b)	9.33E-03
PHENANTHRENE	1.39E-02	1	(b)	1.39E-02
PESTICIDES/PCBs				
4, 4' DDT	9.36E-03	0.42	(a)	2.23E-02
INORGANICS				
ARSENIC	1.70E-02	0.036	(a)	4.73E-01
CADMIUM	9.22E-03	0.509	(a)	1.81E-02
CHROMIUM	3.63E-01	1.73	(a)	2.10E-01
COPPER	9.56E-01	8	(a)	1.20E-01
LEAD	2.04E+00	4.22	(a)	4.84E-01
ZINC	5.24E+01	84.5	(a)	6.20E-01
		HI =		2.0

Note:
(a) Values obtained from Suter et al. 1996
(b) values obtained from Table 0-1B of the RAH.

Table 2-66
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Red Fox

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	6.83E-04	4.728	(b)	1.44E-04
TOLUENE	3.63E-04	7.4	(a)	4.91E-05
TOTAL XYLENES	4.43E-03	0.6	(a)	7.38E-03
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.53E-02	50	(b)	3.06E-04
BENZO(B)FLUORANTHENE	9.64E-06	1	(b)	9.64E-06
BENZO(K)FLUORANTHENE	9.64E-06	1	(b)	9.64E-06
FLUORENE	1.08E-03	12.5	(b)	8.61E-05
NAPHTHALENE	7.36E-03	2.63	(b)	2.80E-03
PHENANTHRENE	7.62E-04	1	(b)	7.62E-04
PESTICIDES/PCBs				
4, 4' DDT	3.72E-05	0.42	(a)	8.85E-05
INORGANICS				
ARSENIC	4.93E-04	0.036	(a)	1.37E-02
CADMIUM	2.51E-03	0.509	(a)	4.92E-03
CHROMIUM	1.39E-03	1.73	(a)	8.03E-04
COPPER	2.06E-01	8	(a)	2.57E-02
LEAD	2.81E-02	4.22	(a)	6.65E-03
ZINC	2.56E+01	84.5	(a)	3.04E-01
		HI =		0.4

Note:
(a) Values obtained from Suter et al. 1996
(b) values obtained from Table 0-1B of the RAH.

Table 2-67
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Upland Sandpiper

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	2.51E-03	0.47	(a)	5.30E-03
TOLUENE	1.22E-03	0.2	(a)	6.19E-03
TOTAL XYLENES	9.83E-02	1.87	(a)	5.26E-02
	0.00E+00			
SEMI-VOLATILE ORGANICS	0.00E+00			
2-METHYLNAPHTHALENE	5.24E-02	5	(a)	1.05E-02
BENZO(B)FLUORANTHENE	4.22E-04	0.1	(a)	4.22E-03
BENZO(K)FLUORANTHENE	4.22E-04	0.1	(a)	4.22E-03
FLUORENE	4.37E-03	1.25	(a)	3.50E-03
NAPHTHALENE	2.20E-02	0.26	(a)	8.38E-02
PHENANTHRENE	6.12E-03	0.1	(a)	6.12E-02
PESTICIDES/PCBs				
4, 4' DDT	2.29E-03	0.003	(b)	7.65E-01
INORGANICS				
ARSENIC	1.36E-03	2.5	(b)	5.45E-04
CADMIUM	3.98E-02	1.45	(b)	2.74E-02
CHROMIUM	1.23E-02	1	(b)	1.23E-02
COPPER	3.02E-02	47	(b)	6.42E-04
LEAD	4.54E-01	1.13	(b)	4.02E-01
ZINC	1.28E+00	14.5	(b)	8.83E-02
		HI =		1.5

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-68
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Upland Sandpiper

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	5.04E-04	0.47	(a)	1.07E-03
TOLUENE	2.45E-04	0.2	(a)	1.24E-03
TOTAL XYLENES	1.97E-02	1.87	(a)	1.05E-02
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.06E-02	5	(a)	2.11E-03
BENZO(B)FLUORANTHENE	1.92E-04	0.1	(a)	1.92E-03
BENZO(K)FLUORANTHENE	1.92E-04	0.1	(a)	1.92E-03
FLUORENE	9.88E-04	1.25	(a)	7.90E-04
NAPHTHALENE	4.47E-03	0.26	(a)	1.70E-02
PHENANTHRENE	1.33E-03	0.1	(a)	1.33E-02
PESTICIDES/PCBs				
4, 4' DDT	5.72E-04	0.003	(b)	1.91E-01
INORGANICS				
ARSENIC	9.76E-04	2.5	(b)	3.90E-04
CADMIUM	1.96E-02	1.45	(b)	1.35E-02
CHROMIUM	6.16E-03	1	(b)	6.16E-03
COPPER	1.62E-02	47	(b)	3.45E-04
LEAD	1.35E-01	1.13	(b)	1.20E-01
ZINC	4.18E-01	14.5	(b)	2.88E-02
		HI =		0.4

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-69
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.32E-04	0.47	(a)	2.79E-04
TOLUENE	6.42E-05	0.2	(a)	3.26E-04
TOTAL XYLENES	5.18E-03	1.87	(a)	2.77E-03
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	2.76E-03	5	(a)	5.53E-04
BENZO(B)FLUORANTHENE	2.22E-05	0.1	(a)	2.22E-04
BENZO(K)FLUORANTHENE	2.22E-05	0.1	(a)	2.22E-04
FLUORENE	2.30E-04	1.25	(a)	1.84E-04
NAPHTHALENE	1.16E-03	0.26	(a)	4.41E-03
PHENANTHRENE	3.22E-04	0.1	(a)	3.22E-03
PESTICIDES/PCBs				
4, 4' DDT	1.21E-04	0.003	(b)	4.03E-02
INORGANICS				
ARSENIC	7.18E-05	2.5	(b)	2.87E-05
CADMIUM	2.09E-03	1.45	(b)	1.44E-03
CHROMIUM	6.49E-04	1	(b)	6.49E-04
COPPER	1.59E-03	47	(b)	3.38E-05
LEAD	2.39E-02	1.13	(b)	2.12E-02
ZINC	6.74E-02	14.5	(b)	4.65E-03
		HI =		0.1

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-70
Calculation of Hazard Index for Food Chain Receptors
for Food Chain Receptors
Mean Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	2.66E-05	0.47	(a)	5.62E-05
TOLUENE	1.29E-05	0.2	(a)	6.56E-05
TOTAL XYLENES	1.04E-03	1.87	(a)	5.54E-04
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	5.56E-04	5	(a)	1.11E-04
BENZO(B)FLUORANTHENE	1.01E-05	0.1	(a)	1.01E-04
BENZO(K)FLUORANTHENE	1.01E-05	0.1	(a)	1.01E-04
FLUORENE	5.20E-05	1.25	(a)	4.16E-05
NAPHTHALENE	2.35E-04	0.26	(a)	8.95E-04
PHENANTHRENE	7.03E-05	0.1	(a)	7.03E-04
PESTICIDES/PCBs				
4, 4' DDT	3.01E-05	0.003	(b)	1.00E-02
INORGANICS				
ARSENIC	5.14E-05	2.5	(b)	2.06E-05
CADMIUM	1.03E-03	1.45	(b)	7.14E-04
CHROMIUM	3.25E-04	1	(b)	3.25E-04
COPPER	8.54E-04	47	(b)	1.82E-05
LEAD	7.12E-03	1.13	(b)	6.30E-03
ZINC	2.20E-02	14.5	(b)	1.52E-03
		HI =		0.02

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-71
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Harrier

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	8.45E-05	0.473	(a)	1.79E-04
TOLUENE	4.57E-05	0.197	(a)	2.32E-04
TOTAL XYLENES	5.49E-04	1.87	(a)	2.93E-04
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.84E-03	5	(a)	3.67E-04
BENZO(B)FLUORANTHENE	4.05E-07	0.1	(a)	4.05E-06
BENZO(K)FLUORANTHENE	4.05E-07	0.1	(a)	4.05E-06
FLUORENE	1.13E-04	1.25	(a)	9.06E-05
NAPHTHALENE	8.86E-04	0.263	(a)	3.37E-03
PHENANTHRENE	8.18E-05	0.1	(a)	8.18E-04
PESTICIDES/PCBs				
4,4' DDT	2.76E-06	0.003	(b)	9.21E-04
INORGANICS				
ARSENIC	2.12E-07	2.5	(b)	8.48E-08
CADMIUM	1.94E-04	1.45	(b)	1.34E-04
CHROMIUM	9.72E-06	1	(b)	9.72E-06
COPPER	1.72E-03	47	(b)	3.65E-05
LEAD	2.97E-03	1.13	(b)	2.63E-03
ZINC	1.46E-01	14.5	(b)	1.01E-02
		HI =		0.02

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-72
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Harrier

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.70E-05	0.473	(a)	3.59E-05
TOLUENE	9.20E-06	0.197	(a)	4.67E-05
TOTAL XYLENES	1.10E-04	1.87	(a)	5.87E-05
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	3.70E-04	5	(a)	7.39E-05
BENZO(B)FLUORANTHENE	1.84E-07	0.1	(a)	1.84E-06
BENZO(K)FLUORANTHENE	1.84E-07	0.1	(a)	1.84E-06
FLUORENE	2.56E-05	1.25	(a)	2.05E-05
NAPHTHALENE	1.80E-04	0.263	(a)	6.84E-04
PHENANTHRENE	1.78E-05	0.1	(a)	1.78E-04
PESTICIDES/PCBs				
4,4' DDT	6.89E-07	0.003	(b)	2.30E-04
INORGANICS				
ARSENIC	1.52E-07	2.5	(b)	6.06E-08
CADMIUM	9.59E-05	1.45	(b)	6.62E-05
CHROMIUM	4.86E-06	1	(b)	4.86E-06
COPPER	9.22E-04	47	(b)	1.96E-05
LEAD	8.85E-04	1.13	(b)	7.83E-04
ZINC	4.77E-02	14.5	(b)	3.29E-03
		HI =		0.01

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-73
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Short-eared Owl

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day	Hazard Quotient
VOLATILE ORGANICS			
ETHYL BENZENE	6.25E-04	0.473 (a)	1.32E-03
TOLUENE	3.38E-04	0.197 (a)	1.72E-03
TOTAL XYLENES	4.06E-03	1.87 (a)	2.17E-03
SEMI-VOLATILE ORGANICS			
2-METHYLNAPHTHALENE	1.36E-02	5 (a)	2.72E-03
BENZO(B)FLUORANTHENE	2.99E-06	0.1 (a)	2.99E-05
BENZO(K)FLUORANTHENE	2.99E-06	0.1 (a)	2.99E-05
FLUORENE	8.37E-04	1.25 (a)	6.70E-04
NAPHTHALENE	6.55E-03	0.263 (a)	2.49E-02
PHENANTHRENE	6.05E-04	0.1 (a)	6.05E-03
PESTICIDES/PCBs			
4, 4' DDT	2.04E-05	0.003 (b)	6.81E-03
INORGANICS			
ARSENIC	1.57E-06	2.5 (b)	6.27E-07
CADMIUM	1.44E-03	1.45 (b)	9.91E-04
CHROMIUM	7.19E-05	1 (b)	7.19E-05
COPPER	1.27E-02	47 (b)	2.70E-04
LEAD	2.20E-02	1.13 (b)	1.95E-02
ZINC	1.08E+00	14.5 (b)	7.46E-02
		HI =	0.1

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-74
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Short-eared Owl

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.26E-04	0.473	(a)	2.66E-04
TOLUENE	6.80E-05	0.197	(a)	3.45E-04
TOTAL XYLENES	8.11E-04	1.87	(a)	4.34E-04
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	2.73E-03	5	(a)	5.47E-04
BENZO(B)FLUORANTHENE	1.36E-06	0.1	(a)	1.36E-05
BENZO(K)FLUORANTHENE	1.36E-06	0.1	(a)	1.36E-05
FLUORENE	1.89E-04	1.25	(a)	1.51E-04
NAPHTHALENE	1.33E-03	0.263	(a)	5.05E-03
PHENANTHRENE	1.32E-04	0.1	(a)	1.32E-03
PESTICIDES/PCBs				
4, 4' DDT	5.10E-06	0.003	(b)	1.70E-03
INORGANICS				
ARSENIC	1.12E-06	2.5	(b)	4.48E-07
CADMIUM	7.09E-04	1.45	(b)	4.89E-04
CHROMIUM	3.59E-05	1	(b)	3.59E-05
COPPER	6.82E-03	47	(b)	1.45E-04
LEAD	6.55E-03	1.13	(b)	5.79E-03
ZINC	3.53E-01	14.5	(b)	2.43E-02
		HI =		0.04

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-75
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Cardinal

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Max Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	9.05E-02	0.473	(a)	1.91E-01
TOLUENE	7.69E-02	0.197	(a)	3.90E-01
TOTAL XYLENES	6.48E-01	1.87	(a)	3.47E-01
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	9.33E-01	5	(a)	1.87E-01
BENZO(B)FLUORANTHENE	6.66E-04	0.1	(a)	6.66E-03
BENZO(K)FLUORANTHENE	6.66E-04	0.1	(a)	6.66E-03
FLUORENE	4.36E-02	1.25	(a)	3.49E-02
NAPHTHALENE	5.90E-01	0.3	(a)	1.97E+00
PHENANTHRENE	2.89E-02	0.1	(a)	2.89E-01
PESTICIDES/PCBs				
4, 4' DDT	3.57E-03	0.003	(b)	1.19E+00
INORGANICS				
ARSENIC	2.22E-03	2.5	(b)	8.87E-04
CADMIUM	6.26E-02	1.45	(b)	4.32E-02
CHROMIUM	1.96E-02	1	(b)	1.96E-02
COPPER	9.88E-02	47	(b)	2.10E-03
LEAD	7.51E-01	1.13	(b)	6.65E-01
ZINC	3.06E+00	14.5	(b)	2.11E-01
		HI =		5.6

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-76
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Cardinal

AOC FS-17
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
VOLATILE ORGANICS				
ETHYL BENZENE	1.82E-02	0.473	(a)	3.85E-02
TOLUENE	1.55E-02	0.197	(a)	7.85E-02
TOTAL XYLENES	1.30E-01	1.87	(a)	6.93E-02
SEMI-VOLATILE ORGANICS				
2-METHYLNAPHTHALENE	1.88E-01	5	(a)	3.76E-02
BENZO(B)FLUORANTHENE	3.02E-04	0.1	(a)	3.02E-03
BENZO(K)FLUORANTHENE	3.02E-04	0.1	(a)	3.02E-03
FLUORENE	9.85E-03	1.25	(a)	7.88E-03
NAPHTHALENE	1.20E-01	0.3	(a)	3.99E-01
PHENANTHRENE	6.30E-03	0.1	(a)	6.30E-02
PESTICIDES/PCBs				
4, 4' DDT	2.82E-03	0.003	(b)	9.39E-01
INORGANICS				
ARSENIC	1.59E-03	2.5	(b)	6.34E-04
CADMIUM	3.09E-02	1.45	(b)	2.13E-02
CHROMIUM	9.80E-03	1	(b)	9.80E-03
COPPER	5.31E-02	47	(b)	1.13E-03
LEAD	2.24E-01	1.13	(b)	1.98E-01
ZINC	9.99E-01	14.5	(b)	6.89E-02
		HI =		1.9

(a) values obtained from Table 0-1D of the RAH.
(b) values obtained from Suter et al. 1996

Table 2-77
Terrestrial Vegetation Risk Characterization
MMR Maximum Background Soil Concentrations

AOC FS-17
Massachusetts Military Reservation

COC	MMR Site-Specific Background Maximum** (mg/kg)	Benchmark	Critical Soil Concentration (mg/kg)	HQ
INORGANICS				
ARSENIC*	3.6	PV	5	7.20E-01
CADMIUM*	1.5	PV	5	3.00E-01
CHROMIUM*	6.8	PV	5	1.36E+00
COPPER*	5.2	PV	20	2.60E-01
LEAD*	12.05	PV	30	4.02E-01
MANGANESE*	124	PV	300	4.02E-01
ZINC*	16	PV	100	1.60E-01

COC = contaminant of concern
HQ = hazard quotient
HI = hazard index
PV = Phytotoxicity Value. MMR Risk Assessment Handbook
Table O-3 or Table O-4.
*Phytotoxicity value given as a range. Risk was calculated using lowest value
**MMR Risk Assessment Handbook, Table E-1. Summary statistics for inorganic concentrations from selected background surface soil samples.
Automated Sciences Group, Inc. 1994.

Table 2-78
Aquatic Risk Characterization
MMR Maximum Background Groundwater Concentrations

AOC FS-17
Massachusetts Military Reservation

COC	Maximum Detected Concentration Total (ug/L)	Maximum Detected Concentration Dissolved (ug/L)	Aquatic Benchmark Value(a) (ug/L)	HQ Total	HQ Dissolved
INORGANICS					
ALUMINUM	312	259	87	3.6E+00	3.0E+00
CADMIUM	2.5(b)	2.5(b)	0.24	1.0E+01	1.0E+01
CHROMIUM	17	5(b)	11	1.5E+00	4.5E-01
COPPER	12.5(b)	12.5(b)	2.2	5.7E+00	5.7E+00
IRON	471	422	1000	4.7E-01	4.2E-01
LEAD	2.9	2	0.26	1.1E+01	7.7E+00
ZINC	66.9	73.5	47	1.4E+00	1.6E+00

Notes:
(a)All values obtained from MMR Risk Assessment Handbook Table O-2 with the exception of aluminum. Values for aluminum are from federal Ambient Water Quality Criteria (AWQC) and Guidelines (USEPA, 1992) Aluminum is pH dependent criterion, a pH of 7.8 was assumed. Cadmium, copper, lead, nickel, and zinc water hardness value of 14 mg CaCO3/L was assumed, and AWQC hardness equation was used to derive benchmark values. Value for iron is based on aesthetics in surface water. Value for chromium VI was used.
(b) A value of 1/2 the SQL was substituted for nondetect values.

Table 2-79
Selection of COCs for Surface Soils - Human Health

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 0.000001 (cancer)	MMR RISK CONCENTRATION (2) HQ=0.2 (non-cancer)	COC
Volatile Organics											
Methylene Chloride	mg/kg	1	3	0.001	0.001	0.0027*	NA	NA	8.54E+01	9.32E+02	
Acetone	mg/kg	1	3	0.005	0.005	0.0055*	NA	NA	--	5.49E+03	
Chloroform	mg/kg	2	3	0.001	0.001	0.001	NA	NA	4.29E-01	5.49E+02	
Toluene	mg/kg	2	3	0.001	0.002	0.003*	NA	NA	--	5.93E+02	
Total Xylenes	mg/kg	1	3	0.003	0.003	0.005*	NA	NA	--	1.10E+05	
Semi-Volatile Organics											
Naphthalene	mg/kg	1	3	0.029	0.029	0.14*	NA	NA	--	2.20E+03	
2-methylnaphthalene	mg/kg	1	3	0.038	0.038	0.14*	NA	NA	--	--	YES
Acenaphthylene	mg/kg	1	3	0.022	0.022	0.13*	NA	NA	--	2.20E+03	
Phenanthrene	mg/kg	3	3	0.035	0.11	0.082	NA	NA	--	2.20E+03	
Anthracene	mg/kg	1	3	0.011	0.011	0.13*	NA	NA	--	1.65E+04	
Di-n-butylphthalate	mg/kg	2	3	0.012	0.02	0.079*	NA	NA	--	5.49E+03	
Fluoranthene	mg/kg	3	3	0.038	0.17	0.11	NA	NA	--	2.20E+03	
Pyrene	mg/kg	3	3	0.035	0.13	0.089	NA	NA	--	1.65E+03	
Benzo(a)anthracene	mg/kg	2	3	0.042	0.064	0.051	NA	NA	8.77E-01	--	
Chrysene	mg/kg	3	3	0.036	0.089	0.062	NA	NA	8.77E+01	--	
Benzo(b)fluoranthene	mg/kg	3	3	0.046	0.16	0.11	NA	NA	8.77E-01	--	
Benzo(k)fluoranthene	mg/kg	3	3	0.046	0.16	0.11	NA	NA	8.75E+00	--	
Benzo(a)pyrene	mg/kg	3	3	0.017	0.065	0.048	NA	NA	8.77E-02	--	
Indeno(1,2,3-cd)pyrene	mg/kg	3	3	0.024	0.049	0.039	NA	NA	8.77E-01	--	
Dibenz(a,h)anthracene	mg/kg	1	3	0.029	0.029	0.14*	NA	NA	8.77E-02	--	
Benzo(g,h,i)perylene	mg/kg	3	3	0.022	0.045	0.034	NA	NA	--	2.20E+03	

Table 2-79 (cont.)
Selection of COCs for Surface Soils - Human Health

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 0.000001 (cancer)	MMR RISK CONCENTRATION (2) HQ=0.2 (non-cancer)	COC
Pesticides/PCBs											
Dieldrin	mg/kg	3	3	0.018	0.12	0.07	NA	NA	1.33E-01	9.15E+00	
4,4'-DDE	mg/kg	3	3	0.011	0.11	0.055	NA	NA	6.28E+00	1.28E+02	
4,4'-DDD	mg/kg	2	3	0.012	0.019	0.011	NA	NA	8.89E+00	5.49E+02	
4,4'-DDT	mg/kg	3	3	0.027	0.93	0.41	NA	NA	6.28E+00	9.15E+01	
Methoxychlor	mg/kg	2	3	0.016	0.034	0.025	NA	NA	--	9.15E+02	
Endrin Ketone	mg/kg	2	3	0.017	0.032	0.021	NA	NA	--	--	YES
Alpha-chlordane	mg/kg	1	3	0.0013	0.0013	0.0012	NA	NA	1.64E+00	1.10E+01	
Gamma-chlordane	mg/kg	2	3	0.0019	0.003	0.0022	NA	NA	1.64E+00	1.10E+01	
Aroclor-1260	mg/kg	2	3	0.26	0.54	0.27	NA	NA	1.58E-01	--	YES
Inorganic Analytes											
Aluminum	mg/kg	3	3	7590	13800	9680	1146	8930	--	5.49E+04	
Arsenic	mg/kg	3	3	2.9	4.8	3.6	0.15	3.6	3.66E-01	1.65E+01	YES
Barium	mg/kg	3	3	15.7	57.9	30	2	10.4	--	3.80E+03	
Beryllium	mg/kg	2	3	0.28	0.39	0.27	0.1	0.65	1.49E-01	2.74E+02	YES
Cadmium	mg/kg	2	3	0.45	1.1	0.78	0.4	1.5	--	2.64E+01	
Calcium	mg/kg	3	3	356	1280	693	26	969	--	--	**
Chromium	mg/kg	3	3	6.6	11.5	8.8	0.8	6.8	6.57E+02	2.74E+02	
Cobalt	mg/kg	3	3	1.5	3.2	2.6	0.5	4.1	--	--	YES
Iron	mg/kg	3	3	9340	13900	11033	2050	12400	--	--	**
Lead	mg/kg	3	3	29.9	119	63	1.3	12.05	--	3.00E+02	YES
Magnesium	mg/kg	3	3	633	1300	988	176	794.5	--	--	**
Manganese	mg/kg	3	3	43.3	92	72	16	108	--	2.74E+02	
Nickel	mg/kg	3	3	4	6	5.1	1.05	5.2	3.21E+04	1.10E+03	
Potassium	mg/kg	3	3	370	717	526	76	551	--	--	**
Vanadium	mg/kg	3	3	13.4	22.5	19	1.13	15.2	--	3.84E+02	
Zinc	mg/kg	3	3	21.6	68	43	3.05	16	--	1.65E+04	
Cyanide	mg/kg	1	3	0.1	0.1	0.053	0.185	0.7	--	1.10E+03	

NOTES:

1. MMR Final Risk Assessment Handbook. Table E-1. Summary Statistics for Inorganic Concentrations Selected Background Surface Soil Samples. Automated Sciences Group, Inc. September 1994.
2. MMR Final Risk Assessment Handbook. Table F-1. Human Health PRE, Risk/Hazard-Equivalent Concentrations for Soils. Automated Sciences Group, Inc. September 1994.

Tier 1 - Outside Flight Line.
* The average concentration exceeds the maximum concentration due to values of one-half the detection limit exceeding the maximum concentration.
-- No risk-based concentration available for this compound.
NA Not Applicable.
** - Calcium, iron, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.

TABLE 2-80
SELECTION OF COCs FOR TEST BORING SUBSURFACE SOILS - HUMAN HEALTH

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (Cancer)	MMR RISK CONCENTRATION (2) HQ = 0.2 (Noncancer)	COC
Volatile Organics											
Acetone	mg/kg	3	6	0.095	0.16	0.099	NA	NA	--	5.49E+03	
2-Butanone	mg/kg	3	6	0.004	0.008	0.0053	NA	NA	--	9.26E+02	
Toluene	mg/kg	1	6	0.003	0.003	0.0046*	NA	NA	--	5.93E+02	
Total Xylenes	mg/kg	2	6	0.004	0.011	0.006	NA	NA	--	1.10E+05	
Semi-Volatile Organics											
Not Detected											
Petroleum Products											
Not Detected											
Pesticides/PCBs											
4,4'-DDT	mg/kg	3	6	0.0034	0.0062	0.0033	NA	NA	6.28E+00	9.15E+01	
Inorganic Analytes											
Aluminum	mg/kg	3	3	982	1170	1094	203.5	1980	--	5.49E+04	
Antimony	mg/kg	1	3	2.7	2.7	1.7	2.25	21.7	--	2.20E+01	
Arsenic	mg/kg	3	3	0.95	2.4	1.5	0.23	2.3	3.66E-01	1.65E+01	
Barium	mg/kg	3	3	2.6	4.9	3.8	0.95	14.7	--	3.80E+03	
Calcium	mg/kg	3	3	60.8	119	96	22.8	933	--	--	**
Chromium	mg/kg	3	3	1.6	3.2	2.1	0.95	3.9	6.57E+02	2.74E+02	
Cobalt	mg/kg	2	3	0.92	1.1	0.81	0.5	2.6	--	--	YES
Copper	mg/kg	3	3	0.65	1.2	0.9	0.3	4.3	--	--	YES
Iron	mg/kg	3	3	220	3030	1870	672	2600	--	--	**
Lead	mg/kg	3	3	1.4	2.3	1.9	0.12	3.7	--	3.00E+02	
Magnesium	mg/kg	3	3	301	412	340	34	742	--	--	**
Manganese	mg/kg	3	3	23	58.1	39	4.55	587	--	2.74E+02	
Nickel	mg/kg	3	3	1.4	2.1	1.6	0.75	3.9	3.21E+04	1.10E+03	
Potassium	mg/kg	3	3	137	238	192	95.5	437	--	--	**
Silver	mg/kg	1	3	0.37	0.37	0.26	0.3	1.1	--	2.74E+02	
Sodium	mg/kg	3	3	135	169	156	10.15	339.5	--	--	**
Vanadium	mg/kg	3	3	3.9	4.8	4.3	0.6	5.7	--	3.84E+02	
Zinc	mg/kg	3	3	4.1	5.6	5.1	1.9	16	--	1.65E+04	

NOTES:

1. MMR Final Risk Assessment Handbook. Table E-2. Summary Statistics for Inorganic Concentrations Selected Background Subsurface Soil Samples. Automated Sciences Group, Inc. September 1994.
2. MMR Final Risk Assessment Handbook. Table F-1. Human Health PRE Risk/Hazard-Equivalent Concentrations for Soils. Automated Sciences Group, Inc. September 1994. Tier I - Outside Flight Line

* The average concentration exceeds the maximum concentration due to values of one-half the detection limit exceeding the maximum concentration.

NA Not Applicable

-- No risk-based concentration available for the compound.

** - Calcium, iron, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.

Table 2-81
Selection of COCs for Groundwater - Human Health
AOC FS-19 RI Study Area
Massachusetts Military Reservation

	Units	Detects	Samples	CONCENTRATION Minimum	CONCENTRATION Maximum	CONCENTRATION Average	MMR SITE-SPECIFIC BACKGROUND Minimum	MMR SITE-SPECIFIC BACKGROUND Maximum	MMR RISK CONCENTRATION (1) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (1) HQ=0.2 (non-cancer)	COPC
Volatile Organics											
1,1,1-Trichloroethane	mg/l	1	5	0.0016	0.0016	0.0004	NA	NA	--	5.57E-01	
Benzene	mg/l	1	5	0.0007	0.0007	0.0002	NA	NA	6.12E-04	--	YES
Toluene	mg/l	3	5	0.0004	0.0076	0.0002	NA	NA	--	1.91E-01	
Ethylbenzene	mg/l	2	5	0.0006	0.0026	0.0007	NA	NA	--	2.99E-01	
M/P-Xylene	mg/l	2	5	0.0029	0.012	0.0003	NA	NA	--	1.29E+01	
O-Xylene	mg/l	2	5	0.001	0.0051	0.0013	NA	NA	--	1.29E+01	
1,3,5-Trimethylbenzene	mg/l	1	5	0.0012	0.0012	0.00036	NA	NA	--	--	YES
1,2,4-Trimethylbenzene	mg/l	2	5	0.0012	0.0038	0.001	NA	NA	--	--	YES
SVOCs											
Bis(2-ethylhexyl)phthalate	mg/l	1	5	0.013	0.013	0.0046	NA	NA	5.11E-03	1.23E-01	YES
Pesticides/PCBs											
None Detected											
Petroleum Products											
TPH	mg/l	5	5	0.001	12	0.78	NA	NA	--	--	
Inorganics (Total Concentrations)											
Aluminum	mg/l	5	5	0.856	15.1	5.2	0.0674	0.312	--	7.30E+00	YES
Arsenic	mg/l	1	5	0.0048	0.0048	0.0018	0.0015	0.002	4.87E-05	2.19E-03	YES
Barium	mg/l	5	5	0.029	0.136	0.07	0.0025	0.0948	--	5.1E-01	
Beryllium	mg/l	1	5	0.0012	0.0012	0.00064	0.005	0.0015	1.98E-05	3.65E-02	YES
Calcium	mg/l	5	5	3.45	10.2	5.8	1.38	6.77	--	--	**
Chromium	mg/l	2	5	0.0091	0.021	0.0077	0.003	0.0174	--	3.65E-02	
Cobalt	mg/l	1	5	0.014	0.014	0.0044	0.0045	0.006	--	--	YES
Copper	mg/l	3	5	0.0047	0.0137	0.0054	0.002	0.0125	--	--	YES
Iron	mg/l	5	5	0.94	19.3	6.2	0.017	0.471	--	--	YES (3)
Lead	mg/l	2	5	0.0024	0.0185	0.0045	0.001	0.0029	--	1.50E-02	YES
Magnesium	mg/l	5	5	2.98	6.1	4.2	1.06	4.93	--	--	**
Manganese	mg/l	5	5	0.031	0.465	0.016	0.001	0.109	--	3.65E-02	YES
Nickel	mg/l	5	5	0.0091	0.022	0.008	0.0055	0.019	--	1.46E-01	
Potassium	mg/l	5	5	1.29	4.18	2.4	0.68	1.975	--	--	**
Sodium	mg/l	5	5	7.04	29.5	19	2.9	22.6	--	--	**
Vanadium	mg/l	3	5	0.0092	0.0244	0.008	0.002	0.0075	--	5.11E-02	
Zinc	mg/l	3	5	0.017	0.0589	0.022	0.0032	0.0669	--	2.19E+00	

Table 2-81 (cont.)
Selection of COCs for Groundwater - Human Health

AOC FS-19 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM	MMR RISK CONCENTRATION (2) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (2) HQ=0.2 (non-cancer)	COC
Inorganics (Dissolved Concentrations)											
Aluminum	mg/l	1	5	0.155	0.155	0.076	0.07	0.259	--	7.30E+00	
Antimony	mg/l	5	5	0.0023	0.0055	0.0043	0.026	0.03	--	2.92E-03	YES
Barium	mg/l	3	5	0.023	0.117	0.036	0.0015	0.1	--	5.11E-01	
Cadmium	mg/l	1	5	0.00022	0.00022	0.00012	0.0025	0.0025	--	3.65E-03	
Calcium	mg/l	5	5	3.04	10.9	5.8	1.21	6.61	--	--	**
Lead	mg/l	1	5	0.0013	0.0013	0.00066	0.001	0.002	--	1.50E-02	
Magnesium	mg/l	5	5	2.1	4.31	2.9	1.13	4.89	--	--	**
Manganese	mg/l	5	5	0.0061	0.0403	0.015	0.001	0.103	--	3.65E-02	YES
Nickel	mg/l	1	5	0.0052	0.0052	0.0026	0.0055	0.019	--	1.46E-01	
Potassium	mg/l	5	5	1.18	1.87	1.4	0.68	1.975	--	--	**
Sodium	mg/l	5	5	6.58	32.5	20	2.96	22.4	--	--	**
Zinc	mg/l	2	5	0.012	0.0362	0.011	0.0034	0.0735	--	2.19E+00	

Notes:
1. MMR Background Inorganics Study. HAZWRAP. January 1994.
Tasks 2-3A, 2-3B, 2-4 and 2-5. Automated Sciences Group, Inc. September 1994.
2. MMR Final Risk Assessment Handbook. Table F-3. Human Health PRE Risk/Hazard-Equivalent Concentrations for Groundwater.
Automated Sciences Group, Inc. September 1994. Tier 1 - Outside Flightline.
3. Iron was selected as a COC based on exceedance of MMR background.
-- No risk-based concentration available for this compound.
NA Not Applicable
** - Calcium, iron, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.

Table 2-82
Identification of COPCs for Surface Water - Human Health
Based on Groundwater Concentrations
Total Inorganics Concentrations
AOC FS-19 RI Study Area
Masachusetts Military Reservation

	Units	Detects	Samples	CONCENTRATION Minimum	CONCENTRATION Maximum	Average	MMR RISK CONCENTRATION (1) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (1) HQ=0.2 (non-cancer)	COPC
Volatile Organics									
1,1,1-Trichloroethane	mg/l	1	5	0.0016	0.0016	0.0004	--	--	YES
Benzene	mg/l	1	5	0.0007	0.0007	0.0002	1.26E-02	--	
Toluene	mg/l	3	5	0.0004	0.0076	0.0002	--	3.69E-01	
Ethylbenzene	mg/l	2	5	0.0006	0.0026	0.0007	--	1.08E-01	
M/P-Xylene	mg/l	2	5	0.0029	0.012	0.0003	--	1.80E+00	
O-Xylene	mg/l	2	5	0.001	0.0051	0.0013	--	1.80E+00	
1,3,5-Trimethylbenzene	mg/l	1	5	0.0012	0.0012	0.00036	--	--	YES
1,2,4-Trimethylbenzene	mg/l	2	5	0.0012	0.0038	0.001	--	--	YES
SVOCs									
Bis(2-ethylhexyl)phthalate	mg/l	1	5	0.013	0.013	0.0046	1.33E-02	3.20E-05	YES
Pesticides/PCBs									
None Detected									
Petroleum Products									
TPH	mg/l	5	5	0.001	12	0.78	NA	NA	
Inorganics (Total Concentrations)									
Aluminum	mg/l	5	5	0.856	15.1	5.2	--	1.72E+01	
Arsenic	mg/l	1	5	0.0048	0.0048	0.0018	3.74E-02	1.85E-04	YES
Barium	mg/l	5	5	0.029	0.136	0.07	--	3.0E+00	
Beryllium	mg/l	1	5	0.0012	0.0012	0.00064	1.52E-02	4.55E-02	
Calcium	mg/l	5	5	3.45	10.2	5.8	--	--	**
Chromium	mg/l	2	5	0.0091	0.021	0.0077	--	4.32E-03	YES
Cobalt	mg/l	1	5	0.014	0.014	0.0044	--	--	YES
Copper	mg/l	3	5	0.0047	0.0137	0.0054	--	--	YES
Iron	mg/l	5	5	0.94	19.3	6.2	--	--	**
Lead	mg/l	2	5	0.0024	0.0185	0.0045	--	--	YES
Magnesium	mg/l	5	5	2.98	6.1	4.2	--	--	**
Manganese	mg/l	5	5	0.031	0.465	0.016	--	2.47E-06	YES
Nickel	mg/l	5	5	0.0091	0.022	0.008	--	3.26E-02	
Potassium	mg/l	5	5	1.29	4.18	2.4	--	--	**
Sodium	mg/l	5	5	7.04	29.5	19	--	--	**
Vanadium	mg/l	3	5	0.0092	0.0244	0.008	--	1.21E-01	
Zinc	mg/l	3	5	0.017	0.0589	0.022	--	5.38E-02	YES

Table 2-82 (cont)
Identification of COPCs for Surface Water - Human Health
Based on Groundwater Concentrations
AOC FS-19 RI Study Area
Massachusetts Military Reservation

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR RISK CONCENTRATION (1) 1.0E-06 (cancer)	MMR RISK CONCENTRATION (1) HQ = 0.2 (non-cancer)	COPC
Inorganics (Dissolved Concentrations)									
Aluminum	mg/l	1	5	0.155	0.155	0.076	--	1.72E+01	
Antimony	mg/l	5	5	0.0023	0.0055	0.0043	--	7.43E-02	
Barium	mg/l	3	5	0.023	0.117	0.036	--	3.00E+00	
Cadimum	mg/l	1	5	0.00022	0.00022	0.00012	--	1.16E-05	YES
Calcium	mg/l	5	5	3.04	10.9	5.8	--	--	**
Lead	mg/l	1	5	0.0013	0.0013	0.00066	--	--	YES
Magnesium	mg/l	5	5	2.1	4.31	2.9	--	--	**
Manganese	mg/l	5	5	0.0061	0.0403	0.015	--	2.47E-06	YES
Nickel	mg/l	1	5	0.0052	0.0052	0.0026	--	3.26E-02	
Potassium	mg/l	5	5	1.18	1.87	1.4	--	--	**
Sodium	mg/l	5	5	6.58	32.5	20	--	--	**
Zinc	mg/l	2	5	0.012	0.0362	0.011	--	5.38E-02	

Notes:
1. MMR Final Risk Assessment Handbook. Table F-4. Human Health and Ecological RRE, Summary for Surface Water Risk Hazard-Equivalent Concentrations. Automated Sciences Group, Inc. September 1994. Tier 1 - Human Health Evaluation.

-- No risk-based concentration available for this compound.

** - Calcium, iron, magnesium, potassium, and sodium are considered as essential macronutrients for human health and are excluded as COCs.

Table 2-83
Exposure Scenarios, Exposure Equations, and Exposure Assumptions Used to Estimate Human Health Risks

AOC FS-19
Massachusetts Military Reservation

Exposure Scenarios Evaluated for AOC FS-17

Land Use	Exposure Scenario	Media Evaluated
Current	Utility Worker	Soil
	Child Trespasser	Soil
Future	Utility Worker	Soil
	Child Trespasser	Soil
	Adult Resident	Soil & Groundwater
	Child Resident	Soil & Groundwater

Soil Dose/Risk Equation: Ingestion; Inhalation; Dermal Contact

$$\text{Risk/HQ} = \frac{C \times ED \times ((TFo \times 1E\text{-}06 kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times (1/VF + 1/PEF)) + (TFo \times 1E\text{-}06 kg/mg \times SA \times AF \times ABSderm \times EF))}{BW \times AT \times 365\ d/yr}$$

Groundwater Dose/Risk Equations: Ingestion; Inhalation; Dermal Contact

$$\text{Risk/HQ} = \frac{C \times ED \times ((EF \times TF1 \times VF \times IRair) + (EFo \times TFo \times SA \times PC \times CF1 \times CF2) + (TFo \times EF \times IRw)}{BW \times AT \times 365\ d/yr}$$

Exposure Assumptions and Parameters

			Current and Future Use		Futue Use	
					Residential	
Parameters	Definition	Units	Utility Worker	Child Trespasser	Child	Adult
C	Concentration (mean or maximum as appropriate)	Soil = mg/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ED	Exposure duration	years	1	6	6	24
EF	Exposure frequency	days/year	42 (Current land use) 183 (Future land use)	52 (Current and future land use)	350	350
TFo	Ingestion slope factor or RfD	$(mg/kg\text{-}d)^{-1}$	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
TF1	Inhalation slope factor or RfD	(mg/kg-d)-1	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
IRsoil	Intake rate for soil	mg/d	480	100	200	100
IRair	Inhalation rate	m^3/day	20	20	20	20
ABSing	Ingestion absorption factor	Unitless	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
ABSderm	Dermal absorption factor	Unitless	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
VF	Volatilization Factor	m^3/kg	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
PEF	Particulate Emission Factor	m^3/kg	4.63E-09	4.63E-09	4.63E-09	4.63E-09
SA	Skin surface area	cm^2	3120	1000	1000	1000
AF	adherance factor	mg/cm^2	1	1	1	1
PC	Dermal permiability	cm/h	Chemical Specific	Chemical Specific	Chemical Specific	Chemical Specific
CF1	Conversion factor	L/cm^3	na	na	na	0.001
CF2	Conversion factor	h/d	na	na	na	24
IRw	Intake rate of water	L/d				2
BW	Body weight	kg	70	36.2	15	70
AT	Averaging time	years	70	70	70	70

Table 2-84
Reference Doses (RFDs) and Cancer Slope Factors (CSFs)
For Site Contaminants of Concern

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

CONTAMINANT	INGESTION CSF (mg/kg/day)-1	INGESTION RFD (mg/kg/day)	INHALATION CSF (mg/kg/day)-1	INHALATION RFD (mg/kg/day)
Benzene	2.90E-02	NA	2.9E-02	1.71E-03 (3)
1,1,1-Trichloroethane	NA	NA	NA	NA
1,2,4-Trimethylbenzene	NA	5.0E-04 (3)	NA	NA
1,3,5-Trimethylbenzene	NA	4.0E-04 (3)	NA	NA
Bis(2-ethylhexyl)phthalate	1.40E-02 (1)	2.0E-02 (1)	NA	NA
2-Methylnaphthalene	NA	NA	NA	NA
Aroclor-1260	7.70E+00 (1)	NA	NA	NA
Endrin Ketone	NA	NA	NA	NA
Aluminum	NA	1.00E+00 (3)	NA	NA
Antimony	NA	4.0E-04 (1,4)	NA	NA
Arsenic	1.75E+00 (1)	3.0E-04 (1,4)	1.51E+01 (1)	NA
Beryllium	4.30E+00 (1)	5.0E-03 (1,4)	8.4E+00 (1)	NA
Chromium	NA	1.0E+00 (+III) (1,4)	4.2E+01 (+VI) (2)	NA
Cobalt	NA	NA	NA	NA
Copper	NA	NA	NA	NA
Iron	NA	NA	NA	NA
Lead	NA	NA	NA	NA
Manganese	NA	5.0E-03 (water) (1,4) 1.4E-01 (food) (1,4)	NA	1.43E-05 (1,4)
Zinc	NA	3.00E-01 (1)	NA	NA

NOTES:
1 - Integrated Risk Information System, on line April 1995.
2 - Health Effects Assessment Summary Tables, U.S. Environmental Protection Agency, Annual Update, March 1994.
3 - Interim RFD. EPA Environmental Criteria and Assessment Office (ECAO).
4 - The chronic oral/inhalation RFD was adopted as the subchronic oral/inhalation RFD.

Table 2-85
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Current and Future Use
Maximum Soil Concentrations
FS-19 RI Study Area

Ingestion **Inhalation** **Dermal**

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0.038	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0.54	70	70	1	480	42	3120	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	1.41E-08	0.00E+00	1.83E-08	**3.23E-08**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
ENDRIN KETONE	0.032	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	4.8	70	70	1	480	42	3120	1.75E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	9.47E-08	1.08E-11	0.00E+00	**9.47E-08**	1.26E-02	0.00E+00	0.00E+00	**1.26E-02**
BERYLLIUM	0.39	70	70	1	480	42	3120	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	1.89E-08	4.86E-13	0.00E+00	**1.89E-08**	6.15E-05	0.00E+00	0.00E+00	**6.15E-05**
COBALT	3.2	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
LEAD	119	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	1.28E-07	**1.12E-11**	**1.83E-08**	**1.46E-07**	**1.27E-02**	**0.00E+00**	**0.00E+00**	**1.27E-02**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration - days of year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency
SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor
IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = soil-to-air particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-86
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Utility Workers, Current and Future Use
Mean Soil Concentrations
FS-19 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: TFo, IRsoil, ABSing; Inhalation: TF1, IRair, VF, PEF; Dermal: SA, AF, ABSderm)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0 038	70	70	1	480	42	3120	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0.27	70	70	1	480	42	3120	7 70E+00	NA	NA	NA	1 0	0 06	0 3	20	1 00E+10	4 63E+09	7 03E-09	0 00E+00	9 14E-09	**1.62E-08**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
ENDRIN KETONE	0 021	70	70	1	480	42	3120	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4.63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	3 6	70	70	1	480	42	3120	1 75E+00	3 33E+03	1 51E+01	NA	1 0	0	1	20	1 00E+10	4 63E+09	7 10E-08	8 07E-12	0 00E+00	**7.10E-08**	9 47E-03	0 00E+00	0 00E+00	**9.47E-03**
BERYLLIUM	0 27	70	70	1	480	42	3120	4 30E+00	2 00E+02	8 40E+00	NA	1 0	0	1	20	1 00E+10	4.63E+09	1 31E-08	3.37E-13	0.00E+00	**1.31E-08**	4.26E-05	0 00E+00	0 00E+00	**4.26E-05**
COBALT	2 6	70	70	1	480	42	3120	NA	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0.00E+00	**0.00E+00**
LEAD	63	70	70	1	480	42	3120	NA	NA	NA	NA	1.0	0	0 3	20	1.00E+10	4 63E+09	0.00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration - days of year receptor is exposed
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = soil-to-air particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	9.11E-08	**8.40E-12**	**9.14E-09**	**1.00E-07**	**9.51E-03**	**0.00E+00**	**0.00E+00**	**9.51E-03**

Table 2-87
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation, and Dermal Pathways
Child Trespasser, Current and Future Use
Maximum Concentrations
FS-19 RI Study Area

Risk/HQ =

$$\frac{\text{C x ED x } \{(\text{TFo x } 10\text{-}6 \text{ kg/mg x IRsoil x ABSing x EF}) + (\text{TF1 x IRair x EF x } [1/\text{VF} + 1/\text{PEF}]) + (\text{TFo x } 10\text{-}6 \text{ kg/mg x SA x AF x ABSderm x EF})\}}{\text{BW x AT x 365 days/yr}}$$

(Ingestion: TFo, IRsoil, ABSing; Inhalation: TF1, IRair, VF, PEF; Dermal: TFo, SA, AF, ABSderm)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0 038	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0 54	36 2	70	6	100	52	1000	7 70E+00	NA	NA	NA	1 0	0 06	0 3	20	1 00E+10	4 63E+09	4 21E-08	0 00E+00	8 42E-08	**1.26E-07**	0 00E+00	0 00E+00	0 00E+00	**0 00E+00**
ENDRIN KETONE	0 032	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0 00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	4 8	36 2	70	6	100	52	1000	1 75E+00	3 33E+03	1 51E+01	NA	1 0	0	1	20	1 00E+10	4 63E+09	2 83E-07	1 55E-10	0 00E+00	**2.84E-07**	6 30E-03	0 00E+00	0 00E+00	**6.30E-03**
BERYLLIUM	0 39	36 2	70	6	100	52	1000	4 30E+00	2 00E+02	8 40E+00	NA	1 0	0	1	20	1 00E+10	4 63E+09	5 66E-08	6 98E-12	0 00E+00	**5.66E-08**	3 07E-05	0 00E+00	0 00E+00	**3.07E-05**
COBALT	3 2	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	1	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
LEAD	119	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	3.82E-07	1.61E-10	8.42E-08	4.66E-07	6.33E-03	0.00E+00	0.00E+00	6 33E-03

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (equal to ED for noncarcinogens)
ED =exposure duration
IRsoil =soil ingestion rate
EF = exposure frequency
SA = skin surface area available for contact

TFO = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = soil to skin adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption rate
IRair = inhalation rate

VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-88
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation, and Dermal Pathways
Child Trespasser, Current and Future Use
Mean Concentrations
FS-19 RI Study Area

$$\text{Risk/HQ} = \frac{\overbrace{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)}^{\text{Ingestion}} + \overbrace{(TF1 \times IRair \times EF \times [1/VF + 1/PEF])}^{\text{Inhalation}} + \overbrace{(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)}^{\text{Dermal}}\}}{BW \times AT \times 365\ days/yr}$$

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0.038	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0.00E+00	0 00E+00	0 00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0 27	36 2	70	6	100	52	1000	7 70E+00	NA	NA	NA	1 0	0.06	0 3	20	1.00E+10	4.63E+09	2.10E-08	0 00E+00	4 21E-08	**6.31E-08**	0 00E+00	0.00E+00	0 00E+00	**0.00E+00**
ENDRIN KETONE	0 021	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0.00E+00	0.00E+00	0 00E+00	**0.00E+00**	0.00E+00	0 00E+00	0 00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	3 6	36 2	70	6	100	52	1000	1 75E+00	3 33E+03	1.51E+01	NA	1 0	0	1	20	1 00E+10	4 63E+09	2 13E-07	1.16E-10	0 00E+00	**2.13E-07**	4 72E-03	0.00E+00	0 00E+00	**4.72E-03**
BERYLLIUM	0.27	36 2	70	6	100	52	1000	4 30E+00	2 00E+02	8 40E+00	NA	1.0	0	1	20	1 00E+10	4.63E+09	3.92E-08	4.83E-12	0 00E+00	**3.92E-08**	2.13E-05	0 00E+00	0 00E+00	**2.13E-05**
COBALT	2 6	36 2	70	6	100	52	1000	NA	NA	NA	NA	1 0	0	1	20	1.00E+10	4.63E+09	0 00E+00	0 00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0 00E+00	**0.00E+00**
LEAD	63	36 2	70	6	100	52	1000	NA	NA	NA	NA	1.0	0	0 3	20	1 00E+10	4.63E+09	0 00E+00	0 00E+00	0.00E+00	**0.00E+00**	0.00E+00	0 00E+00	0 00E+00	**0.00E+00**

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	2.73E-07	**1.21E-10**	**4.21E-08**	**3.15E-07**	**4.74E-03**	**0.00E+00**	**0.00E+00**	**4.74E-03**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (equal to ED for noncarcinogens)
ED =exposure duration
IRsoil =soil ingestion rate
EF = exposure frequency
SA = skin surface area available for contact

TF0 = ingestion slope factor for carcinogens or
1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or
1/inhalation reference dose for noncarcinogens
AF = soil to skin adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption rate
IRair = inhalation rate

VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-89
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Dermal and Inhalation Pathways
Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone)
Maximum Concentrations
FS-19 RI Study Area

Ingestion **Inhalation** **Dermal**

Risk/HQ = C x ED x {(TFo x 10-6 kg/mg x IRsoil x ABSing x EF) + (TF1 x IRair x EF x [1/VF + 1/PEF]) + (TFo x 10-6 kg/mg x SA x AF x ABSderm x EF)}
BW x AT x 365 days/yr

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0 038	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0.54	15	70	6	200	350	1000	7 70E+00	NA	NA	NA	1 0	0 06	0 3	20	1 00E+10	4 63E+09	1 37E-06	0 00E+00	1 37E-06	**2.73E-06**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
ENDRIN KETONE	0 032	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0.00E+00	0 00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	4.8	15	70	6	200	350	1000	1 75E+00	3 33E+03	1 51E+01	NA	1 0	0	1	20	1 00E+10	4 63E+09	9 21E-06	2 51E-09	0 00E+00	**9.21E-06**	2 05E-01	0 00E+00	0 00E+00	**2.05E-01**
BERYLLIUM	0 39	15	70	6	200	350	1000	4 30E+00	2 00E+02	8 40E+00	NA	1.0	0	1	20	1 00E+10	4 63E+09	1.84E-06	1 13E-10	0 00E+00	**1.84E-06**	9 97E-04	0 00E+00	0 00E+00	**9.97E-04**
COBALT	3 2	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	1	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
LEAD	119	15	70	6	200	350	1000	NA	NA	NA	NA	1.0	0	0 3	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**

	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
		1.24E-05	**2.62E-09**	**1.37E-06**	**1.38E-05**	**2.06E-01**	**0.00E+00**	**0.00E+00**	**2.06E-01**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-90
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Dermal and Inhalation Pathways
Residential (Child 1-6 years), Future Use, Onsite (Outside Security Zone)
Mean Concentrations
FS-19 RI Study Area

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

Ingestion — Inhalation — Dermal

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0 038	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 49E+05	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0.00E+00	0 00E+00	0 00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0 27	15	70	6	200	350	1000	7 70E+00	NA	NA	NA	1 0	0 06	0.3	20	1 00E+10	4 63E+09	6 84E-07	0 00E+00	6 84E-07	**1.37E-06**	0 00E+00	0 00E+00	0.00E+00	**0.00E+00**
ENDRIN KETONE	0 021	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4 63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	3 6	15	70	6	200	350	1000	1 75E+00	3 33E+03	1 51E+01	NA	1 0	0	1	20	1.00E+10	4.63E+09	6 90E-06	1 88E-09	0 00E+00	**6.91E-06**	1 53E-01	0 00E+00	0 00E+00	**1.53E-01**
BERYLLIUM	0.27	15	70	6	200	350	1000	4 30E+00	2 00E+02	8 40E+00	NA	1 0	0	1	20	1 00E+10	4 63E+09	1 27E-06	7.85E-11	0.00E+00	**1.27E-06**	6 90E-04	0 00E+00	0 00E+00	**6.90E-04**
COBALT	2 6	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	1	20	1 00E+10	4.63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
LEAD	63	15	70	6	200	350	1000	NA	NA	NA	NA	1 0	0	0 3	20	1 00E+10	4.63E+09	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**

	Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
		8.86E-06	**1.96E-09**	**6.84E-07**	**9.55E-06**	**1.54E-01**	**0.00E+00**	**0.00E+00**	**1.54E-01**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-91
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Residential (7 yrs.- Adult), Future Use, Onsite (Outside Security Zone)
Maximum Soil Concentrations

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: $(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF)$; Inhalation: $(TF1 \times IRair \times EF \times [1/VF + 1/PEF])$; Dermal: $(TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)$)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0.038	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0.54	70	70	24	100	350	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	5.86E-07	0.00E+00	1.17E-06	**1.76E-06**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
ENDRIN KETONE	0.032	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	4.8	70	70	24	100	350	1000	1.75E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	3.95E-06	2.15E-09	0.00E+00	**3.95E-06**	2.19E-02	0.00E+00	0.00E+00	**2.19E-02**
BERYLLIUM	0.39	70	70	24	100	350	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	7.88E-07	9.72E-11	0.00E+00	**7.88E-07**	1.07E-04	0.00E+00	0.00E+00	**1.07E-04**
COBALT	3.2	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
LEAD	119	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil-to-air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	5.32E-06	**2.25E-09**	**1.17E-06**	**6.49E-06**	**2.20E-02**	**0.00E+00**	**0.00E+00**	**2.20E-02**

Table 2-92
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Maximum Groundwater Concentrations - Total Inorganics

FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$\text{RISK/HQ} = \frac{C \times ED \times [(EF \times TF1 \times K \times IRair) + (EFs \times TFo \times SA \times PC \times CF1 \times CF2) + (TFo \times EF \times IRw)]}{BW \times AT \times 365\ \text{days/yr}}$$

(Inhalation: EF × TF1 × K × IRair; Dermal: EFs × TFo × SA × PC × CF1 × CF2; Ingestion: TFo × EF × IRw)

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Benzene	0.0007	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	2.90E-02	5.85E+02	2.90E-02	NA	2.48E-02	8.94E-07	1.14E-06	2.38E-07	1.14E-06	4.21E-02	0.00E+00	0.00E+00	4.21E-02
1,3,5-Trimethylbenzene	0.0012	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.22E-02	8.22E-02
1,2,4-Trimethylbenzene	0.0038	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.00E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.08E-01	2.08E-01
SVOCS																									
Bis(2-ethylhexyl)phthalate	0.013	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	1.40E-02	5.00E+01	9.83E-02	0.00E+00	4.05E-07	2.14E-06	2.54E-06	0.00E+00	3.38E-03	1.78E-02	2.12E-02
INORGANICS																									
Aluminum	15.1	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Arsenic	0.0048	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	1.51E+01	NA	1.75E+00	3.33E+03	0.00E+00	0.00E+00	0.00E+00	9.86E-05	9.86E-05	0.00E+00	0.00E+00	4.38E-01	4.38E-01
Beryllium	0.0012	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	8.40E+00	NA	4.30E+00	2.00E+02	0.00E+00	0.00E+00	0.00E+00	6.06E-05	6.06E-05	0.00E+00	0.00E+00	6.58E-03	6.58E-03
Cobalt	0.014	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Copper	0.0137	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iron	19.3	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Lead	0.0185	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	NA	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Manganese	0.465	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E+00	2.55E+00

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	8.94E-07	4.17E-07	1.62E-04	1.63E-04	4.21E-02	3.38E-03	3.30E+00	3.35E+00

Notes:
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair=daily indoor inhalation rate
K=volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor

EF = exposure frequency
EFs=showering frequency
SA = skin surface area exposed
TF1=inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI= hazard index

Table 2-93
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Maximum Groundwater Concentrations - Dissolved Inorganics

FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$\text{RISK/HQ} = \frac{C \times ED \times [\overbrace{(EF \times TF1 \times K \times IRdair)}^{\text{Inhalation}} + \overbrace{(EFs \times TFo \times SA \times PC \times CF1 \times CF2)}^{\text{Dermal}} + \overbrace{(TFo \times EF \times IRw)}^{\text{Ingestion}}]}{BW \times AT \times 365\ \text{days/yr}}$$

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	**Cancer Risk**	HQ Inhalation	HQ Dermal	HQ Ingestion	**HQ**
VOCs																									
Benzene	0 0007	70	70	30	15	0.5	2	0 001	24	350	2 9	1 94E+04	2 90E-02	5 85E+02	2 90E-02	NA	2 48E-02	8 94E-07	1 14E-08	2 38E-07	**1.14E-06**	4 21E-02	0 00E+00	0 00E+00	**4.21E-02**
1,3,5-Trimethylbenzene	0 0012	70	70	30	15	0.5	2	0 001	24	350	2.9	1 94E+04	NA	NA	NA	2 50E+03	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	8 22E-02	**8.22E-02**
1,2,4-Trimethylbenzene	0 0038	70	70	30	15	0 5	2	0 001	24	350	2 9	1.94E+04	NA	NA	NA	2 00E+03	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	2 08E-01	**2.08E-01**
SVOCS																									
Bis(2-ethylhexyl)phthalate	0.013	70	70	30	15	0 5	2	0 001	24	350	2 9	1 94E+04	NA	NA	1.40E-02	5.00E+01	9 83E-02	0 00E+00	4 05E-07	2 14E-06	**2.54E-06**	0 00E+00	3.38E-03	1 78E-02	**2.12E-02**
INORGANICS																									
Antimony	0 0055	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	2 50E+03	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	3.77E-01	**3.77E-01**
Manganese	0 04	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	NA	6 99E+04	NA	2.00E+02	0 00E+00	0 00E+00	0.00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	2 19E-01	**2.19E-01**

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	8.94E-07	**4.17E-07**	**2.38E-06**	**3.69E-06**	**4.21E-02**	**3.38E-03**	**9.04E-01**	**9.50E-01**

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair=daily indoor inhalation rate
K=volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
EF = exposure frequency
EFs=showering frequency
SA = skin surface area exposed
TF1=inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI= hazard index

Table 2-94
Equation for Deriving Risk/Hazard Quotient
for Soils for Human Health
Ingestion, Inhalation and Dermal Pathways
Residential (7 yrs - Adult), Future Use, Onsite (Outside Security Zone)
Mean Soil Concentrations

$$\text{Risk/HQ} = \frac{C \times ED \times \{(TFo \times 10\text{-}6\ kg/mg \times IRsoil \times ABSing \times EF) + (TF1 \times IRair \times EF \times [1/VF + 1/PEF]) + (TFo \times 10\text{-}6\ kg/mg \times SA \times AF \times ABSderm \times EF)\}}{BW \times AT \times 365\ days/yr}$$

(Ingestion: TFo, IRsoil, ABSing; Inhalation: TF1, IRair, VF, PEF; Dermal: TFo, SA, AF, ABSderm)

COC	C (mg/kg)	BW (kg)	AT (yr)	ED (yr)	IRsoil (mg/d)	EF (d/yr)	SA (cm2)	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	AF (mg/cm2)	ABS derm	ABS ing	IRair (m3/d)	VF (m3/kg)	PEF (m3/kg)	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HQ Ingestion	HQ Inhalation	HQ Dermal	HQ
SVOCs																									
2-METHYLNAPHTHALENE	0.038	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.49E+05	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
PESTICIDES/PCBs																									
AROCLOR-1260	0.27	70	70	24	100	350	1000	7.70E+00	NA	NA	NA	1.0	0.06	0.3	20	1.00E+10	4.63E+09	2.93E-07	0.00E+00	5.86E-07	**8.79E-07**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
ENDRIN KETONE	0.021	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
INORGANICS																									
ARSENIC	3.6	70	70	24	100	350	1000	1.75E+00	3.33E+03	1.51E+01	NA	1.0	0	1	20	1.00E+10	4.63E+09	2.96E-06	1.61E-09	0.00E+00	**2.96E-06**	1.64E-02	0.00E+00	0.00E+00	**1.64E-02**
BERYLLIUM	0.27	70	70	24	100	350	1000	4.30E+00	2.00E+02	8.40E+00	NA	1.0	0	1	20	1.00E+10	4.63E+09	5.45E-07	6.73E-11	0.00E+00	**5.45E-07**	7.40E-05	0.00E+00	0.00E+00	**7.40E-05**
COBALT	2.6	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	1	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
LEAD	63	70	70	24	100	350	1000	NA	NA	NA	NA	1.0	0	0.3	20	1.00E+10	4.63E+09	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**

Total Risk	Cancer Ingestion	Cancer Inhalation	Cancer Dermal	Cancer Risk	HI Ingestion	HI Inhalation	HI Dermal	HI Total
	3.80E-06	**1.68E-09**	**5.86E-07**	**4.38E-06**	**1.65E-02**	**0.00E+00**	**0.00E+00**	**1.65E-02**

COC = contaminant of concern
C = soil concentration
BW = body weight
AT = averaging time (for noncarcinogens = ED)
ED = exposure duration
IRsoil = soil ingestion rate
EF = exposure frequency

SA = skin surface area exposed
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
TF1 = inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
AF = adherence factor
ABSderm = dermal absorption factor
ABSing = ingestion absorption factor

IRair = inhalation rate
VF = soil to air volatilization factor
PEF = particulate emission factor
HQ = hazard quotient
HI = hazard index
NA = not applicable

Table 2-95
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Mean Groundwater Concentrations - Total Inorganics

FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$\text{RISK/HQ} = \frac{C \times ED \times [(EF \times TF1 \times K \times IRdair) + (EFs \times TFo \times SA \times PC \times CF1 \times CF2) + (TFo \times EF \times IRw)]}{BW \times AT \times 365\ days/yr}$$

(Inhalation: EF x TF1 x K x IRdair; Dermal: EFs x TFo x SA x PC x CF1 x CF2; Ingestion: TFo x EF x IRw)

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Benzene	0 0002	70	70	30	15	0 5	2	0 001	24	350	2 9	1 94E+04	2.90E-02	5.85E+02	2 90E-02	NA	2 48E-02	2.55E-07	3 26E-09	6 81E-08	**3.27E-07**	1 20E-02	0 00E+00	8.20E-05	**1.21E-02**
1,3,5-Trimethylbenzene	0.00036	70	70	30	15	0 5	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	2 50E+03	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	2 47E-02	**2.47E-02**
1,2,4-Trimethylbenzene	0 001	70	70	30	15	0 5	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	2 00E+03	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	5 48E-02	**5.48E-02**
SVOCS																									
Bis(2-ethylhexyl)phthalate	0 0046	70	70	30	15	0 5	2	0 001	24	350	2.9	1 94E+04	NA	NA	1.40E-02	5 00E+01	9 83E-02	0 00E+00	1 43E-07	7 56E-07	**9.00E-07**	0 00E+00	1 19E-03	6 30E-03	**7.50E-03**
INORGANICS																									
Aluminum	5 2	70	70	30	15	0	2	0.001	24	350	2 9	1 94E+04	NA	NA	NA	1 00E+00	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	1 42E-01	**1.42E-01**
Arsenic	0 0018	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	1 51E+01	NA	1 75E+00	3 33E+03	0 00E+00	0 00E+00	0 00E+00	3 70E-05	**3.70E-05**	0 00E+00	0 00E+00	1 64E-01	**1.64E-01**
Beryllium	0.00064	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	8 40E+00	NA	4 30E+00	2 00E+02	0 00E+00	0 00E+00	0 00E+00	3.23E-05	**3.23E-05**	0 00E+00	0 00E+00	3 51E-03	**3.51E-03**
Cobalt	0 0044	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	NA	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0.00E+00	0 00E+00	**0.00E+00**
Copper	0 0054	70	70	30	15	0	2	0.001	24	350	2 9	1 94E+04	NA	NA	NA	NA	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0.00E+00	0.00E+00	**0.00E+00**
Iron	6 2	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	NA	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0.00E+00	0.00E+00	**0.00E+00**
Lead	0.0045	70	70	30	15	0	2	0 001	24	350	2 9	1 94E+04	NA	NA	NA	NA	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**
Manganese	0.016	70	70	30	15	0	2	0.001	24	350	2 9	1 94E+04	NA	6.99E+04	NA	2 00E+02	0 00E+00	0 00E+00	0 00E+00	0 00E+00	**0.00E+00**	0 00E+00	0 00E+00	8 77E-02	**8.77E-02**

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	2.55E-07	1.47E-07	7.01E-05	7.05E-05	1.20E-02	1.19E-03	4.84E-01	4.97E-01

Notes
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair=daily indoor inhalation rate
K=volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor
EF = exposure frequency
EFs=showering frequency
SA = skin surface area exposed
TF1=inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI= hazard index

Table 2-96
Equation for Deriving Risk/Hazard Quotient
for Groundwater for Human Health
Ingestion, Inhalation, and Dermal Pathways
Adult Resident, Future Use, Onsite/Offsite
Mean Groundwater Concentrations - Dissolved Inorganics

FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

$$\text{RISK/HQ} = \frac{C \times ED \times [(EF \times TF1 \times K \times IRdair)_{\text{Inhalation}} + (EFs \times TFo \times SA \times PC \times CF1 \times CF2)_{\text{Dermal}} + (TFo \times EF \times IRw)_{\text{Ingestion}}]}{BW \times AT \times 365 \text{ days/yr}}$$

COC	C (mg/L)	BW (kg)	AT (yr)	ED (yr)	IRair m3/day	K (L/m3)	IRw (L/d)	CF1 (L/cm3)	CF2 (h/d)	EF (d/yr)	EFs (d/yr)	SA (cm2)	TF1 (mg/kg/d)-1 carc	TF1 (mg/kg/d) noncarcin	TFo (mg/kg/d)-1 carc	TFo (mg/kg/d) noncarcin	PC (cm/h)	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HQ Inhalation	HQ Dermal	HQ Ingestion	HQ
VOCs																									
Benzene	0.0002	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	2.90E-02	NA	2.90E-02	NA	2.48E-02	2.55E-07	3.26E-09	6.81E-08	**3.27E-07**	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
1,3,5-Trimethylbenzene	0.00036	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	2.47E-02	**2.47E-02**
1,2,4-Trimethylbenzene	0.001	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.00E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	5.48E-02	**5.48E-02**
SVOCS																									
Bis(2-ethylhexyl)phthalate	0.0046	70	70	30	15	0.5	2	0.001	24	350	2.9	1.94E+04	NA	NA	1.40E-02	5.00E+01	9.83E-02	0.00E+00	1.43E-07	7.56E-07	**9.00E-07**	0.00E+00	1.19E-03	6.30E-03	**7.50E-03**
INORGANICS																									
Antimony	0.0043	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	NA	NA	2.50E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	2.95E-01	**2.95E-01**
Manganese	0.015	70	70	30	15	0	2	0.001	24	350	2.9	1.94E+04	NA	6.99E+04	NA	2.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**	0.00E+00	0.00E+00	8.22E-02	**8.22E-02**

Total Risk	Cancer Inhalation	Cancer Dermal	Cancer Ingestion	Cancer Risk	HI Inhalation	HI Dermal	HI Ingestion	HI Total
	2.55E-07	**1.47E-07**	**8.24E-07**	**1.23E-06**	**0.00E+00**	**1.19E-03**	**4.62E-01**	**4.64E-01**

Notes:
COC = contaminant of concern
C = concentration
BW = body weight
AT = averaging time (for noncarcinogens, equal to ED)
ED = exposure duration
IRair=daily indoor inhalation rate
K=volatilization factor
IRw = daily water ingestion rate
CF1 = conversion factor for water
CF2 = conversion factor

EF = exposure frequency
EFs=showering frequency
SA = skin surface area exposed
TF1=inhalation slope factor for carcinogens or 1/inhalation reference dose for noncarcinogens
TFo = ingestion slope factor for carcinogens or 1/ingestion reference dose for noncarcinogens
PC = dermal permeability constant
HQ = hazard quotient
HI= hazard index

TABLE 2-96a
SUMMARY OF RISKS AND HAZARD QUOTIENTS

AOC FS-19 STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

CURRENT USE	Maximum	Mean
	Utility Worker (Soil)	
Total Cancer Risk	1.46E-07	1.00E-07
Total HI	1.27E-02	9.51E-03
	Child Trespasser (Soil)	
Total Cancer Risk	4.66E-07	3.15E-07
Total HI	6.33E-03	4.74E-03

FUTURE USE	Maximum	Mean
	Child Resident (Soil)	
Total Cancer Risk	1.38E-05	9.55E-06
Total HI	2.06E-01	1.54E-01
	Adult Resident (Soil and Groundwater)	
Total Cancer Risk Soil	6.49E-06	4.38E-06
Total Cancer Risk Groundwater	1.63E-04 (3.69E-06*)	7.05E-05 (1.23E-06*)
Total HI Soil	2.20E-02	1.65E-02
Total HI Groundwater	3.35E+00 (9.50E-01*)	4.97E-01 (4.64E-01*)
Total Lifetime Cancer Risk (Child + Adult) (Soil +Groundwater)	1.83E-04 (2.40E-05*)	8.44E-05 (1.52E-05*)

* Values in parentheses based on dissolved inorganics concentrations for groundwater.

Table 2-97
Terrestrial Vegetation Risk Characterization
MMR Maximum Background Soil Concentrations

AOC FS-19
Massachusetts Military Reservation

COC	Maximum Concentration in Surface Soil (mg/kg)	Critical Soil Concentration(a) (mg/kg)	HQ
INORGANICS			
ALUMINUM	8930	NA	NE
ARSENIC	3.6	20	0.18
BARIUM	10.4	NA	NE
BERYLIUM	0.65	NA	NE
CADMIUM	1.5	3	0.5
CHROMIUM	6.8	75	0.09
COBALT	4.1	25	0.164
CYANIDE	0.7	NA	NE
LEAD	12.05	100	0.1205
MANGANESE	108	1500	0.07
NICKEL	5.2	100	0.052
VANADIUM	15.2	NA	NE
ZINC	16	70	0.23
		HI	1.41

(a)Values obtained from Tables O-3 and O-4 of the RAH

Table 2-97 (cont.)
Aquatic Risk Characterization
MMR Maximum Background Groundwater Concentrations

AOC FS-19
Massachusetts Military Reservation

COC	MMR Site-Specific Background Maximum (ug/L) Total	Dissolved	Aquatic Benchmark Value (ug/L) (a,b)	HQ Total	HQ Dissolved
INORGANICS					
CHROMIUM (c)	17.4	5	*11*	1.58	0.45
COPPER (d)	12.5	12.5	*2.2*	5.68	5.68
LEAD (d)	2.9	2	*0.26*	11.15	7.69
NICKEL (d)	19	19	*21.45*	0.88	0.88
ZINC (d)	67	73.5	*47*	1.42	1.56
			HI =	19	15

(a) Values from MMR RAH Table O-2
(b) Italicized values represent CCC values in Ambient Water Quality Criteria (AWQC) (U.S. EPA, May 1991)
(c) Assumed Chromium IV
(d) For hardness-dependent metals Ni, Cu, Pb, and Zn assumed water hardness value of 14 mg CACO2/L and used the AWQC hardness equation for the metal to derive the CCC value.
(e) MMR background concentrations for groundwater from MMR Background Inorganics Study

TABLE 2-98
Contaminants of Ecological Concern in Surface Soils for Food Chain Receptors

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Max Conc. (*) in Surface soil (mg/kg)	MMR Site-Specific Background Maximum (mg/kg)	Mouse	Vole	Shrew	Fox	Upland Sandpiper	Grasshopper Sparrow	Northern Harrier	Short-eared Owl	Cardinal
			From Attachment F - Hazard Equivalent Concentrations For Ecological PRE (mg/kg)								
Inorganics											
Aluminum	13800	8930	2.64E+04	4.28E+04	4.00E+04	3.17E+05	4.84E+08	2.70E+08	4.80E+08	4.53E+08	3.35E+05
Arsenic	4.8	3.6	2.57E+01	1.11E+03	3.12E-01	7.62E+02	2.37E+00	7.55E+00	2.41E+07	2.39E+07	3.37E+01
Barium	57.9	10.4	1.39E+04	6.00E+03	9.20E+03	7.30E+04	9.41E+07	5.14E+07	5.85E+07	5.64E+07	1.05E+04
Beryllium	0.39	0.65	4.14E+04	5.87E+04	1.92E+04	1.52E+05	8.17E+04	4.47E+04	1.08E+05	1.00E+05	2.37E+05
Cadmium	1.1	1.5	1.39E+00	1.35E+01	5.08E-02	3.97E+02	2.09E-01	6.68E-01	7.11E+05	7.58E+05	2.93E+00
Chromium	11.5	8.8	7.28E+00	7.18E+01	7.00E-01	1.85E+02	5.04E+01	1.61E+02	8.97E+07	9.87E+07	7.12E+02
Cobalt	3.2	4.1	5.95E+02	7.72E+02	3.33E+02	2.64E+03	2.17E+05	1.18E+05	1.26E+05	1.22E+05	8.19E+02
Cyanide	0.1	0.7	2.33E-01	3.59E-01	5.44E-01	2.51E+01	5.00E-02	1.59E-01	2.48E-01	2.49E-01	4.88E-02
Lead	119	12.05	1.73E+02	5.18E+03	3.67E+01	6.61E+04	1.58E+01	5.04E+01	1.13E+07	1.05E+07	2.25E+07
Manganese	92	109	7.87E+02	3.84E+02	1.67E+03	1.32E+04	3.81E+08	2.06E+08	4.46E+08	4.46E+08	2.98E+02
Nickel	6	5.2	2.72E+03	4.32E+03	1.67E+04	1.32E+05	9.41E+07	5.14E+07	1.13E+07	1.13E+07	9.55E+02
Vanadium	22.5	15.2	2.75E+01	4.53E+01	1.40E+01	1.11E+02	5.53E+07	3.02E+07	2.73E+05	2.74E+05	8.03E+01
Zinc	68	18	4.02E+01	1.03E+02	5.13E+00	7.72E+03	3.98E+00	1.47E+01	2.03E+04	2.04E+04	4.60E+01
Semivolatile Organics											
2-Methylnaphthalene	0.038	NA	1.67E+03	4.16E+03	3.40E+02	2.50E+04	3.12E+01	9.96E+01	2.83E+02	2.83E+02	2.61E+02
Acenaphthylene	0.022	NA	4.14E+01	1.24E+02	6.80E+00	5.85E+02	6.25E-01	1.99E+00	6.81E+00	6.82E+00	6.09E+00
Anthracene	0.011	NA	5.53E+03	2.52E+04	6.78E+02	7.97E+04	6.24E+01	1.98E+02	1.03E+03	1.03E+03	7.44E+02
Benzo(a)anthracene	0.064	NA	7.67E+01	1.69E+03	6.80E+00	3.03E+03	6.25E-01	1.99E+00	8.60E+01	8.61E+01	8.86E+00
Benzo(a)pyrene	0.065	NA	7.13E+01	7.97E+02	6.80E+00	6.37E+02	6.25E-01	1.99E+00	8.13E+00	8.15E+00	8.52E+00
Benzo(b)fluoranthene	0.16	NA	7.73E+01	1.91E+03	6.80E+00	3.83E+03	6.25E-01	1.99E+00	1.91E+02	1.91E+02	8.90E+00
Benzo(ghi)perylene	0.045	NA	7.75E+01	2.01E+03	6.80E+00	4.58E+03	6.25E-01	1.99E+00	7.18E+02	7.12E+02	8.91E+00
Benzo(k)fluoranthene	0.16	NA	7.73E+01	1.91E+03	6.80E+00	3.83E+03	6.25E-01	1.99E+00	1.91E+02	1.91E+02	8.90E+00
Chrysene	0.089	NA	7.67E+01	1.69E+03	6.80E+00	3.03E+03	6.25E-01	1.99E+00	8.60E+01	8.61E+01	8.86E+00
Dibenzo(ah)anthracene	0.029	NA	7.75E+01	2.01E+03	6.80E+00	4.57E+03	6.25E-01	1.99E+00	6.99E+02	6.93E+02	8.91E+00
Di-n-butyl phthalate	0.02	NA	4.62E+02	6.74E+03	4.25E+01	1.63E+04	3.90E+00	1.24E+01	6.18E+03	6.10E+03	5.43E+01
Fluoranthene	0.17	NA	8.67E+02	8.23E+03	8.50E+01	1.70E+04	7.81E+00	2.49E+01	2.49E+02	2.49E+02	1.05E+02
Indeno(123-cd)pyrene	0.049	NA	7.75E+01	2.01E+03	6.80E+00	4.58E+03	6.25E-01	1.99E+00	7.18E+02	7.12E+02	8.91E+00
Naphthalene	0.029	NA	7.33E+01	1.55E+02	1.79E+01	1.12E+03	1.64E+00	5.24E+00	1.23E+01	1.23E+01	1.24E+01
Phenanthrene	0.11	NA	5.68E+01	2.73E+02	6.80E+00	8.39E+02	6.25E-01	1.99E+00	1.05E+01	1.06E+01	7.47E+00
Pyrene	0.13	NA	5.62E+02	9.44E+03	5.10E+01	1.64E+04	4.69E+00	1.49E+01	3.17E+02	3.17E+02	6.57E+01
Volatile Organics											
Acetone	0.005	NA	5.69E+01	9.08E+01	6.75E+01	2.04E+04	6.25E+00	1.98E+01	5.39E+02	5.36E+02	1.17E+01
Chloroform	0.001	NA	5.53E+01	8.60E+01	2.00E+02	8.37E+03	1.87E+01	5.83E+01	9.15E+01	9.15E+01	1.15E+01
Methylene Chloride	0.001	NA	1.23E+01	1.87E+01	4.06E+01	2.15E+03	3.75E+00	1.19E+01	2.23E+01	2.24E+01	2.60E+00
Toluene	0.002	NA	1.72E+01	2.85E+01	1.33E+01	6.16E+02	1.23E+00	3.90E+00	6.67E+00	6.67E+00	3.42E+00
Total Xylenes	0.003	NA	7.94E+02	1.46E+03	3.37E+02	1.75E+04	1.17E+01	3.70E+01	7.35E+01	7.36E+01	5.61E+01
Pesticides/PCBs											
4,4'-DDD	0.019	NA	9.35E+01	2.31E+03	8.22E+00	3.58E+03	2.41E+00	7.69E+00	1.46E+02	1.46E+02	3.44E+01
4,4'-DDE	0.11	NA	1.28E+02	1.04E+03	1.29E+01	1.29E+02	3.75E-01	1.19E+00	2.27E-01	2.27E-01	4.95E+00
4,4'-DDT	0.93	NA	7.58E+02	1.44E+04	6.80E+00	7.10E+02	2.50E-01	7.97E-01	4.38E+00	4.38E+00	3.52E+00
alpha-Chlordane	0.0013	NA	2.55E+00	4.87E+01	2.28E-01	7.20E+01	8.75E-02	2.79E-01	1.09E+01	1.10E+01	1.23E+00
Aroclor-1260	0.54	NA	1.78E+01	3.16E+02	1.60E+00	2.99E+01	1.25E+00	3.98E+00	1.34E+00	1.34E+00	1.76E+01
Dieldrin	0.12	NA	4.40E-01	3.68E+00	3.40E-01	5.40E+00	3.50E-02	1.12E-01	5.87E-02	5.57E-02	4.63E-01
Endrin ketone	0.032	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND
gamma-Chlordane	0.003	NA	2.55E+00	4.87E+01	2.28E-01	7.20E+01	8.75E-02	2.79E-01	1.09E+01	1.10E+01	1.23E+00
Methoxychlor	0.034	NA	2.04E+02	1.73E+03	2.04E+01	3.76E+03	1.25E+01	3.98E+01	3.57E+02	3.57E+02	1.66E+02

* Italicized numbers indicate that maximum concentrations were less than MMR background concentrations for soils
HI - Hazard Index
ND - Not Derived
NA - Not Available
NE - Not Evaluated

TABLE 98-8 (cont)
Contaminants of Ecological Concern in Surface Soils for Food Chain Receptors

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

Unit - mg/kg	Mouse HI	Vole HI	Shrew HI	Fox HI	Upland Sandpiper HI	Grasshopper Sparrow HI	Northern Harrier HI	Short-eared Owl HI	Cardinal HI	Contaminant of Ecological Concern
Inorganics										
Aluminum	0.5	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	N
Arsenic	0.2	0.0	15.4	0.0	2.9	0.6	0.0	0.0	0.1	Y
Barium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Beryllium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Cadmium	0.9	0.1	12.1	0.0	6.3	1.6	0.0	0.0	0.4	Y
Chromium	1.6	0.2	16.4	0.1	0.2	0.1	0.0	0.0	0.0	Y
Cobalt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Cyanide	0.4	0.3	0.2	0.0	2.0	0.6	0.4	0.4	2.0	Y
Lead	0.7	0.0	3.2	0.0	7.3	2.4	0.0	0.0	0.0	Y
Manganese	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.3	Y
Nickel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Vanadium	0.8	0.5	1.4	0.2	0.0	0.0	0.0	0.0	0.3	Y
Zinc	1.7	0.7	13.3	0.0	17.1	5.4	0.0	0.0	1.5	Y
Semi-volatile Organics										
2-Methylnaphthalene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Acenaphthylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Benzo(a)anthracene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	N
Benzo(a)pyrene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	N
Benzo(b)fluoranthene	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	N
Benzo(ghi)perylene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	N
Benzo(k)fluoranthene	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	N
Chrysene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	N
Dibenzo(ah)anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Di-n-butyl phthalate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Fluoranthene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Indeno(123-cd)pyrene	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	N
Naphthalene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Phenanthrene	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	N
Pyrene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Volatile Organics										
Acetone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Chloroform	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Methylene Chloride	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Toluene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Total Xylenes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Pesticides/PBCs										
4,4'-DDD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
4,4'-DDE	0.0	0.0	0.0	0.0	0.3	0.1	0.5	0.5	0.0	N
4,4'-DDT	0.0	0.0	0.1	0.0	3.7	1.2	0.2	0.2	0.3	Y
alpha-Chlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Aroclor-1260	0.0	0.0	0.3	0.0	0.4	0.1	0.4	0.4	0.0	N
Dieldrin	0.3	0.0	0.4	0.0	3.4	1.1	2.2	2.2	0.3	Y
Endrin ketone	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
gamma-Chlordane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N
Methoxychlor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N

HI - Hazard Index
NE - Not Evaluated
N - No
Y - Yes

TABLE 2-99
Selection of Contaminants of Ecological Concern For Groundwater

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	F-19 Site Data Maximum (ug/L) Total	F-19 Site Data Maximum (ug/L) Dissolved (f)	MMR Site-Specific Background Maximum (ug/L) Total	MMR Site-Specific Background Maximum (ug/L) Dissolved (e)	Aquatic Benchmark Value (ug/L) (a,b)	HQ Total	HQ Dissolved	Contaminant of Ecological Concern
VOCs								
1,1,1-Trichloroethane	1.6				18000	0.0001		N
Benzene	0.7				5300	0.0001		N
Toluene	7.6				17500	0.0004		N
Ethylbenzene	2.6				32000	0.0001		N
M/P-Xylene	12				13500	0.0009		N
O-Xylene	5.1				13500	0.0004		N
1,3,5-Trimethylbenzene	1.2				NA	NE		NE
1,2,4-Trimethylbenzene	3.8				NA	NE		NE
SVOCs					NA	NE		NE
Bis(2-ethylhexyl)phthalate	13				NA	NE		NE
Inorganics								
Aluminum	15100	**155**	312	259	NA	NE	NE	NE
Antimony	ND	**5.5**	30	30	30	ND	0.183	N
Arsenic	4.8	ND	2	2	2962	0.0016	ND	N
Barium	136	117	94.8	100	NA	NE	NE	NE
Beryllium	1.2	ND	1.5	5.1	5.3	0.23	ND	NE
Cadmium (d)	ND	**0.22**	2.5	2.5	*0.24*	ND	0.92	N
Chromium (c)	21	ND	17.4	5	*11*	1.91	ND	Y
Cobalt	14	ND	6	6	NA	NE	ND	NE
Copper (d)	13.7	ND	12.5	12.5	*2.2*	6.23	ND	Y
Iron	19300	ND	471	422	1000	19.30	ND	Y
Lead (d)	18.5	**1.3**	2.9	2	*0.26*	71.15	5.00	Y
Manganese	465	**1.5**	109	103	NA	NE	NE	NE
Nickel (d)	22	**5.2**	19	19	*21.45*	1.03	0.24	Y
Vanadium	24.4	ND	7.5	7.5	NA	NE	NE	N
Zinc (d)	58.9	**36.2**	66.9	73.5	47	1.25	0.77	Y

NOTES:
a) Values from MMR Handbook Table O-2.
b) Italicized values represent CCC values in Ambient Water Quality Criteria (U.S. EPA, May 1991. Water Quality Criteria. [Fresh Chronic Criteria]).
c) Assumed chromium VI.
d) For hardness-dependent metals, Ni, Zn, Pb, Cu, and Cd, assumed water hardness value of 14 mg CaCO3/L and used AWQC hardness equation for the metal to derive the CCC value.
e) MMR maximum groundwater concentrations from Table 1 in MMR Background Inorganics Study. HAZWRAP. January 1994
f) Bold values are less than MMR site-specific background dissolved concentrations
NA = AWQC are not available for the compound and no value is presented in Table O-2 of MMR Handbook.
NE = Compound detected in groundwater, but could not be evaluated in terms of potential adverse impacts to aquatic receptors because of lack of aquatic toxicity information in MMR Handbook.
ND = Not detected
N = No
Y = Yes
HQ = Hazard Quotient

TABLE 2-100
Summary of Data for Surface Soils

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM
Volatile Organics								
Methylene Chloride	mg/kg	1	3	0.001	0.001	0.0027*	NA	NA
Acetone	mg/kg	1	3	0.005	0.005	0.0055*	NA	NA
Chloroform	mg/kg	2	3	0.001	0.001	0.001	NA	NA
Toluene	mg/kg	2	3	0.001	0.002	0.003*	NA	NA
Total Xylenes	mg/kg	1	3	0.003	0.003	0.005*	NA	NA
Semi-Volatile Organics								
Naphthalene	mg/kg	1	3	0.029	0.029	0.14*	NA	NA
2-methylnaphthalene	mg/kg	1	3	0.038	0.038	0.14*	NA	NA
Acenaphthylene	mg/kg	1	3	0.022	0.022	0.13*	NA	NA
Phenanthrene	mg/kg	3	3	0.035	0.11	0.062	NA	NA
Anthracene	mg/kg	1	3	0.011	0.011	0.13*	NA	NA
Di-n-butylphthalate	mg/kg	2	3	0.012	0.02	0.079*	NA	NA
Fluoranthene	mg/kg	3	3	0.038	0.17	0.11	NA	NA
Pyrene	mg/kg	3	3	0.035	0.13	0.089	NA	NA
Benzo(a)anthracene	mg/kg	2	3	0.042	0.064	0.051	NA	NA
Chrysene	mg/kg	3	3	0.036	0.089	0.062	NA	NA
Benzo(b)fluoranthene	mg/kg	3	3	0.046	0.16	0.11	NA	NA
Benzo(k)fluoranthene	mg/kg	3	3	0.046	0.16	0.11	NA	NA
Benzo(a)pyrene	mg/kg	3	3	0.017	0.065	0.048	NA	NA
Indeno(1,2,3-cd)pyrene	mg/kg	3	3	0.024	0.049	0.039	NA	NA
Dibenz(a,h)anthracene	mg/kg	1	3	0.029	0.029	0.14*	NA	NA
Benzo(g,h,i)perylene	mg/kg	3	3	0.022	0.045	0.034	NA	NA
PETROLEUM PRODUCTS								
Total Petroleum Hydrocarbons	mg/kg	2	3	48	100	52	NA	NA
Diesel Range	mg/kg	3	3	14	39	23	NA	NA

TABLE 2-100 (cont.)
Summary of Data for Surface Soils

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

	UNITS	DETECTS	SAMPLES	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	CONCENTRATION AVERAGE	MMR SITE-SPECIFIC BACKGROUND (1) MINIMUM	MMR SITE-SPECIFIC BACKGROUND (1) MAXIMUM
Pesticides/PCBs								
Dieldrin	mg/kg	3	3	0.018	0.12	0.07	NA	NA
4,4'-DDE	mg/kg	3	3	0.011	0.11	0.055	NA	NA
4,4'-DDD	mg/kg	2	3	0.012	0.019	0.011	NA	NA
4,4'-DDT	mg/kg	3	3	0.027	0.93	0.41	NA	NA
Methoxychlor	mg/kg	2	3	0.016	0.034	0.025	NA	NA
Endrin Ketone	mg/kg	2	3	0.017	0.032	0.021	NA	NA
Alpha-chlordane	mg/kg	1	3	0.0013	0.0013	0.0012	NA	NA
Gamma-chlordane	mg/kg	2	3	0.0019	0.003	0.0022	NA	NA
Aroclor-1260	mg/kg	2	3	0.26	0.54	0.27	NA	NA
Inorganic Analytes								
Aluminum	mg/kg	3	3	7590	13800	9680	1146	8930
Arsenic	mg/kg	3	3	2.9	4.8	3.6	0.15	3.6
Barium	mg/kg	3	3	15.7	57.9	30	2	10.4
Beryllium	mg/kg	2	3	0.28	0.39	0.27	0.1	0.65
Cadmium	mg/kg	2	3	0.45	1.1	0.78	0.4	1.5
Calcium	mg/kg	3	3	356	1280	693	26	969
Chromium	mg/kg	3	3	6.6	11.5	8.8	0.8	6.8
Cobalt	mg/kg	3	3	1.5	3.2	2.6	0.5	4.1
Iron	mg/kg	3	3	9340	13900	11033	2050	12400
Lead	mg/kg	3	3	29.9	119	63	1.3	12.05
Magnesium	mg/kg	3	3	633	1300	988	176	794.5
Manganese	mg/kg	3	3	43.3	92	72	16	108
Nickel	mg/kg	3	3	4	6	5.1	1.05	5.2
Potassium	mg/kg	3	3	370	717	526	76	551
Vanadium	mg/kg	3	3	13.4	22.5	19	1.13	15.2
Zinc	mg/kg	3	3	21.6	68	43	3.05	16
Cyanide	mg/kg	3	3	0.1	0.1	0.053	0.185	0.7

NOTES:

1. MMR Final Risk Assessment Handbook. Table E-1. Summary Statistics for Inorganic Concentrations Selected Background Surface Soil Samples. Automated Sciences Group, Inc. September 1994.

* The average concentration exceeds the maximum concentration due to values of one-half the detection limit exceeding the maximum concentration.

NA Not Applicable

Table 2-101
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Meadow Vole

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Max SC (mg/g)	Max PC (mg/g)	PP	PS	IR(a) (g/d)	PI (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs													
DIELDREN	1.00E-01	1.20E-04	1.20E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	7.62E-04
4,4' DDT	1.58E-02	9.30E-04	1.47E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.11E-03
INORGANICS													
ARSENIC	4.00E-02	4.80E-03	1.92E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.65E-02
CADMIUM	5.50E-01	1.10E-03	6.05E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.10E-02
CHROMIUM	7.50E-03	1.15E-02	8.63E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.14E-02
CYANIDE	1.75E+01	1.00E-04	1.75E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	8.51E-02
LEAD	4.50E-02	1.19E-01	5.36E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	4.38E-01
MANGANESE	2.50E-01	9.20E-02	2.30E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.25E+00
VANADIUM	5.50E-03	2.25E-02	1.24E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.98E-02
ZINC	1.50E+00	6.80E-02	1.02E-01	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	5.05E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(a) EPA 1993

Table 2-102
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Meadow Vole

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	SCFs (kg dry soil)/ (kg dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	PP	PS	IR(a) (g/d)	PI (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs													
DIELDRIN	1.00E-01	7.00E-05	7.00E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	4.45E-04
4,4' DDT	1.58E-02	4.10E-04	6.48E-06	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	9.30E-04
INORGANICS													
ARSENIC	4.00E-02	3.60E-03	1.44E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.24E-02
CADMIUM	5.50E-01	7.80E-04	4.29E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.20E-02
CHROMIUM	7.50E-03	8.80E-03	6.60E-05	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	1.64E-02
CYANIDE	1.75E+01	5.30E-05	9.28E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	4.51E-02
LEAD	4.50E-02	6.30E-02	2.84E-03	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	2.32E-01
MANGANESE	2.50E-01	7.20E-02	1.80E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	9.81E-01
VANADIUM	5.50E-03	1.90E-02	1.05E-04	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.36E-02
ZINC	1.50E+00	4.30E-02	6.45E-02	0.97	0.03	3.60	3.49	0.108054	0	0.00205	0.5	0.036	3.19E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern(dry weight)
IT = invertebrate ingestion rate(dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate(dry weight)
SI = soil ingestion rate
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(a) EPA 1993

Table 2-103
Ecological Exposure Dose for Food Chain Receptors
Maximum concentrations
Surface Soil
White-footed Mouse

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCFs (kg dry soil/ (kg dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAFinv		Max IC (mg/g)	PInv	PP	PS	IR(s) (g/d)	IT (g/d)	PI (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(s) (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs																		
DIELDRIN	1.00E-01	1.20E-04	1.20E-05	3	(4)	3.60E-04	0.17	0.8	0.03	0.864	1.47E-01	5.88E-06	2.59E-02	0	0.0355	0.50	0.022	1.27E-03
4,4'-DDT	1.58E-02	9.30E-04	1.47E-05	3	(4)	2.79E-03	0.17	0.8	0.03	0.864	1.47E-01	6.94E-06	2.59E-02	0	0.0355	0.50	0.022	9.86E-03
INORGANICS																		
ARSENIC	6.00E-03	4.80E-03	2.88E-05	0.24	(3)	1.15E-03	0.17	0.8	0.03	0.864	1.47E-01	1.36E-05	2.59E-02	0	0.0355	0.50	0.022	6.67E-03
CADMIUM	1.50E-01	1.10E-03	1.65E-04	14	(3)	1.54E-02	0.17	0.8	0.03	0.864	1.47E-01	7.79E-05	2.59E-02	0	0.0355	0.50	0.022	5.21E-02
CHROMIUM	4.50E-03	1.15E-02	5.18E-05	0.3	(3)	3.45E-03	0.17	0.8	0.03	0.864	1.47E-01	4.07E-05	2.59E-02	0	0.0355	0.50	0.022	1.83E-02
CYANIDE	1.75E+01	1.00E-04	1.75E-03	0.31	(1)	3.10E-05	0.17	0.8	0.03	0.864	1.47E-01	8.26E-04	2.59E-02	0	0.0355	0.50	0.022	1.95E-04
LEAD	9.00E-03	1.19E-01	1.07E-03	0.27	(3)	3.21E-02	0.17	0.8	0.03	0.864	1.47E-01	5.06E-04	2.59E-02	0	0.0355	0.50	0.022	1.77E-01
MANGANESE	5.00E-02	9.20E-02	8.28E-02	0.054	(3)	4.97E-03	0.17	0.8	0.03	0.864	1.47E-01	2.17E-03	2.59E-02	0	0.0355	0.50	0.022	7.49E-02
VANADIUM	3.00E-03	2.25E-02	6.75E-05	0.042	(3)	9.45E-04	0.17	0.8	0.03	0.864	1.47E-01	3.19E-05	2.59E-02	0	0.0355	0.50	0.022	1.64E-02
ZINC	9.00E-01	6.80E-02	6.12E-02	3.78	(3)	2.57E-01	0.17	0.8	0.03	0.864	1.47E-01	2.89E-02	2.59E-02	0	0.0355	0.50	0.022	9.38E-01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate (dry weight)
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent soil ingestion
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-104
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
White-footed Mouse

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCFs (kg dry soil/ kg dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAFinv		Mean IC (mg/g)	PInv	PP	PS	IR(a) (g/d)	IT (g/d)	PI (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs																		
DIELDRIN	1.00E-01	7.00E-05	7.00E-06	3	(4)	2.10E-04	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	8.52E-04
4,4'-DDT	1.58E-02	4.10E-04	6.48E-06	3	(4)	1.23E-03	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	4.45E-03
INORGANICS																		
ARSENIC	6.00E-03	3.60E-03	2.16E-05	0.24	(3)	8.64E-04	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	5.34E-03
CADMIUM	1.50E-01	7.80E-04	1.17E-04	14	(3)	1.09E-02	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	3.88E-02
CHROMIUM	4.50E-03	8.80E-03	3.96E-05	0.3	(3)	2.64E-03	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.46E-02
CYANIDE	1.75E+01	5.30E-05	9.28E-04	0.31	(1)	1.64E-05	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.47E-02
LEAD	9.00E-03	6.30E-02	5.67E-04	0.27	(3)	1.70E-02	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.03E-01
MANGANESE	5.00E-02	7.20E-02	3.60E-03	0.054	(3)	3.89E-03	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.12E-01
VANADIUM	3.00E-03	1.90E-02	5.70E-05	0.042	(3)	7.98E-04	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.48E-02
ZINC	9.00E-01	4.30E-02	3.87E-02	3.78	(3)	1.63E-01	0.17	0.8	0.03	0.864	1.47E-01	6.91E-01	2.59E-02	0	0.0355	0.50	0.022	1.18E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
PC = plant concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

PI = plant ingestion rate (dry weight)
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PP = percent plant ingestion
PS = percent
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose
IC = invertebrate concentration

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

Table 2-105
Ecological Exposure dose for food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max SC (mg/g)	BAFinv		Max IC (mg/g)	PInv	PS	IR(a) (g/d)	IT (g/d)	SI (g/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs														
DIELDRIN	1.20E-04	3	(4)	3.60E-04	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.50E-02
4,4'-DDT	9.30E-04	3	(4)	2.79E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.16E-01
INORGANICS														
ARSENIC	4.80E-03	0.24	(3)	1.15E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	5.35E-02
CADMIUM	1.10E-03	14	(3)	1.54E-02	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	6.35E-01
CHROMIUM	1.15E-02	0.3	(3)	3.45E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.57E-01
CYANIDE	1.00E-04	0.31	(3)	3.10E-05	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.40E-03
LEAD	1.19E-01	0.27	(3)	3.21E-02	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.47E+00
MANGANESE	9.20E-02	0.054	(3)	4.97E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	3.21E-01
VANADIUM	2.25E-02	0.042	(3)	9.45E-04	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	6.75E-02
ZINC	6.80E-02	3.78	(3)	2.57E-01	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.07E+01

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

IC = invertebrate concentration (dry weight)
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PS = percent soil inges
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-106
Ecological Exposure Dose for Food Chain Receptors
Mean concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean SC (mg/g)	BAFinv		Mean IC (mg/g)	PInv	PS	IR(a) (g/d)	IT (g/d)	SI (g/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(a) (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs														
DIELDRIN	7.00E-05	3	(4)	2.10E-04	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	8.73E-03
4,4'-DDT	4.10E-04	3	(4)	1.23E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	5.11E-02
INORGANICS														
ARSENIC	3.60E-03	0.24	(3)	8.64E-04	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	4.01E-02
CADMIUM	7.80E-04	14	(3)	1.09E-02	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	4.50E-01
CHROMIUM	8.80E-03	0.3	(3)	2.64E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	1.20E-01
CYANIDE	5.30E-05	0.31	(3)	1.64E-05	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	7.43E-04
LEAD	6.30E-02	0.27	(3)	1.70E-02	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	7.80E-01
MANGANESE	7.20E-02	0.054	(3)	3.89E-03	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	2.51E-01
VANADIUM	1.90E-02	0.042	(3)	7.98E-04	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	5.70E-02
ZINC	4.30E-02	3.78	(3)	1.63E-01	0.97	0.03	1.272	1.23E+00	3.82E-02	0	0.0125	0.5	0.015	6.74E+00

COC = contaminant of concern
SCFs = soil-to-plant concentration factor
SC = soil concentration
IR = ingestion rate of species of concern (dry weight)
IT = invertebrate ingestion rate (dry weight)
BAFinv = bioaccumulation factor for invertebrates

IC = invertebrate concentration (dry weight)
SI = soil ingestion rate (dry weight)
PInv = percent invertebrate ingestion
PS = percent
HRF = home range factor
BW = body weight

WC = water concentration
WI = water intake rate
D = exposure dose

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-107
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Upland Sandpiper

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max SC (mg/g)	BAFinv		Max IC (mg/g)	IT(a) (g/d)	HRF	ED	BW (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs									
DIELDRIN	1.20E-04	3	(4)	3.60E-04	2.867	0.5	0.5	0.164	1.57E-03
4,4'-DDT	9.30E-04	3	(4)	2.79E-03	2.867	0.5	0.5	0.164	1.22E-02
INORGANICS									
ARSENIC	4.80E-03	0.24	(3)	1.15E-03	2.867	0.5	0.5	0.164	5.04E-03
CADMIUM	1.10E-03	14	(3)	1.54E-02	2.867	0.5	0.5	0.164	6.73E-02
CHROMIUM	1.15E-02	0.3	(3)	3.45E-03	2.867	0.5	0.5	0.164	1.51E-02
CYANIDE	1.00E-04	0.31	(1)	3.10E-05	2.867	0.5	0.5	0.164	1.35E-04
LEAD	1.19E-01	0.27	(3)	3.21E-02	2.867	0.5	0.5	0.164	1.40E-01
MANGANESE	9.20E-02	0.054	(3)	4.97E-03	2.867	0.5	0.5	0.164	2.17E-02
VANADIUM	2.25E-02	0.042	(3)	9.45E-04	2.867	0.5	0.5	0.164	4.13E-03
ZINC	6.80E-02	3.78	(3)	2.57E-01	2.867	0.5	0.5	0.164	1.12E+00

BAFinv = bioaccumulation factor for invertebrates
BW = body weight (kg)
D = exposure dose (mg/kg/d)
ED = exposure duration (migration) (year)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IT = COC intake via invertebrate ingestion (dry weight) (g/d)
SC = soil concentration (dry weight) (mg/g)

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-108
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Upland Sandpiper

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean SC (mg/g)	BAFinv		Mean IC (mg/g)	IT(a) (g/d)	HRF	ED	BW (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs									
DIELDRIN	7.00E-05	3	(4)	2.10E-04	2.867	0.5	0.5	0.164	9.18E-04
4,4'-DDT	4.10E-04	3	(4)	1.23E-03	2.867	0.5	0.5	0.164	5.38E-03
INORGANICS									
ARSENIC	3.60E-03	0.24	(3)	8.64E-04	2.867	0.5	0.5	0.164	3.78E-03
CADMIUM	7.80E-04	14	(3)	1.09E-02	2.867	0.5	0.5	0.164	4.77E-02
CHROMIUM	8.80E-03	0.3	(3)	2.64E-03	2.867	0.5	0.5	0.164	1.15E-02
CYANIDE	5.30E-05	0.31	(1)	1.64E-05	2.867	0.5	0.5	0.164	7.18E-05
LEAD	6.30E-02	0.27	(3)	1.70E-02	2.867	0.5	0.5	0.164	7.43E-02
MANGANESE	7.20E-02	0.054	(3)	3.89E-03	2.867	0.5	0.5	0.164	1.70E-02
VANADIUM	1.90E-02	0.042	(3)	7.98E-04	2.867	0.5	0.5	0.164	3.49E-03
ZINC	4.30E-02	3.78	(3)	1.63E-01	2.867	0.5	0.5	0.164	7.10E-01

BAFinv = bioaccumulation factor for invertebrates
BW = body weight (kg)
D = exposure dose (mg/kg/d)
ED = exposure duration (migration) (year)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IT = COC intake via invertebrate ingestion (dry weight) (g/d)
SC = soil concentration (dry weight) (mg/g)

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-100
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Cardinal

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAFinv	Max IC (mg/g)	PInv	PP	PS	IR (g/d)	IT (mg/d)	PI (mg/d)	SI (mg/d)	Max WC (mg/L)	WI (L/day)	HRF	BW (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs																	
DIELDRIN	1.00E-01	1.20E-04	1.20E-05	3 (4)	3.60E-04	0.3	0.70	0.03	0.90	1.08E-04	8.27E-06	3.54E-06	0	NA	0.5	0.044	1.34E-03
4,4'- DDT	1.58E-02	9.30E-04	1.47E-05	3 (4)	2.79E-03	0.3	0.70	0.03	0.90	8.24E-04	1.01E-05	2.75E-05	0	NA	0.5	0.044	9.79E-03
INORGANICS																	
ARSENIC	6.00E-03	4.80E-03	2.88E-05	0.24 (3)	1.15E-03	0.3	0.70	0.03	0.90	3.40E-04	1.98E-05	1.42E-04	0	NA	0.5	0.044	5.70E-03
CADMIUM	1.50E-01	1.10E-03	1.65E-04	14 (3)	1.54E-02	0.3	0.70	0.03	0.90	4.55E-03	1.14E-04	3.25E-05	0	NA	0.5	0.044	5.34E-02
CHROMIUM	4.50E-03	1.15E-02	5.18E-05	0.3 (3)	3.45E-03	0.3	0.70	0.03	0.90	1.02E-03	3.57E-05	3.40E-04	0	NA	0.5	0.044	1.58E-02
CYANIDE	1.75E+01	1.00E-04	1.75E-03	0.31 (1)	3.10E-05	0.3	0.70	0.03	0.90	9.18E-06	1.21E-03	2.95E-06	0	NA	0.5	0.044	1.38E-02
LEAD	9.00E-03	1.19E-01	1.07E-03	0.27 (3)	3.21E-02	0.3	0.70	0.03	0.90	9.49E-03	7.38E-04	3.52E-03	0	NA	0.5	0.044	1.56E-01
MANGANESE	5.00E-02	9.20E-02	4.60E-03	0.054 (3)	4.97E-03	0.3	0.70	0.03	0.90	1.47E-03	3.17E-03	2.72E-03	0	NA	0.5	0.044	8.36E-02
VANADIUM	3.00E-03	2.25E-02	6.75E-05	0.042 (3)	9.45E-04	0.3	0.70	0.03	0.90	2.79E-04	4.85E-05	8.85E-04	0	NA	0.5	0.044	1.13E-02
ZINC	9.00E-01	6.80E-02	6.12E-02	3.78 (3)	2.57E-01	0.3	0.70	0.03	0.90	7.59E-02	4.22E-02	2.01E-03	0	NA	0.5	0.044	1.36E+00

BW = body weight (kg)
BAFinv = bioaccumulation factor for invertebrates
D = exposure dose (mg/kg/d)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IR = ingestion rate of species of concern (dry weight) (g/d)
IT = COC intake via invertebrate ingestion (mg/d)
PC = plant concentration (dry weight) (mg/g)

PI = COC intake via plant ingestion (mg/d)
PInv = percentage of diet from invertebrates
PP = percentage of diet from plants
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to-mg/g dry plant)
SI = COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al. 1998
(4) MJE RAH

Table 2-110
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Cardinal

AOC FS-10 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAFinv	Mean IC (mg/g)	PInv	PP	PS	IR (g/d)	IT (mg/d)	PI (mg/d)	SI (mg/d)	Mean WC (mg/L)	WI (L/d)	HRF	BW (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs																	
DIELDRIN	1.00E-01	7.00E-05	7.00E-06	3 (4)	2.10E-04	0.3	0.70	0.03	0.98	6.20E-05	4.82E-06	2.07E-06	0	NA	0.5	0.044	7.83E-04
4,4'-DDT	1.58E-02	4.10E-04	6.48E-06	3 (4)	1.23E-03	0.3	0.70	0.03	0.98	3.63E-04	4.46E-06	1.21E-05	0	NA	0.5	0.044	4.32E-03
INORGANICS																	
ARSENIC	6.00E-03	3.60E-03	2.16E-05	0.24 (3)	8.64E-04	0.3	0.70	0.03	0.98	2.55E-04	1.49E-05	1.06E-04	0	NA	0.5	0.044	4.28E-03
CADMIUM	1.50E-01	7.80E-04	1.17E-04	14 (3)	1.09E-02	0.3	0.70	0.03	0.98	3.23E-03	8.06E-05	2.30E-05	0	NA	0.5	0.044	3.78E-02
CHROMIUM	4.50E-03	8.80E-03	3.96E-05	0.3 (3)	2.64E-03	0.3	0.70	0.03	0.98	7.80E-04	2.73E-05	2.60E-04	0	NA	0.5	0.044	1.21E-02
CYANIDE	1.75E+01	5.30E-05	9.28E-04	0.31 (1)	1.64E-05	0.3	0.70	0.03	0.98	4.85E-06	8.39E-04	1.57E-06	0	NA	0.5	0.044	7.34E-03
LEAD	9.00E-03	6.30E-02	5.67E-04	0.27 (3)	1.70E-02	0.3	0.70	0.03	0.98	5.02E-03	3.91E-04	1.86E-03	0	NA	0.5	0.044	8.27E-02
MANGANESE	5.00E-02	7.20E-02	3.60E-03	0.054 (3)	3.89E-03	0.3	0.70	0.03	0.98	1.15E-03	2.48E-03	2.13E-03	0	NA	0.5	0.044	8.54E-02
VANADIUM	3.00E-03	1.90E-02	5.70E-05	0.042 (3)	7.98E-04	0.3	0.70	0.03	0.98	2.36E-04	3.93E-05	5.81E-04	0	NA	0.5	0.044	9.50E-03
ZINC	9.00E-01	4.30E-02	3.87E-02	3.78 (3)	1.63E-01	0.3	0.70	0.03	0.98	4.80E-02	2.67E-02	1.27E-03	0	NA	0.5	0.044	8.63E-01

BW = body weight (kg)
BAFinv = bioaccumulation factor for invertebrates
D = exposure dose (mg/kg/d)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IR = ingestion rate of species of concern (dry weight) (g/d)
IT = COC intake via invertebrate ingestion (mg/d)
PC = plant concentration (dry weight) (mg/g)

(1) Mercie et al. 1992
(2) Beyer and Stafford 1993

PI = COC intake via plant ingestion (mg/d)
PInv = percentage of diet from invertebrates
PP = percentage of diet from plants
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to-mg/g dry plant)
SI = COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-111
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max SC (mg/g)	BAFinv	Max IC (mg/g)	IT(a) (g/d)	HRF	ED	BW (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs								
DIELDRIN	1.20E-04	3 (4)	3.60E-04	0.01	0.5	0.5	0.0139	4.14E-05
4,4'-DDT	9.30E-04	3 (4)	2.79E-03	0.01	0.5	0.5	0.0139	3.21E-04
INORGANICS								
ARSENIC	4.80E-03	0.24 (3)	1.15E-03	0.01	0.5	0.5	0.0139	1.33E-04
CADMIUM	1.10E-03	14 (3)	1.54E-02	0.01	0.5	0.5	0.0139	1.77E-03
CHROMIUM	1.15E-02	0.3 (3)	3.45E-03	0.01	0.5	0.5	0.0139	3.97E-04
CYANIDE	1.00E-04	0.31 (1)	3.10E-05	0.01	0.5	0.5	0.0139	3.57E-06
LEAD	1.19E-01	0.27 (3)	3.21E-02	0.01	0.5	0.5	0.0139	3.70E-03
MANGANESE	9.20E-02	0.054 (3)	4.97E-03	0.01	0.5	0.5	0.0139	5.72E-04
VANADIUM	2.25E-02	0.042 (3)	9.45E-04	0.01	0.5	0.5	0.0139	1.09E-04
ZINC	6.80E-02	3.78 (3)	2.57E-01	0.01	0.5	0.5	0.0139	2.96E-02

BAFinv = bioaccumulation factor for invertebrates
BW = body weight (kg)
D = exposure dose (mg/kg/d)
ED = exposure duration (migration) (year)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IT = COC intake via invertebrate ingestion (dry weight) (g/d)
SC = soil concentration (dry weight) (mg/g)

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-112
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean SC (mg/g)	BAFinv	Mean IC (mg/g)	IT(a) (g/d)	HRF	ED	BW (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs								
DIELDRIN	7.00E-05	3 (4)	2.10E-04	0.01	0.5	0.5	0.0139	2.42E-05
4,4'-DDT	4.10E-04	3 (4)	1.23E-03	0.01	0.5	0.5	0.0139	1.42E-04
INORGANICS								
ARSENIC	3.60E-03	0.24 (3)	8.64E-04	0.01	0.5	0.5	0.0139	9.95E-05
CADMIUM	7.80E-04	14 (3)	1.09E-02	0.01	0.5	0.5	0.0139	1.26E-03
CHROMIUM	8.80E-03	0.3 (3)	2.64E-03	0.01	0.5	0.5	0.0139	3.04E-04
CYANIDE	5.30E-05	0.31 (1)	1.64E-05	0.01	0.5	0.5	0.0139	1.89E-06
LEAD	6.30E-02	0.27 (3)	1.70E-02	0.01	0.5	0.5	0.0139	1.96E-03
MANGANESE	7.20E-02	0.054 (3)	3.89E-03	0.01	0.5	0.5	0.0139	4.48E-04
VANADIUM	1.90E-02	0.042 (3)	7.98E-04	0.01	0.5	0.5	0.0139	9.19E-05
ZINC	4.30E-02	3.78 (3)	1.63E-01	0.04	0.5	0.5	0.0139	1.17E-01

BAFinv = bioaccumulation factor for invertebrates
BW = body weight (kg)
D = exposure dose (mg/kg/d)
ED = exposure duration (migration) (year)
HRF = home range factor
IC = invertebrate concentration (dry weight) (mg/g)
IT = COC intake via invertebrate ingestion (dry weight) (g/d)
SC = soil concentration (dry weight) (mg/g)

(1) Menzie et al. 1992
(2) Beyer and Stafford 1993
(3) Sample et al 1998
(4) MMR RAH

(a) EPA 1993

Table 2-113
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Harrier

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAF kg diet kg mammal	Max Cm (mg/g)	IR (g/d)	PS	PM	SI (mg/d)	MI (mg/d)	Max WC (mg/L)	WI (L/day)	HRF	BW (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs															
DIELDRIN	1.00E-01	1.20E-04	1.20E-05	1.07E+00	1.28E-05	160	0.00	1.00	0.00E+00	2.05E-03	0	NA	0.00013	0.530	5.04E-07
4,4'-DDT	1.58E-02	9.30E-04	1.47E-05	6.13E-01	9.01E-06	160	0.00	1.00	0.00E+00	1.44E-03	0	NA	0.00013	0.530	3.53E-07
INORGANICS															
ARSENIC	4.00E-02	4.80E-03	1.92E-04	2.50E-03 (a)	4.80E-07	160	0.00	1.00	0.00E+00	7.68E-05	0	NA	0.00013	0.530	1.88E-08
CADMIUM	5.50E-01	1.10E-03	6.05E-04	3.33E-01 (a)	2.02E-04	160	0.00	1.00	0.00E+00	3.23E-02	0	NA	0.00013	0.530	7.91E-06
CHROMIUM	7.50E-03	1.15E-02	8.63E-05	8.46E-02 (a)	7.30E-06	160	0.00	1.00	0.00E+00	1.17E-03	0	NA	0.00013	0.530	2.86E-07
CYANIDE	1.75E+01	2.44E-02	4.27E-01	1.95E-03	8.33E-04	160	0.00	1.00	0.00E+00	1.33E-01	0	NA	0.00013	0.530	3.27E-05
LEAD	4.50E-02	1.19E-01	5.36E-03	1.05E-01 (a)	5.64E-04	160	0.00	1.00	0.00E+00	9.03E-02	0	NA	0.00013	0.530	2.22E-05
MANGANESE	2.50E-01	9.20E-02	2.30E-02	2.05E-02 (a)	4.72E-04	160	0.00	1.00	0.00E+00	7.54E-02	0	NA	0.00013	0.530	1.85E-05
VANADIUM	5.50E-03	2.25E-02	1.24E-04	1.23E-02 (a)	1.52E-06	160	0.00	1.00	0.00E+00	2.44E-04	0	NA	0.00013	0.530	5.97E-08
ZINC	1.50E+00	6.80E-02	1.02E-01	7.72E-01 (a)	7.87E-02	160	0.00	1.00	0.00E+00	1.26E+01	0	NA	0.00013	0.530	3.09E-03

BW = body weight (kg)
BAF kg diet/kg mammal = bioaccumulation rate
D = exposure dosage (mg/kg/d)
Cm = concentration in mammal (dry weight) (mg/g)
HRF = home range factor
IR = ingestion rate of species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available
PC = plant concentration (dry weight) (mg/g)

(a) Sample et al 1998 (RAH is current for all others)

PM = percentage of diet from small mammals
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to mg/g dry plant)
SI =COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-114
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Harrier

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAF kg diet kg mammal	Mean Cm (mg/g)	IR (g/d)	PS	PM	SI (mg/d)	MI (mg/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs															
DIELDRIN	1.00E-01	7.00E-05	7.00E-06	1.07E+00	7.49E-06	160	0.00	1.00	0.00E+00	1.20E-03	0	NA	0.00013	0.530	2.94E-07
4,4'-DDT	1.58E-02	4.10E-04	6.48E-06	6.13E-01	3.97E-06	160	0.00	1.00	0.00E+00	6.35E-04	0	NA	0.00013	0.530	1.56E-07
INORGANICS															
ARSENIC	4.00E-02	3.60E-03	1.44E-04	2.50E-03 (a)	3.60E-07	160	0.00	1.00	0.00E+00	5.76E-05	0	NA	0.00013	0.530	1.41E-08
CADMIUM	5.50E-01	7.80E-04	4.29E-04	3.33E-01 (a)	1.43E-04	160	0.00	1.00	0.00E+00	2.29E-02	0	NA	0.00013	0.530	5.61E-06
CHROMIUM	7.50E-03	8.80E-03	6.60E-05	8.46E-02 (a)	5.58E-06	160	0.00	1.00	0.00E+00	8.93E-04	0	NA	0.00013	0.530	2.19E-07
CYANIDE	1.75E+01	1.70E-02	2.98E-01	1.95E-03	5.80E-04	160	0.00	1.00	0.00E+00	9.28E-02	0	NA	0.00013	0.530	2.28E-05
LEAD	4.50E-02	6.30E-02	2.84E-03	1.05E-01 (a)	2.99E-04	160	0.00	1.00	0.00E+00	4.78E-02	0	NA	0.00013	0.530	1.17E-05
MANGANESE	2.50E-01	7.20E-02	1.80E-02	2.05E-02 (a)	3.69E-04	160	0.00	1.00	0.00E+00	5.90E-02	0	NA	0.00013	0.530	1.45E-05
VANADIUM	5.50E-03	1.90E-02	1.05E-04	1.23E-02 (a)	1.29E-06	160	0.00	1.00	0.00E+00	2.06E-04	0	NA	0.00013	0.530	5.04E-08
ZINC	1.50E+00	4.30E-02	6.45E-02	7.72E-01 (a)	4.98E-02	160	0.00	1.00	0.00E+00	7.96E+00	0	NA	0.00013	0.530	1.95E-03

BW = body weight (kg)
BAF kg diet/kg mammal = bioaccumulation rate
D = exposure dosage (mg/kg/d)
Cm = concentration in mammal (dry weight) (mg/g)
HRF = home range factor
IR = ingestion rate of species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available
PC = plant concentration (dry weight) (mg/g)

(a) Sample et al 1998 (RAH is current for all others)

PM = percentage of diet from small mammals
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to mg/g dry plant)
SI =COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-115
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Short-eared Owl

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAF kg diet/ kg mammal	Max Cm (mg/g)	IR (g/d)	PS	PM	SI (mg/d)	MI (mg/d)	Max WC (mg/L)	WI (L/day)	HRF	BW (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs															
DIELDRIN	1.00E-01	1.20E-04	1.20E-05	1.07E+00	1.28E-05	113.92	0.00	1.00	0.00E+00	1.46E-03	0	NA	0.001	0.378	3.87E-06
4,4'- DDT	1.58E-02	9.30E-04	1.47E-05	6.13E-01	9.01E-06	113.92	0.00	1.00	0.00E+00	1.03E-03	0	NA	0.001	0.378	2.71E-06
INORGANICS															
ARSENIC	4.00E-02	4.80E-03	1.92E-04	2.50E-03 (a)	4.80E-07	113.92	0.00	1.00	0.00E+00	5.47E-05	0	NA	0.001	0.378	1.45E-07
CADMIUM	5.50E-01	1.10E-03	6.05E-04	3.33E-01 (a)	2.02E-04	113.92	0.00	1.00	0.00E+00	2.30E-02	0	NA	0.001	0.378	6.08E-05
CHROMIUM	7.50E-03	1.15E-02	8.63E-05	8.46E-02 (a)	7.30E-06	113.92	0.00	1.00	0.00E+00	8.31E-04	0	NA	0.001	0.378	2.20E-06
CYANIDE	1.75E+01	1.00E-04	1.75E-03	1.95E-03	3.41E-06	113.92	0.00	1.00	0.00E+00	3.89E-04	0	NA	0.001	0.378	1.03E-06
LEAD	4.50E-02	1.19E-01	5.36E-03	1.05E-01 (a)	5.64E-04	113.92	0.00	1.00	0.00E+00	6.43E-02	0	NA	0.001	0.378	1.70E-04
MANGANESE	2.50E-01	9.20E-02	2.30E-02	2.05E-02 (a)	4.72E-04	113.92	0.00	1.00	0.00E+00	5.37E-02	0	NA	0.001	0.378	1.42E-04
VANADIUM	5.50E-03	2.25E-02	1.24E-04	1.23E-02 (a)	1.52E-06	113.92	0.00	1.00	0.00E+00	1.73E-04	0	NA	0.001	0.378	4.59E-07
ZINC	1.50E+00	6.80E-02	1.02E-01	7.72E-01 (a)	7.87E-02	113.92	0.00	1.00	0.00E+00	8.97E+00	0	NA	0.001	0.378	2.37E-02

BW = body weight (kg)
BAF kg diet/kg mammal = bioaccumulation rate
D = exposure dosage (mg/kg/d)
Cm = concentration in mammal (dry weight) (mg/g)
HRF = home range factor
IR = ingestion rate of species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available
PC = plant concentration (dry weight) (mg/g)

(a) Sample et al. 1998 (RAH is current for all others)

PM = percentage of diet from small mammals
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to mg/g dry plant)
SI = COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-116
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Short-eared Owl

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAF kg diet/ kg mammal	Mean Cm (mg/g)	IR (g/d)	PS	PM	SI (mg/d)	MI (mg/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs															
DIELDRIN	1 00E-01	7 00E-05	7 00E-06	1.07E+00	7 49E-06	113.92	0.00	1.00	0 00E+00	8.53E-04	0	NA	0 001	0 378	2 26E-06
4, 4'-DDT	1.58E-02	4 10E-04	6 48E-06	6 13E-01	3 97E-06	113 92	0.00	1.00	0 00E+00	4 52E-04	0	NA	0 001	0 378	1 20E-06
INORGANICS															
ARSENIC	4 00E-02	3.60E-03	1.44E-04	2 50E-03 (a)	3 60E-07	113 92	0 00	1 00	0.00E+00	4.10E-05	0	NA	0 001	0 378	1.08E-07
CADMIUM	5 50E-01	7 80E-04	4 29E-04	3 33E-01 (a)	1 43E-04	113 92	0 00	1 00	0.00E+00	1 63E-02	0	NA	0 001	0 378	4 31E-05
CHROMIUM	7 50E-03	8 80E-03	6 60E-05	8 46E-02 (a)	5 58E-06	113 92	0 00	1 00	0 00E+00	6.36E-04	0	NA	0 001	0 378	1 68E-06
CYANIDE	1.75E+01	5 30E-05	9 28E-04	1 95E-03	1 81E-06	113 92	0 00	1.00	0 00E+00	2 06E-04	0	NA	0 001	0 378	5 45E-07
LEAD	4 50E-02	6 30E-02	2 84E-03	1 05E-01 (a)	2 99E-04	113 92	0.00	1.00	0 00E+00	3 40E-02	0	NA	0 001	0 378	9 01E-05
MANGANESE	2 50E-01	7 20E-02	1 80E-02	2 05E-02 (a)	3 69E-04	113 92	0.00	1.00	0 00E+00	4 20E-02	0	NA	0.001	0.378	1 11E-04
VANADIUM	5 50E-03	1 90E-02	1 05E-04	1 23E-02 (a)	1 29E-06	113 92	0 00	1.00	0 00E+00	1 46E-04	0	NA	0.001	0 378	3 87E-07
ZINC	1 50E+00	4 30E-02	6 45E-02	7 72E-01 (a)	4 98E-02	113.92	0 00	1 00	0.00E+00	5.67E+00	0	NA	0.001	0 378	1.50E-02

BW = body weight (kg)
BAF kg diet/kg mammal = bioaccumulation rate
D = exposure dosage (mg/kg/d)
Cm = concentration in mammal (dry weight) (mg/g)
HRF = home range factor
IR = ingestion rate of species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available
PC = plant concentration (dry weight) (mg/g)

(a) Sample et al 1998 (RAH is current for all others)

PM = percentage of diet from small mammals
PS = percentage of diet from soil
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor (mg/g dry soil-to mg/g dry plant)
SI =COC intake via soil ingestion (mg/d)
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-117
Ecological Exposure Dose for Food Chain Receptors
Maximum Concentrations
Surface Soil
Red Fox

AOC FS-16 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Max SC (mg/g)	Max PC (mg/g)	BAF kg diet kg bird	BAF kg diet kg mammal	Max Cb (mg/g)	Max Cm (mg/g)	IR(b) (g/d)	PS	PB	PM	SI (mg/d)	BI (mg/d)	MI (mg/d)	Max WC (mg/L)	WI (L/day)	HRF	BW(b) (kg)	Max D (mg/kg/d)
PESTICIDES/PCBs																			
DIELDRIN	1.00E-01	1.20E-04	1.20E-05	2.00E+00	1.07E+00	3.22E-05	1.20E-05	115.90	0.03	0.25	0.72	4.17E-04	9.32E-04	1.07E-03	0	0.5669	0.0002	5.25	9.22E-08
4,4'- DDT	1.58E-02	9.30E-04	1.47E-05	3.08E+00	8.13E-01	4.53E-05	9.01E-06	115.90	0.03	0.25	0.72	3.23E-03	1.31E-03	7.52E-04	0	0.5669	0.0002	5.25	2.02E-07
INORGANICS																			
ARSENIC	4.00E-02	4.80E-03	1.92E-04	1.18E+00	2.50E-03 (a)	2.27E-04	4.80E-07	115.90	0.03	0.25	0.72	1.87E-02	8.56E-03	4.01E-05	0	0.5669	0.0002	5.25	8.87E-07
CADMIUM	5.50E-01	1.10E-03	6.05E-04	3.25E-01	3.33E-01 (a)	1.96E-04	2.02E-04	115.90	0.03	0.25	0.72	3.82E-03	5.89E-03	1.68E-02	0	0.5669	0.0002	5.25	1.00E-06
CHROMIUM	7.50E-03	1.15E-02	8.63E-05	3.25E+00	8.46E-02 (a)	2.80E-04	7.30E-06	115.90	0.03	0.25	0.72	4.00E-02	8.11E-03	6.09E-04	0	0.5669	0.0002	5.25	1.98E-06
CYANIDE	1.75E+01	1.00E-04	1.75E-03	5.20E-03	1.95E-03	9.26E-06	3.41E-06	115.90	0.03	0.25	0.72	3.48E-04	2.88E-04	2.85E-04	0	0.5669	0.0002	5.25	3.43E-08
LEAD	4.50E-02	1.19E-01	5.36E-03	1.77E-01	1.05E-01 (a)	8.48E-04	5.84E-04	115.90	0.03	0.25	0.72	4.14E-01	2.75E-02	4.71E-02	0	0.5669	0.0002	5.25	1.86E-05
MANGANESE	2.50E-01	8.20E-02	2.30E-02	2.38E-01	2.05E-02 (a)	5.43E-03	4.72E-04	115.90	0.03	0.25	0.72	3.20E-01	1.57E-01	3.83E-02	0	0.5669	0.0002	5.25	1.07E-05
VANADIUM	5.50E-03	2.25E-02	1.24E-04	1.48E+00	1.23E-02 (a)	1.83E-04	1.52E-08	115.90	0.03	0.25	0.72	7.82E-02	5.29E-03	1.27E-04	0	0.5669	0.0002	5.25	3.19E-06
ZINC	1.50E+00	6.80E-02	1.02E-01	5.90E+01	7.72E-01 (a)	6.02E+00	7.87E-02	115.90	0.03	0.25	0.72	2.36E-01	1.74E+02	6.57E+00	0	0.5669	0.0002	5.25	6.90E-03

BAF kg diet/kg bird = bioaccumulation rate
BW = body weight (kg)
BI =COC intake via bird ingestion
Cb = whole body burden in bird (dry weight) (mg/g)
Cm = concentration in mammal(dry weight) (mg/g)
D = exposure dose (mg/kg/d)
HRF = home range factor
IR = ingestion rate by species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available

PB = percentage of diet from birds
PC = plant concentration (dry weight) (mg/g)
PM = percentage of diet from small mammals
PS = percentage of diet from soil
SI =COC intake via soil ingestion (mg/d)
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor
WC = water concentration (mg/L)
WI = water intake rate (L/d)

(a) Sample et al 1996 (RAH is current for all others)
(b) EPA 1993

Table 2-118
Ecological Exposure Dose for Food Chain Receptors
Mean Concentrations
Surface Soil
Red Fox

AOC PS-19 Study Area
Massachusetts Military Reservation

COC	SCF (mg/g dry soil) (mg/g dry plant)	Mean SC (mg/g)	Mean PC (mg/g)	BAF kg diet kg bird	BAF kg diet kg mammal	Mean Cb (mg/g)	Mean Cm (mg/g)	IR(b) (g/d)	PS	PB	PM	SI (mg/d)	BI (mg/d)	MI (mg/d)	Mean WC (mg/L)	WI (L/day)	HRF	BW(b) (kg)	Mean D (mg/kg/d)
PESTICIDES/PCBs																			
DIELDRIN	1.00E-01	7.00E-05	7.00E-06	2.60E+00	1.07E+00	1.00E-06	7.49E-06	115.90	0.03	0.25	0.72	2.43E-04	6.44E-04	6.25E-04	0	0.5669	0.0002	5.25	5.38E-08
4,4'-DDT	1.50E-02	4.10E-04	6.40E-06	3.00E+00	6.13E-01	2.00E-06	3.97E-06	115.90	0.03	0.25	0.72	1.43E-03	5.70E-04	3.31E-04	0	0.5669	0.0002	5.25	8.90E-08
INORGANICS																			
ARSENIC	4.00E-02	3.60E-03	1.44E-04	1.10E+00	2.50E-03 (a)	1.70E-04	3.60E-07	115.90	0.03	0.25	0.72	1.25E-02	4.92E-03	3.00E-06	0	0.5669	0.0002	5.25	6.66E-07
CADMIUM	5.50E-01	7.00E-04	4.25E-04	3.25E-01	3.33E-01 (a)	1.39E-04	1.43E-04	115.90	0.03	0.25	0.72	2.71E-03	4.03E-03	1.19E-02	0	0.5669	0.0002	5.25	7.12E-07
CHROMIUM	7.50E-03	8.00E-03	6.00E-05	3.25E+00	8.49E-02 (a)	2.14E-04	5.50E-06	115.90	0.03	0.25	0.72	3.06E-02	6.21E-03	4.66E-04	0	0.5669	0.0002	5.25	1.42E-06
CYANIDE	1.75E+01	5.30E-05	9.28E-04	5.25E-03	1.95E-03	4.91E-06	1.01E-06	115.90	0.03	0.25	0.72	1.04E-04	1.42E-04	1.51E-04	0	0.5669	0.0002	5.25	1.02E-08
LEAD	4.50E-02	6.30E-02	2.84E-03	1.77E-01	1.05E-01 (a)	6.02E-04	2.99E-04	115.90	0.03	0.25	0.72	2.19E-01	1.45E-02	2.49E-02	0	0.5669	0.0002	5.25	9.85E-06
MANGANESE	2.50E-01	7.20E-02	1.80E-02	2.36E-01	2.05E-02 (a)	4.25E-03	3.69E-04	115.90	0.03	0.25	0.72	2.50E-01	1.23E-01	3.08E-02	0	0.5669	0.0002	5.25	1.54E-05
VANADIUM	5.50E-03	1.90E-02	1.05E-04	1.48E+00	1.23E-02 (a)	1.64E-04	1.29E-06	115.90	0.03	0.25	0.72	6.61E-02	4.47E-03	1.07E-04	0	0.5669	0.0002	5.25	2.69E-06
ZINC	1.50E+00	4.30E-02	6.45E-02	5.90E+01	7.72E-01 (a)	3.81E+00	4.90E-02	115.90	0.03	0.25	0.72	1.50E-01	1.10E+02	4.15E+00	0	0.5669	0.0002	5.25	4.36E-03

BAF kg diet/kg bird = bioaccumulation rate
BW = body weight (kg)
BI =COC intake via bird ingestion
Cb = whole body burden in bird (dry weight) (mg/g)
Cm = concentration in mammal(dry weight) (mg/g)
D = exposure dose (mg/kg/d)
HRF = home range factor
IR = ingestion rate by species of concern (dry weight) (g/d)
MI = COC intake via mammal ingestion (mg/d)
NA = not available

(a) Sample et al 1998 (RAI is current for all others)
(b) EPA 1993

PB = percentage of diet from birds
PC = plant concentration (dry weight) (mg/g)
PM = percentage of diet from small mammals
PS = percentage of diet from soil
SI =COC intake via soil ingestion (mg/d)
SC = soil concentration (dry weight) (mg/g)
SCF = soil-to-plant concentration factor
WC = water concentration (mg/L)
WI = water intake rate (L/d)

Table 2-119
Terrestrial Vegetation Risk Characterization
Maximum Soil Concentrations
FS19

Unit - mg/kg	Max conc. in Surface soil mg/kg	Critical Soil Concentration (a) mg/kg	HQ
Inorganics			
Aluminum	13800	NA	NE
Arsenic	4.8	20	2.40E-01
Barium	57.9	NA	NE
Beryllium	0.39	NA	NE
Cadmium	1.1	3	3.67E-01
Chromium	11.5	75	1.53E-01
Cobalt	3.2	25	1.28E-01
Cyanide	0.1	NA	NE
Lead	119	100	1.19E+00
Manganese	92	1500	6.13E-02
Nickel	6	100	6.00E-02
Vanadium	22.5	NA	NE
Zinc	68	70	9.71E-01
	Inorganic HI =	3.17	
Semi-volatile Organics			
2-Methylnaphthalene	0.038	8.6	4.42E-03
Acenaphthylene	0.022	5.77	3.81E-03
Anthracene	0.011	6.59	1.67E-03
Benzo(a)anthracene	0.064	7.82	8.18E-03
Benzo(a)pyrene	0.065	8.48	7.67E-03
Benzo(b)fluoranthene	0.16	8.46	1.89E-02
Benzo(ghi)perylene	0.045	8.98	5.01E-03
Benzo(k)fluoranthene	0.16	8.46	1.89E-02
Chrysene	0.089	7.82	1.14E-02
Dibenzo(ah)anthracene	0.029	9	3.22E-03
Di-n-butyl phthalate	0.02	38.7	5.17E-04
Fluoranthene	0.17	7.26	2.34E-02
Indeno(123-cd)pyrene	0.049	8.98	5.46E-03
Naphthalene	0.029	10	2.90E-03
Phenanthrene	0.11	4.16	2.64E-02
Pyrene	0.13	7.08	1.84E-02
	SVOC HI =	0.16	
Volatile Organics			
Acetone	0.005	318.25	1.57E-05
Chloroform	0.001	73.43	1.36E-05
Methylene Chloride	0.001	138.4	7.23E-06
Toluene	0.002	33.6	5.95E-05
Total Xylenes	0.003	1.68	1.79E-03
	VOC HI =	0.002	
Pesticides/PBCs			
4,4'-DDD	0.019	50	3.80E-04
4,4'-DDE	0.11	50	2.20E-03
4,4'-DDT	0.93	50	1.86E-02
alpha-Chlordane	0.0013	NA	NE
Aroclor-1260	0.54	10	5.40E-02
Dieldrin	0.12	1.39	8.63E-02
Endrin ketone	0.032	29.42	1.09E-03
gamma-Chlordane	0.003	NA	NE
Methoxychlor	0.034	12.5	2.72E-03
	Pesticide/PCB HI =	0.17	

HI = 3.5

obtained from Tables O-3 and O-4

HI - Hazard Index
NA - Not Available
NE - Not Evaluated

Table 2-120
Terrestrial Vegetation Risk Characterization
Mean Soil Concentrations
FS19

Unit - mg/kg	Mean conc. in Surface soil mg/kg	Critical Soil Concentration (a) mg/kg	HQ
Inorganics			
Aluminum	9680	NA	NE
Arsenic	3.6	20	0.180
Barium	30	NA	NE
Beryllium	0.27	NA	NE
Cadmium	0.78	3	0.260
Chromium	8.8	75	0
Cobalt	2.6	25	0.104
Cyanide	0.053	NA	NE
Lead	63	100	0.630
Manganese	72	1500	0.048
Nickel	5.1	100	0.051
Vanadium	19	NA	NE
Zinc	43	70	0.6143
	Inorganic HI =	**2.0**	
Semi-volatile Organics			
2-Methylnaphthalene	0.14	8.6	0.016
Acenaphthylene	0.14	5.77	0.024
Anthracene	0.13	6.59	0.020
Benzo(a)anthracene	0.051	7.82	0.007
Benzo(a)pyrene	0.048	8.48	0.006
Benzo(b)fluoranthene	0.11	8.46	0.013
Benzo(ghi)perylene	0.034	8.98	0.004
Benzo(k)fluoranthene	0.11	8.46	0.013
Chrysene	0.062	7.82	0.008
Dibenzo(ah)anthracene	0.14	9	0.016
Di-n-butyl phthalate	0.079	38.7	0.002
Fluoranthene	0.11	7.26	0.015
Indeno(123-cd)pyrene	0.039	8.98	0.004
Naphthalene	0.14	10	0.014
Phenanthrene	0.062	4.16	0.015
Pyrene	0.089	7.08	0.013
	SVOC HI =	**0.2**	
Volatile Organics			
Acetone	0.0055	318.25	1.7282E-05
Chloroform	0.001	73.43	1.3618E-05
Methylene Chloride	0.0027	138.4	1.9509E-05
Toluene	0.003	33.6	8.929E-05
Total Xylenes	0.005	1.68	0.003
	VOC HI =	**0.003**	
Pesticides/PBCs			
4,4'-DDD	0.011	50	2.200E-04
4,4'-DDE	0.055	50	0.001
4,4'-DDT	0.41	50	0.008
alpha-Chlordane	0.0012	NA	NE
Aroclor-1260	0.27	10	0.027
Dieldrin	0.07	1.39	0.050
Endrin ketone	0.21	29.42	0.007
gamma-Chlordane	0.0022	NA	NE
Methoxychlor	0.025	12.5	0.002
	Pesticide/PCB HI =	**0.096**	

HI = 2.3

obtained from Tables O-3 and O-4

HI - Hazard Index
NA - Not Available
NE - Not Evaluated

Table 2-121
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Meadow Vole

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day	Hazard Quotient
PESTICIDES/PCBs			
DIELDRIN	7.62E-04	0.034	2.24E-02
4, 4' DDT	2.11E-03	1.34	1.57E-03
INORGANICS			
ARSENIC	1.65E-02	0.114	1.45E-01
CADMIUM	3.10E-02	1.62	1.91E-02
CHROMIUM	2.14E-02	5.51	3.89E-03
CYANIDE	8.51E-02	108.4	7.85E-04
LEAD	4.38E-01	13.44	3.26E-02
MANGANESE	1.25E+00	148	8.47E-03
VANADIUM	3.98E-02	0.327	1.22E-01
ZINC	5.05E+00	268.7	1.88E-02
		HI =	0.4

(a) values obtained from Suter et al. 1996

Table 2-122
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Meadow Vole

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day	Hazard Quotient
PESTICIDES/PCBs			
DIELDREN	4.45E-04	0.034	1.31E-02
4, 4' DDT	9.30E-04	1.34	6.94E-04
INORGANICS			
ARSENIC	1.24E-02	0.114	1.09E-01
CADMIUM	2.20E-02	1.62	1.36E-02
CHROMIUM	1.64E-02	5.51	2.98E-03
CYANIDE	4.51E-02	108.4	4.16E-04
LEAD	2.32E-01	13.44	1.73E-02
MANGANESE	9.81E-01	148	6.63E-03
VANADIUM	3.36E-02	0.327	1.03E-01
ZINC	3.19E+00	268.7	1.19E-02
		HI =	0.3

(a) values obtained from Suter et al. 1996

Table 2-123
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
White-footed Mouse

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day	Hazard Quotient
PESTICIDES/PCBs			
DIELDRIN	1.27E-03	0.04	3.18E-02
4,4'-DDT	9.86E-03	1.6	6.16E-03
INORGANICS			
ARSENIC	6.67E-03	0.136	4.91E-02
CADMIUM	5.21E-02	1.926	2.70E-02
CHROMIUM	1.83E-02	6.55	2.79E-03
CYANIDE	1.95E-04	128.9	1.51E-06
LEAD	1.77E-01	15.98	1.11E-02
MANGANESE	7.49E-02	176	4.25E-04
VANADIUM	1.64E-02	0.389	4.22E-02
ZINC	9.38E-01	319.5	2.94E-03

0.2

(a) values obtained from Suter et al. 1996

Table 2-124
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
White-footed Mouse

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day	Hazard Quotient
PESTICIDES/PCBs			
DIELDREN	8.52E-04	0.04	2.13E-02
4, 4' DDT	4.45E-03	1.60	2.78E-03
INORGANICS			
ARSENIC	5.34E-03	0.136	3.93E-02
CADMIUM	3.88E-02	1.926	2.01E-02
CHROMIUM	1.46E-02	6.55	2.23E-03
CYANIDE	1.47E-02	128.9	1.14E-04
LEAD	1.03E-01	15.98	6.43E-03
MANGANESE	1.12E-01	176	6.36E-04
VANADIUM	1.48E-02	0.389	3.79E-02
ZINC	1.18E+00	319.5	3.68E-03
		HI =	0.1

(a) values obtained from Suter et al. 1996

Table 2-125
Calculation of Hazard Index for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	1.50E-02	0.044	(a)	3.40E-01
4,4'-DDT	1.16E-01	1.76	(a)	6.59E-02
INORGANICS				
ARSENIC	5.35E-02	0.15	(a)	3.57E-01
CADMIUM	6.35E-01	2.12	(a)	2.99E-01
CHROMIUM	1.57E-01	7.21	(a)	2.17E-02
CYANIDE	1.40E-03	141.9	(a)	9.88E-06
LEAD	1.47E+00	17.58	(a)	8.38E-02
MANGANESE	3.21E-01	193	(a)	1.67E-03
VANADIUM	6.75E-02	0.428	(a)	1.58E-01
ZINC	1.07E+01	351.7	(a)	3.03E-02
		HI =		1.4

(a) values obtained from Suter et al. 1996

Table 2-126
Calculation of Hazard Index for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Short-tailed Shrew

AOC FS-19
MASSACHUSETTS MILITARY RESERVATION

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (a) mg/kg/day	Hazard Quotient
PESTICIDES/PCBs			
DIELDRIN	8.73E-03	0.044	1.98E-01
4,4'-DDT	5.11E-02	1.76	2.90E-02
INORGANICS			
ARSENIC	4.01E-02	0.15	2.67E-01
CADMIUM	4.50E-01	2.12	2.12E-01
CHROMIUM	1.20E-01	7.21	1.66E-02
CYANIDE	7.43E-04	141.9	5.24E-06
LEAD	7.80E-01	17.58	4.44E-02
MANGANESE	2.51E-01	193	1.30E-03
VANADIUM	5.70E-02	0.428	1.33E-01
ZINC	6.74E+00	351.7	1.92E-02
		HI =	0.9

(a) values obtained from Suter et al. 1996

Table 2-127
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Upland Sandpiper

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	1.57E-03	0.077	(a)	2.04E-02
4, 4' DDT	1.22E-02	0.003	(a)	4.06E+00
INORGANICS				
ARSENIC	5.04E-03	2.5	(a)	2.01E-03
CADMIUM	6.73E-02	1.45	(a)	4.64E-02
CHROMIUM	1.51E-02	1	(a)	1.51E-02
CYANIDE	1.35E-04	0.008	(b)	1.69E-02
LEAD	1.40E-01	1.13	(a)	1.24E-01
MANGANESE	2.17E-02	997	(a)	2.18E-05
VANADIUM	4.13E-03	11.4	(a)	3.62E-04
ZINC	1.12E+00	14.5	(a)	7.75E-02
		HI =		4.4

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-128
Calculation of Hazard Index
for Food Chain Receptors
Mean Concentrations
Surface Soil
Upland Sandpiper

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	9.18E-04	0.077	(a)	1.19E-02
4, 4' DDT	5.38E-03	0.003	(a)	1.79E+00
INORGANICS				
ARSENIC	3.78E-03	2.5	(a)	1.51E-03
CADMIUM	4.77E-02	1.45	(a)	3.29E-02
CHROMIUM	1.15E-02	1	(a)	1.15E-02
CYANIDE	7.18E-05	0.008	(b)	8.98E-03
LEAD	7.43E-02	1.13	(a)	6.58E-02
MANGANESE	1.70E-02	997	(a)	1.70E-05
VANADIUM	3.49E-03	11.4	(a)	3.06E-04
ZINC	7.10E-01	14.5	(a)	4.90E-02
		HI =		2.0

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-129
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Cardinal

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	1.34E-03	0.077	(a)	1.74E-02
4, 4' DDT	9.79E-03	0.003	(a)	3.26E+00
INORGANICS				
ARSENIC	5.70E-03	2.5	(a)	2.28E-03
CADMIUM	5.34E-02	1.45	(a)	3.68E-02
CHROMIUM	1.58E-02	1	(a)	1.58E-02
CYANIDE	1.38E-02	0.008	(b)	1.73E+00
LEAD	1.56E-01	1.13	(a)	1.38E-01
MANGANESE	8.36E-02	997	(a)	8.38E-05
VANADIUM	1.13E-02	11.4	(a)	9.87E-04
ZINC	1.36E+00	14.5	(a)	9.41E-02
		HI =		5.3

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-130
Calculation of Hazard Index
for Food Chain Receptors
Surface Soil
Mean Concentrations
Northern Cardinal

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	7.83E-04	0.077	(a)	1.02E-02
4, 4' DDT	4.32E-03	0.003	(a)	1.44E+00
INORGANICS				
ARSENIC	4.28E-03	2.5	(a)	1.71E-03
CADMIUM	3.78E-02	1.45	(a)	2.61E-02
CHROMIUM	1.21E-02	1	(a)	1.21E-02
CYANIDE	7.34E-03	0.008	(b)	9.17E-01
LEAD	8.27E-02	1.13	(a)	7.32E-02
MANGANESE	6.54E-02	997	(a)	6.56E-05
VANADIUM	9.50E-03	11.4	(a)	8.34E-04
ZINC	8.63E-01	14.5	(a)	5.95E-02
		HI =		2.5

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-131
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	4.14E-05	0.077	(a)	5.38E-04
4, 4' DDT	3.21E-04	0.003	(a)	1.07E-01
INORGANICS				
ARSENIC	1.33E-04	2.5	(a)	5.30E-05
CADMIUM	1.77E-03	1.45	(a)	1.22E-03
CHROMIUM	3.97E-04	1	(a)	3.97E-04
CYANIDE	3.57E-06	0.008	(b)	4.46E-04
LEAD	3.70E-03	1.13	(a)	3.27E-03
MANGANESE	5.72E-04	997	(a)	5.74E-07
VANADIUM	1.09E-04	11.4	(a)	9.54E-06
ZINC	2.96E-02	14.5	(a)	2.04E-03
		HI =		0.1

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-132
Calculation of Hazard Index
for Food Chain Receptors
Mean Concentrations
Surface Soil
Grasshopper Sparrow

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	2.42E-05	0.077	(a)	3.14E-04
4, 4' DDT	1.42E-04	0.003	(a)	4.72E-02
INORGANICS				
ARSENIC	9.95E-05	2.5	(a)	3.98E-05
CADMIUM	1.26E-03	1.45	(a)	8.67E-04
CHROMIUM	3.04E-04	1	(a)	3.04E-04
CYANIDE	1.89E-06	0.008	(b)	2.36E-04
LEAD	1.96E-03	1.13	(a)	1.73E-03
MANGANESE	4.48E-04	997	(a)	4.49E-07
VANADIUM	9.19E-05	11.4	(a)	8.06E-06
ZINC	1.17E-01	14.5	(a)	8.06E-03

HI = 0.1

(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH

Table 2-133
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Northern Harrier

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/da	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	5.04E-07	0.077	(a)	6.54E-06
4,4' DDT	3.53E-07	0.003	(a)	1.18E-04
INORGANICS (c)				
ARSENIC	1.88E-08	2.5	(a)	7.54E-09
CADMIUM	7.91E-06	1.45	(a)	5.46E-06
CHROMIUM	2.86E-07	1	(a)	2.86E-07
CYANIDE	3.27E-05	0.008	(b)	4.08E-03
LEAD	2.22E-05	1.13	(a)	1.96E-05
MANGANESE	1.85E-05	997	(a)	1.86E-08
VANADIUM	5.97E-08	11.4	(a)	5.24E-09
ZINC	3.09E-03	14.5	(a)	2.13E-04
		HI =		0.004

Note:
(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH
(c) Exposure to inorganic COCs through the food chain pathway not only incidental soil ingestion.

Table 2-134
Calculation of Hazard Index
for Food Chain Receptors
Mean Concentrations
Surface Soil
Northern Harrier

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	2.94E-07	0.077	(a)	3.82E-06
4,4' DDT	1.56E-07	0.003	(a)	5.19E-05
INORGANICS (c)				
ARSENIC	1.41E-08	2.5	(a)	5.65E-09
CADMIUM	5.61E-06	1.45	(a)	3.87E-06
CHROMIUM	2.19E-07	1	(a)	2.19E-07
CYANIDE	2.28E-05	0.008	(b)	2.85E-03
LEAD	1.17E-05	1.13	(a)	1.04E-05
MANGANESE	1.45E-05	997	(a)	1.45E-08
VANADIUM	5.04E-08	11.4	(a)	4.42E-09
ZINC	1.95E-03	14.5	(a)	1.35E-04
		HI =		0.003

Note:
(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH
(c) Exposure to inorganic COCs through the food chain pathway not evaluat
only incidental soil ingestion.

Table 2-135
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Short-eared Owl

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/da	Adjusted Oral Benchmark Value mg/kg/day		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	3.87E-06	0.077	(a)	5.03E-05
4, 4' DDT	2.71E-06	0.003	(a)	9.05E-04
INORGANICS (c)				
ARSENIC	1.45E-07	2.5	(a)	5.79E-08
CADMIUM	6.08E-05	1.45	(a)	4.19E-05
CHROMIUM	2.20E-06	1	(a)	2.20E-06
CYANIDE	1.03E-06	0.008	(b)	1.29E-04
LEAD	1.70E-04	1.13	(a)	1.51E-04
MANGANESE	1.42E-04	997	(a)	1.43E-07
VANADIUM	4.59E-07	11.4	(a)	4.02E-08
ZINC	2.37E-02	14.5	(a)	1.64E-03
		HI =		0.003

Note:
(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH
(c) Exposure to inorganic COCs through the food chain pathway no only incidental soil ingestion.

Table 2-136
Calculation of Hazard Index
for Food Chain Receptors
Mean Concentrations
Surface Soil
Short-eared Owl

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Ora Dose mg/kg/da	Adjusted Oral Benchmark Value		Hazard Quotient
PESTICIDES/PCBs				
DIELDRIN	2.26E-06	0.077	(a)	2.93E-05
4, 4' DDT	1.20E-06	0.003	(a)	3.99E-04
INORGANICS (c)				
ARSENIC	1.08E-07	2.5	(a)	4.34E-08
CADMIUM	4.31E-05	1.45	(a)	2.97E-05
CHROMIUM	1.68E-06	1	(a)	1.68E-06
CYANIDE	5.45E-07	0.008	(b)	6.81E-05
LEAD	9.01E-05	1.13	(a)	7.97E-05
MANGANESE	1.11E-04	997	(a)	1.12E-07
VANADIUM	3.87E-07	11.4	(a)	3.40E-08
ZINC	1.50E-02	14.5	(a)	1.03E-03

HI = 0.002

Note:
(a) values obtained from Suter et al. 1996
(b) value obtained from MMR RAH
(c) Exposure to inorganic COCs through the food chain pathway only incidental soil ingestion.

Table 2-137
Calculation of Hazard Index
for Food Chain Receptors
Maximum Concentrations
Surface Soil
Red Fox

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Max Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (b)	Hazard Quotient
PESTICIDES/PCBs			
DIELDRIN	9.22E-08	0.011	8.38E-06
4, 4' DDT	2.02E-07	0.42	4.80E-07
INORGANICS (a)			
ARSENIC	8.87E-07	0.036	2.47E-05
CADMIUM	1.00E-06	0.509	1.97E-06
CHROMIUM	1.86E-06	1.73	1.07E-06
CYANIDE	3.43E-08	34.1	1.01E-09
LEAD	1.86E-05	4.22	4.41E-06
MANGANESE	1.97E-05	46	4.28E-07
VANADIUM	3.19E-06	0.103	3.09E-05
ZINC	6.90E-03	84.5	8.17E-05
		HI =	0.0002

Note:
(a) Exposure to inorganic COCs through the food chain pathway not evalua
only incidental soil ingestion.
(b) Values obtained from Suter et al. 1996

Table 2-138
Calculation of Hazard Index
for Food Chain Receptors
Mean Concentrations
Surface Soil
Red Fox

AOC FS-19 Study Area
Massachusetts Military Reservation

COC	Mean Oral Dose mg/kg/day	Adjusted Oral Benchmark Value (b)	Hazard Quotient
PESTICIDES/PCBs			
DIELDRIN	5.38E-08	0.011	4.89E-06
4, 4' DDT	8.90E-08	0.42	2.12E-07
INORGANICS (a)			
ARSENIC	6.66E-07	0.036	1.85E-05
CADMIUM	7.12E-07	0.509	1.40E-06
CHROMIUM	1.42E-06	1.73	8.21E-07
CYANIDE	1.82E-08	34.1	5.33E-10
LEAD	9.85E-06	4.22	2.33E-06
MANGANESE	1.54E-05	46	3.35E-07
VANADIUM	2.69E-06	0.103	2.61E-05
ZINC	4.36E-03	84.5	5.17E-05
		HI =	0.0001

Note:
(a) Exposure to inorganic COCs through the food chain pathway not evaluated; only incidental soil ingestion.
(b) Values obtained from Suter et al. 1996

Table 2-139
Aquatic Risk Characterization - Maximum Concentrations

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

COCs	C (ug/L) Total	C (ug/L) Dissolved	Aquatic Benchmark Value (ug/L)	HQ Total	HQ Dissolved
INORGANICS					
Chromium (1)	21	ND	11	1.91	NE
Copper	13.7	ND	2.2	6.23	NE
Lead	18.5	1.3	0.26	71.15	5.00
Nickel	22	5.2	21.45	1.03	0.24
Zinc	58.9	36.2	47	1.25	0.77
			Inoganic HI =	**81.6**	**6.0**
			Total HI=	81.6	6.0

Notes:
All values obtained from MMR Ecological Assessment Guidance, Table O-2.
COC = contaminant of concern
HQ = hazard quotient
ND = Not Detected
NE = Not Evaluated

—u1~ Value for chromium VI used.

Table 2-140
Aquatic Risk Characterization - Mean Concentrations

AOC FS-19 RI STUDY AREA
MASSACHUSETTS MILITARY RESERVATION

COCs	C (ug/L) Total	C (ug/L) Dissolved	Aquatic Benchmark Value (ug/L)	HQ Total	HQ Dissolved
INORGANICS					
Chromium (1)	7.7	ND	11	0.70	NE
Copper	5.4	ND	2.2	2.45	NE
Lead	4.5	0.66	0.26	17.31	2.54
Nickel	8	2.6	21.45	0.37	0.12
Zinc	22	11	47	0.47	0.23
			Inorganic HI =	**21.3**	**2.9**
			Total HI =	21.3	2.9

Notes:
All values obtained from MMR Ecological Assessment Guidance, Table O-2.
COC = contaminant of concern
HQ = hazard quotient
HI = hazard index
ND = Not Detected
NE = Not Evaluated

—u1˜ Value for chromium VI used.

APPENDIX C

RESPONSIVENESS SUMMARY

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RESPONSE TO COMMENTS
TO
PROPOSED PLAN FOR NO FURTHER ACTION FOR SOILS AND GROUNDWATER
AT THE FS-17 AND FS-19 SITES
MASSACHUSETTS MILITARY RESERVATION
November 1998

No comments were received by AFCEE during the public comment period for the *Proposed Plan for No Further Action at the FS-17 and FS-19 Sites*. Because no comments were received, no responses are necessary. This statement constitutes the Response to Comments for the *Record of Decision for AOC FS-17 and AOC FS-19*.

APPENDIX D

TRANSCRIPT OF PUBLIC HEARING

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5 Proposed Plan for No Further :
6 Action at Fuel Spill 17/Fuel :
7 Spill 19 :
8 :
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13 Building 330
14 East Inner Road
15 Mass. Military Reservation
16 Tuesday, January 5, 1999
17 7:02 p.m.
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21
22
23 Mary E. Phillips
Registered Professional Reporter
24 P.O. Box 160
Sagamore Beach, MA 02562-0160
25 (508) 888-6717

1 ATTENDEES:

2 Douglas Karson	AFCEE
3 Lee Perry	AFCEE
4 Chuck Paone	UNITEC
5 Henry Cu	MA DEP
6 Wells Hunt	Robbins-Giora
7 Carl Gustafson	Jacobs
8 Jane Dolan	US EPA
9 David Motson	Robbins-Giora

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1 P R O C E E D I N G S.

2 MR. KARSON: The official record is now
3 open. My name is Douglas Karson. And I will be the
4 hearing officer for tonight. The purpose of the
5 hearing is to accept oral comments, testimony and
6 written comments on The Proposed Plan for Fuel Spill
7 17 and 19 sites.

8 All comments and testimony that are given
9 tonight will be transcribed verbatim and become part
10 of the official record on this project.

11 Each and every comment will be responded to
12 in the form of a Responsiveness Summary that will be
13 issued after the close of the public comment period.
14 This will be attached to The Record of Decision,
15 which will be the final decision on the two sites.

16 Everyone wanting to comment must speak into
17 the microphone. Please state your name and town of
18 residence.

19 The floor is now open to comment on The
20 Proposed Plan for the Fuel Spill 17 and 19 sites.

21 Are there any comments to be offered
22 tonight?

23 (No response.)

24 MR. KARSON: I will ask one more time. Are
25 there any comments to be offered tonight?

1 (No response.)

2 MR. KARSON: If there are no comments to be

3 made, then I shall now close the official record for

4 oral testimony. The record is now closed. Please

5 note that you can still provide written comments

6 through January 8th. I thank you all for coming and

7 have a good evening.

8 (Whereupon the hearing adjourned

9 at 7:05 p.m.)

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1 C E R T I F I C A T E

2

3 I, MARY E. PHILLIPS, Registered Professional
4 Reporter, do hereby certify that the foregoing transcript,
5 pages 2 through 5 inclusive, was taken by me
6 stenographically and thereafter under my direction was
7 reduced to typewriting and is a true record of the testimony
8 of the proceedings to the best of my ability.

9

10

11 Dated at Bourne, Massachusetts, this 15th
12 day of January, 1999.

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21 MARY E. PHILLIPS, RPR

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APPENDIX E

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION LETTER OF CONCURRENCE

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Massachusetts Department of Environmental Protection
Concurrence Letter

This page is inserted pending receipt of a letter of concurrence to the AOC FS-17 and AOC-19 Record of Decision.

APPENDIX F
CLOSURE REPORTS

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Metcalf & Eddy
An Air & Water Technologies Company

12/5/95 FS-17 TANK PULL RPT

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 4
To JULIA NAULT	From ED GROSTICK
Co. CDM FEDERAL	Co. CDM
Dept.	Phone # 423-435-3629
Fax # 617-227-3851	Fax #

DO YOU NEED HARD COPY?

October 17, 1994

Mr. Christopher Faux
Environmental Management Officer
Otis Environmental Management Office
Otis Air National Guard Base 02542

RE: Weekly Report, Week Ending 8/12/94
Building 3693
Removal of 2-5,000 gallon Underground Storage Tanks

Dear Mr. Faux,

On August 9, 1994, Metcalf & Eddy (M&E) personnel met Mr. John Cronan, Mr. Bob Blair, and Mr. Joe Guimar of Otis Air National Guard (ANG) Base, on-site to provide environmental monitoring services during the removal of two steel, 5,000-gallon underground storage tanks (USTs) at Building 3693. As per the Scope of Work, the environmental monitoring services included open air soil screening for the presence of total volatile organic compounds (VOCs) using a Photovac Microtip photoionization detector (PID), and soil headspace screening in accordance with the Jar Headspace Screening Procedure which is outlined in the Department of Environmental Protection's Policy WSC-94-400, "Interim Remediation Waste Management Policy for Petroleum Contaminated Soils".

According to Otis ANG Base personnel, the USTs were approximately 50 years old, and had been in use until August 4, 1994. One of the USTs held diesel fuel and the other held gasoline. On August 8, 1994, prior to M&E's site visit, ATEC Environmental Consultants (ATEC) removed the Building 3693, and the pump islands, asphalt, and concrete located above the USTs. In addition, ATEC removed soil to expose the USTs. The soil covering the USTs was stockpiled on site pending field screening. Refer to Attachment I for an illustration of the excavation area. The following chronicles the activities performed at Building 3591 with M&E personnel present.

30 Harvard Mill Square, Wakefield, MA 01880
Mailing Address: PO Box 4043, Woburn, MA 01888-4043
617-246-5200 FAX 246-5293

Recycled Paper

AWT

Mr. Christopher Faux
October 17, 1994

August 9, 1994

On August 9, 1994, ATEC cleaned both USTs, generating two 55-gallon drums of sludge and absorbent materials.

On August 8, 1994, ATEC excavated approximately 100 cubic yards of soil to expose the surface of the USTs. Pending field screening by M&E personnel, ATEC stockpiled soil on site. Field screening performed by M&E personnel on August 9, 1994, yielded results of 0 ppm total volatile organic compounds (VOCs). The field screening results of all other soil excavated to remove the USTs were 0 ppm total VOCs. A test pit was excavated in the area of the former pump island to a depth of 4 feet. No petroleum odor, staining, or PID readings were detected in the area of the former pump island.

Results of Jar Headspace Screening performed on in-situ soil of the final excavation base at 12 feet below grade, and of the final excavation sidewalls were also 0 ppm total VOCs. The final excavation was approximately 15 feet wide by 35 feet long by 13 feet deep. No groundwater was encountered in the excavation.

Please do not hesitate to call me if you have any questions or comments. I may be reached at (617) 246-8482, extension 4124.

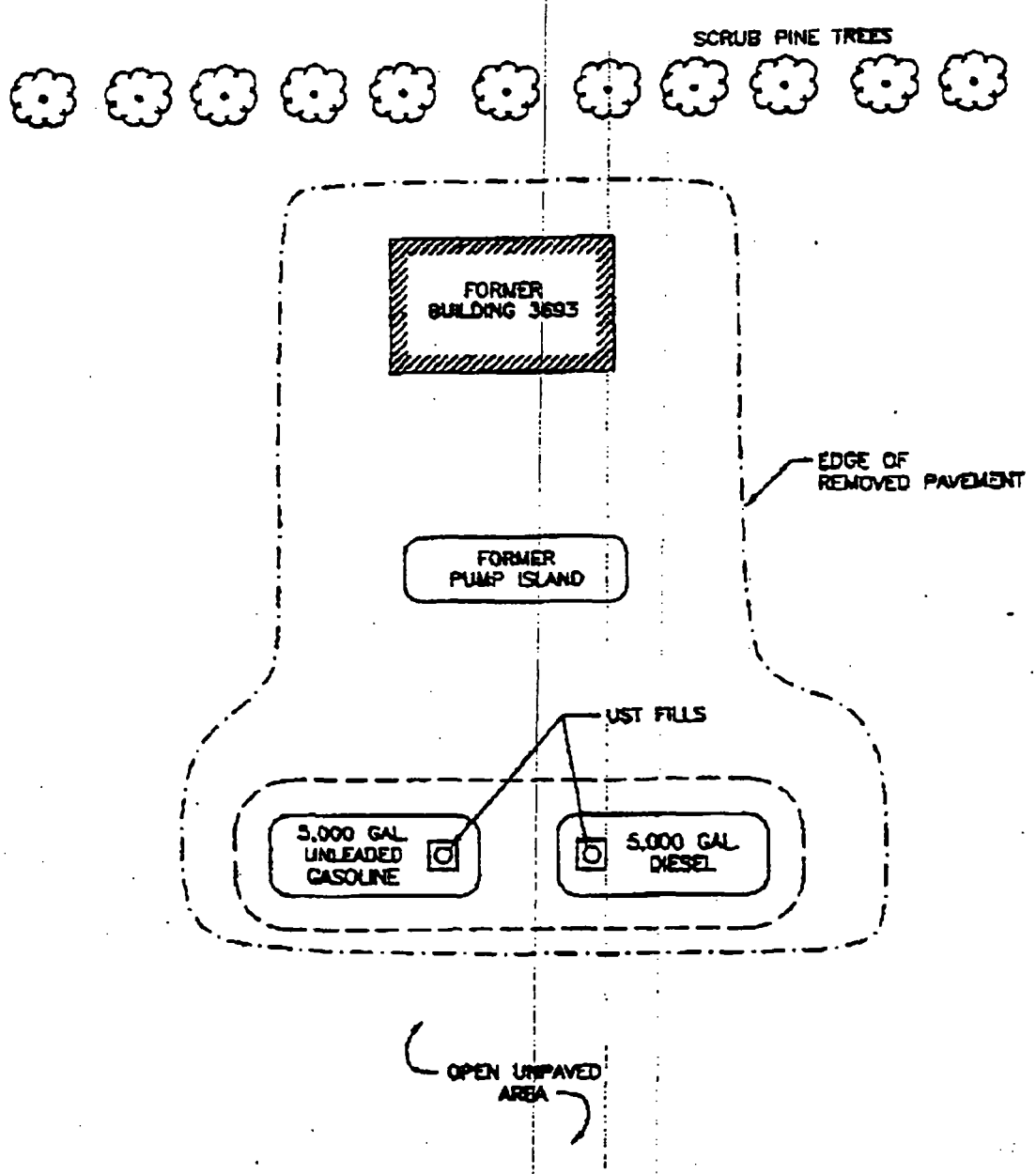
Sincerely,
METCALF & EDDY

Rebecca J. Hartwell
Engineer II

cc: Mr. Bob Blair, OTIS ANG Base
Michael McGrath, Metcalf & Eddy
File

Mr. Christopher Faux
October 17, 1994

ATTACHMENT I



NOTES:

- UST's WERE 7' DIAMETER, 17'-7" LONG AND 5' BELOW GRADE

— — — APPROXIMATE LIMIT OF EXCAVATION

Metcalf & Eddy
An Air & Water Technologies Company

OTIS ANG BASE
UST REMOVALS
BUILDING 3693

SCALE: NONE	OTIS3.DWG	11/3/94

CLOSURE REPORT

1. INTRODUCTION

1.1 DRAINAGE STRUCTURE REMOVAL PROGRAM

Massachusetts Military Reservation (MMR) is listed on the U.S. Environmental Protection Agency (USEPA) National Priority List. Remedial studies and activities are currently being conducted at MMR in accordance with guidelines and procedures of the USEPA Superfund program and the National Contingency Plan (NCP). Two types of action can be initiated under the NCP: remedial actions and removal actions. Remedial actions are long-term, permanent remediation of hazardous waste sites. Removal actions are short-term actions to abate or eliminate the release of contamination. The drainage structure removal program is a removal action program.

The National Guard Bureau (NGB) evaluated the drainage structures in a separate basewide program because of the similarity in operations and contaminants. The drainage structure removal program is based on the Phase I Sump Investigation Program conducted by ABB Environmental Services Inc. (ABB) and the Phase II Sump Investigation Program conducted by Metcalf and Eddy for the NGB. ABB characterized approximately 100 drainage structures. This characterization included sampling to identify potential contaminant sources. Also during this phase an additional 161 drainage structures were identified. Fifteen of these structures were characterized by Metcalf and Eddy as a high priority.

- A total of 185 drainage structures are included in the program. One hundred sixty-five of these structures are funded for removal. Currently, Jacobs Engineering Group is under contract through the Air Force Center for Environmental Excellence for the following work under the drainage structure removal program. The scope of work includes: The removal or abandonment in place of approximately 165 existing drainage structures on the Massachusetts Military Reservation and the associated liquid and sediment contents.
- Demolition of 12 existing vehicle maintenance slabs and foundations.
- Testing soil, liquid, sludge and sediment for contamination.
- Stockpiling and treatment or disposal of excavated drainage structure debris and surrounding soil.
- Backfilling and restoring excavations as specified.
- Preparing closure reports.

The work Jacobs is performing on the drainage structure removal program is governed by the "Final Drainage Structure Removal Program Specifications", July 1995, prepared for Massachusetts Military Reservation by Metcalf and Eddy; and the approved Jacobs' Plans (Drainage Structure Removal Program Volume I - Quality Project Plan and Volume II - Remedial Action Work Plan, January 1996, prepared for Massachusetts Military Reservation). These documents detail the procedures utilized by Jacobs during the removal of drainage structures.

1.2 CLEAN-UP LEVELS

The clean-up levels for the drainage structure removal program (DSRP) are determined by the MMR specific soil target clean-up levels (STCLs) in accordance with the HAZWRAP Soil Target Clean Up Levels dated January 30, 1996. The STCLs are risk based standards.. The depth utilized for the DRSP is the 2 to 15 foot depth. Additionally, the STCLs are divided into several sub-categories: inside the flightline, outside the flightline, and clean fill. The inside and outside the flightline STCLs are based upon future use as well as risk. These standards apply to the bottom, inlet, and outlet samples and are used to determine that the drainage structure removal is a clean closure.

The clean fill STCLs apply to the paylimit sample. This data determines if the paylimit can be used for clean fill or requires treatment. The soil will be treated in the OABF if any of the contaminants tested are above the STCLs for clean fill. Additionally, if the soil fails the "twenty times" rule as defined in specification 01410, the paylimit sample will be analyzed for TCLP. If the soil passes the TCLP, it will be treated in the OABF. Any soil failing TCLP limits will be disposed off-site at a RCRA-regulated facility.

1.3 DRAINAGE STRUCTURE DESCRIPTION AND LOCATION

Drainage structure 23CDXX1 was located off the southwest end of former building 3694, west of Frank Perkins Road in the FS-17 Study Area. This structure is located outside the flightline area. The drainage structure was a Leaching Well Type III (See Figure 1). The drainage structure was visible at the ground surface and had a depth of 10 feet. The survey coordinates are 246,652.7 North and 858,285.4 East.

The drainage structure had a round metal manhole type cover. The structure walls were constructed of approximately one foot of brick and inner and outer corrugated metal walls. The structure bottom was not visible due to the presence of liquids. A single inlet pipe, 2-inch steel, was observed entering the structure. No outlet pipes were present.

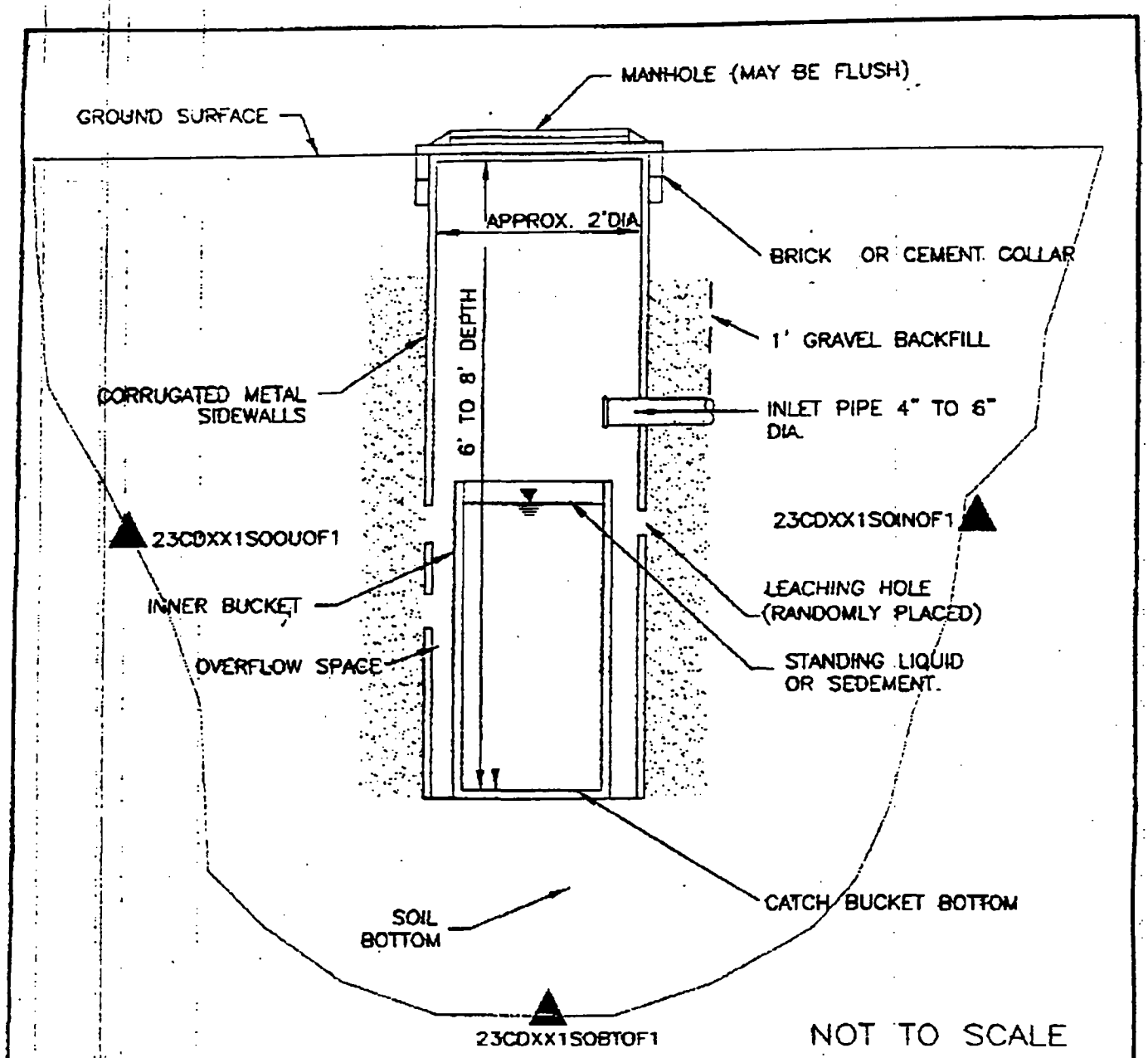
1.4 PREVIOUS INVESTIGATION HISTORY

1.4.1 FUEL SPILL 17 (FS-17) STUDY AREA

Study area FS-17 is a former World War II motor pool. The study area is located west of Frank Perkins Road. Two type III leaching well structures and a french drain were identified during the Phase I Investigation. Drainage structures 23CDXX1 and 23CDXX2 were sampled during the Phase I Sump Investigation Program conducted by ABB. At that time, eight soil borings were drilled in the FS-17 area to assess contamination.

1.4.2 PHASE I INVESTIGATION SUMMARY

At the time of ABB investigation (Sump Removal Action Program, Phase I Sump Investigation Program Work Completion Report, October 1992), drainage structure 23CDXX1 was characterized. Three soil borings were drilled at this site. Results from the soil sampling had TPH, benzene, and zinc detections.



▲ SAMPLE POINT

Figure 1
Otis Air National Guard Base
23CDXX1
Leaching Well Type III

Drawn By: S. LEWIS Date: 09/23/96	Jacobs Project Number: 10K79701	Drawing File Name: 23CDXX1.DWG

JACOBS ENGINEERING GROUP INC.
1300 N. 17th St., Suite 602, Arlington, Virginia 22209

2. LIQUID REMOVAL AND DISPOSAL

On February 1, 1996, 50-gallons of liquid were removed from drainage structure 23CDXX1. This liquid was transported to the Central Storage Area and transferred to the frac tank. The frac tank received similar liquid waste from other drainage structure as well as the water generated during decontamination of equipment and debris. The contents of this frac tank has been sampled and based on the analytical results, will be properly disposed. The disposal records and manifests will be included in the Disposal Report which will be submitted at the completion of the project.

3. SEDIMENT/SLUDGE REMOVAL AND DISPOSAL

On February 7, 1996, a backhoe was used to remove one 55-gallon drum of sediment/sludge from this structure. The sediment/sludge was black and oily in appearance. It was transported to the drum storage area in the Central Storage Area (CSA). The initial PID reading, taken when the structure was opened, was 7.8 ppm. The PID was used for field screening throughout the removal process. The drum has been sampled and the sample composited with drums from similar drainage structures. The final disposition of the sediment/sludge will be determined when the analytical results are received. The disposal records and manifests will be included in the Disposal Report.

4. DRAINAGE STRUCTURE REMOVAL AND DISPOSAL

4.1 PROCEDURES USED TO REMOVE PAYLIMIT

4.1.1 EXCAVATION

On February 7, 1996, a backhoe was used to excavate and remove the drainage structure and paylimit soils. The soil was removed and directly loaded into dumptrucks. Approximately 20 cubic yards of soil and debris were excavated. The final excavation size was 10 feet long by 10 feet wide by 13 feet deep. The excavated soil was stored by structure in the CSA. During the removal of the paylimit approximately 10 linear feet of steel pipe was removed. The pipe ends were plugged with concrete. Structure closure was observed by ABB Environmental, the Title II subcontractor to IRP. Photos are located in the photo log of the master copy of this document in the IRP office.

4.1.2 FIELD SCREENING

Field screening for volatile organic compounds and dust was conducted throughout the excavation activities. PID results were non-detect in the breathing zone. Mini-RAM results were also non-detect in the breathing zone. Headspace PID readings were also taken at the inlet, outlet, and bottom sample location. The headspace readings were used as an initial determination of contamination. The headspace readings were 0.2 ppm at the bottom, 0.3 ppm at the inlet, and 3.9 ppm at the outlet.

4.1.3 BACKFILL

The backfill used for this excavation came from an on-base source, either the former Landfill 1 common borrow pit located on Turpentine Road or a drainage structure paylimit soil with analytical results below the clean fill STCLs. Approximately 28 cubic yards of backfill soil were used to backfill the excavation.

4.1.4 FINAL RESTORATION

A former parking lot was impacted during the excavation and the area will be regraded in the Spring. No repaving is required.

4.2 *ANALYTICAL RESULTS*

The on-site and off-site laboratories analyzed the samples according to the Quality Assurance Plan and the laboratory specification (Section 01410 of the Specifications). All data was validated in accordance with HAZWRAP/DOE and EPA guidelines. The samples were analyzed for the volatile compounds including EDB by EPA method 8010/8020, the semivolatile organic compounds by EPA method 8270, pesticides and PCBs by EPA method 8080, metals by EPA method series 6000 and 7000, and TPH by EPA method 8015 modified as diesel or gasoline. The off-site laboratory has established analyte detection levels which are below the method required quantitation levels. The concentrations reported for those analytes detected below the method quantitation levels are estimated and are noted as such in the following tables.

A sample was collected from the bottom, inlet, and outlet. The outlet sample was collected from the wall opposite the inlet because no outlet pipe was present. These samples were analyzed in the on-site laboratory as part of our field screening program. When the on-site laboratory results demonstrated the excavation was clean, additional samples were sent to the off-site laboratory for confirmation. The off-site analytical detection results are summarized in Tables 4-1 through 4-3, respectively. The complete on-site and off-site analytical data are in Appendix A and B, respectively. None of the analytes detected in the bottom, inlet, and outlet samples exceeded the STCLs; therefore, structure 23CDXX1 is a clean closure.

TABLE 4-1 - Bottom Sample - 23CDXX1SOBTOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	15 mg/kg			500 mg/kg
Aluminum	1120 mg/kg			54900 mg/kg
Barium	4.3 mg/kg			3800 mg/kg
Beryllium	0.06 mg/kg			1 mg/kg
Calcium	119 mg/kg			
Chromium	1.9 mg/kg			274 mg/kg
Cobalt	1.6 mg/kg			
Copper	1.8 mg/kg			
Iron	2200 mg/kg			
Lead	15.3 mg/kg			300 mg/kg
Magnesium	281 mg/kg			
Manganese	34.5 mg/kg			274 mg/kg
Nickel	2.1 mg/kg			1100 mg/kg
Potassium	188 mg/kg			
Vanadium	3.3 mg/kg			384 mg/kg
Zinc	34.0 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	68 ug/kg	YES		45700 ug/kg

[1]STCL outside is used when the structure was located outside the flightline.

TABLE 4-2 - Inlet Sample - 23CDXX1SOINOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	55 mg/kg			500 mg/kg
Aluminum	3320 mg/kg			54900 mg/kg
Arsenic	1.9 mg/kg			3.6 mg/kg
Barium	8.9 mg/kg			3800 mg/kg
Beryllium	0.15 mg/kg			1 mg/kg
Cadmium	0.32 mg/kg			
Calcium	274 mg/kg			
Chromium	3.8 mg/kg			274 mg/kg
Cobalt	2.3 mg/kg			
Copper	3.1 mg/kg			
Iron	4030 mg/kg			
Lead	106 mg/kg			300 mg/kg
Magnesium	562 mg/kg			
Manganese	48.8 mg/kg			274 mg/kg
Nickel	3.5 mg/kg			1100 mg/kg
Potassium	253 mg/kg			
Vanadium	5.7 mg/kg			384 mg/kg
Zinc	125 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	56 mg/kg	YES		45700 mg/kg
Di-n-butyl phthalate	63 ug/kg	YES		5490000 ug/kg

[1]STCL outside is used when the structure was located outside the flightline.

TABLE 4-3 - Outlet Sample - 23CDXX1SOOUOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	20 mg/kg			500 mg/kg
Aluminum	2000 mg/kg			54900 mg/kg
Arsenic	1.2 mg/kg			3.6 mg/kg
Barium	4.6 mg/kg			3800 mg/kg
Beryllium	0.07 mg/kg			1 mg/kg
Calcium	113 mg/kg			
Chromium	1.5 mg/kg			274 mg/kg
Cobalt	1.1 mg/kg			
Copper	2.0 mg/kg			
Iron	2030 mg/kg			
Lead	7.3 mg/kg			300 mg/kg
Magnesium	356 mg/kg			
Manganese	44.0 mg/kg			274 mg/kg
Nickel	2.0 mg/kg			1100 mg/kg
Potassium	223 mg/kg			
Vanadium	3.1 mg/kg			384 mg/kg
Zinc	26.6 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	53 ug/kg	YES		45700 ug/kg

[1]STCL outside is used when the structure was located outside the flightline.

4.3 ANALYTICAL QA

The analytical data was validated in accordance with DOE/HWP - 65/R1: "Requirements for Quality Control of Analytical Data." The validation was a Level C DQO validation and found the data to be usable. Samples were collected from the sidewalls and bottom of the excavation for analysis by the on-site laboratory. This laboratory used gas chromatography and immunoassay techniques for the organic analyses and x-ray fluorescence (XRF) for inorganic analysis. There is good agreement between the on-site and off-site analytical data, with the exception of the PAH and barium results. The on-site laboratory measures PAHs as a total concentration while the off-site laboratory measures the concentration of individual PAHS. No PAHs were detected by the off-site laboratory. The total PAH concentrations found by the on-site laboratory were low and could result from summing the concentrations of several PAHs which are each present at below the off-site detection limit or which are not target compounds for off-site analysis. The barium concentrations reported by the on-site laboratory are approximately 30 to 75 times the corresponding off-site data. It is possible that the sample digestion process used by the off-site laboratory is not efficient for barium and this is compounded by a matrix effect. Due to the high STCL value for barium, it is unlikely that barium is present in any sample from this structure at levels approaching the STCLs.

Low levels of contaminants were found in blanks associated with the off-site metals and SVOC analyses and the data were appropriately qualified by the laboratory. Due to blank contamination, the barium detection in the paylimit sample and the di-n-butyl phthalate detect in the inlet sample are considered to be laboratory artifacts. The off-site laboratory analyzed the paylimit sample for metals on an instrument which had a detection limit of 2.4 mg/kg (accounting for percent moisture) for thallium. The clean fill limit for thallium is 2 mg/kg, which is slightly lower than the instruments detection limit. Thallium was not detected in the paylimit sample. As thallium is not an expected contaminant, the impact on data usability is assessed to be minimal. A similar issue arose with

arsenic. Since arsenic is an analyte of concern, arsenic detections in the inlet and outlet samples were reanalyzed. The reanalysis results are used in this report.

4.4 SOIL FINAL DISPOSITION

The analytical results for the paylimit from this drainage structure were reviewed and summarized in Table 4-4. All analytes were below the STCLs for clean fill. Based upon these results, the paylimit was used as clean fill.

TABLE 4-4 - Paylimit Sample - 23CDXX1SOPLOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Clean	TCLP Limits	20X Rule
TPH as Diesel	5.8 mg/kg			500 mg/kg		
Aluminum	1370 mg/kg			26400 mg/kg		
Barium	3.3 mg/kg			3800 mg/kg	100 mg/L	2000 mg/kg
Beryllium	0.10 mg/kg			1 mg/kg		
Calcium	64.7 mg/kg					
Chromium	1.4 mg/kg			6.8 mg/kg	5 mg/L	100 mg/kg
Cobalt	1.3 mg/kg			333 mg/kg		
Copper	1.4 mg/kg			19.3 mg/kg		
Iron	2030 mg/kg					
Lead	7.6 mg/kg			15.8 mg/kg	5 mg/L	100 mg/kg
Magnesium	282 mg/kg					
Manganese	30.9 mg/kg			274 mg/kg		
Nickel	2.9 mg/kg			955 mg/kg		
Potassium	171 mg/kg					
Vanadium	3.1 mg/kg			15.2 mg/kg		
Zinc	5.7 mg/kg			16 mg/kg		
bis(2-Ethylhexyl) phthalate	48 ug/kg	YES		812 ug/kg		

4.5 DEBRIS FINAL DISPOSITION

The debris from this structure was decontaminated. It will be sorted into suitable and non-suitable debris. The suitable debris will be used for aggregate in the OABF. The unsuitable debris will be sent to a construction debris landfill.

5. APPENDICES

A. ON-SITE ANALYTICAL DATA
B. OFF-SITE ANALYTICAL DATA

4.4 SOIL FINAL DISPOSITION

The analytical results for paylimit from this drainage structure were reviewed. Based upon the results summarized in Table 4-5, none of the STCLs for clean fill were exceeded. Therefore, the paylimit was used as clean fill.

TABLE 4-5 - Paylimit Sample - 23CDXX2SOPLOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Clean	TCLP Limits	20X Rule
TPH as Diesel	9.5 mg/kg			500 mg/kg		
Toluene	0.97 ug/kg			1000 ug/kg		
Aluminum	3210 mg/kg			26400 mg/kg		
Arsenic	1.4 mg/kg			3.6 mg/kg	5 mg/L	100 mg/kg
Barium	5.2 mg/kg			3800 mg/kg	100 mg/L	2000 mg/kg
Beryllium	0.15 mg/kg			1 mg/kg		
Calcium	62.1 mg/kg					
Chromium	4.0 mg/kg			6.8 mg/kg	5 mg/L	100 mg/kg
Cobalt	1.3 mg/kg			333 mg/kg		
Copper	3.4 mg/kg			19.3 mg/kg		
Iron	3780 mg/kg					
Lead	7.4 mg/kg			15.8 mg/kg	5 mg/L	100 mg/kg
Magnesium	540 mg/kg					
Manganese	47.4 mg/kg			274 mg/kg		
Potassium	199 mg/kg					
Vanadium	5.4 mg/kg			15.2 mg/kg		
Zinc	11.4 mg/kg			16 mg/kg		
Benzo(b)fluoranthene	47 ug/kg	YES		5000 ug/kg		
bis(2-Ethylhexyl) phthalate	41 ug/kg	YES		812 ug/kg		
Pyrene	35 ug/kg	YES		4690 ug/kg		

4.5 DEBRIS FINAL DISPOSITION

The debris from this structure was decontaminated. It will be sorted into suitable and non-suitable debris. The suitable debris will be used for aggregate in the OABF. The unsuitable debris will be sent to a construction debris landfill.

5. APPENDICES

A. ON-SITE ANALYTICAL DATA
B. OFF-SITE ANALYTICAL DATA

CLOSURE REPORT

1. INTRODUCTION

1.1 *DRAINAGE STRUCTURE REMOVAL PROGRAM*

Massachusetts Military Reservation (MMR) is listed on the U.S. Environmental Protection Agency (USEPA) National Priority List. Remedial studies and activities are currently being conducted at MMR in accordance with guidelines and procedures of the USEPA Superfund program and the National Contingency Plan (NCP). Two types of action can be initiated under the NCP: remedial actions and removal actions. Remedial actions are long-term, permanent remediation of hazardous waste sites. Removal actions are short-term actions to abate or eliminate the release of contamination. The drainage structure removal program is a removal action program.

The National Guard Bureau (NGB) evaluated the drainage structures in a separate basewide program because of the similarity in operations and contaminants. The drainage structure removal program is based on the Phase I Sump Investigation Program conducted by ABB Environmental Services Inc. (ABB) and the Phase II Sump Investigation Program conducted by Metcalf and Eddy for the NGB. ABB characterized approximately 100 drainage structures.. This characterization included sampling to identify potential contaminant sources. Also during this phase an additional 161 drainage structures were identified. Fifteen of these structures were characterized by Metcalf and Eddy as a high priority.

A total of 185 drainage structures are included in the program. One hundred sixty-five of these structures are funded for removal. Currently, Jacobs Engineering Group is under contract through the Air Force Center for Environmental Excellence for the following work under the drainage structure removal program. The scope of work includes:

- The removal or abandonment in place of approximately 165 existing drainage structures on the Massachusetts Military Reservation and the associated liquid and sediment contents.
- Demolition of 12 existing vehicle maintenance slabs and foundations.
- Testing soil, liquid, sludge and sediment for contamination.
- Stockpiling and treatment or disposal of excavated drainage structure debris and surrounding soil.
- Backfilling and restoring excavations as specified.
- Preparing closure reports.

The work Jacobs is performing on the drainage structure removal program is governed by the "Final Drainage Structure Removal Program Specifications", July 1995, prepared for Massachusetts Military Reservation by Metcalf and Eddy; and the approved Jacobs' Plans (Drainage Structure Removal Program Volume I - Quality Project Plan and Volume II - Remedial Action Work Plan, January 1996, prepared for Massachusetts Military Reservation). These documents detail the procedures utilized by Jacobs during the removal of drainage structures.

1.2 CLEAN-UP LEVELS

The clean-up levels for the drainage structure removal program (DSRP) are determined by the MMR specific soil target clean-up levels (STCLs) as developed by HAZWRAP and presented in their letter; Soil Target Clean Up Levels dated January 30, 1996. The STCLs are risk based standards. The depth utilized for the DRSP is the 2 to 15 foot depth. Additionally, the STCLs are divided into several sub-categories: inside the flightline, outside the flightline, and clean fill. The inside and outside the flightline STCLs are based upon future use as well as risk. These standards apply to the bottom, inlet, and outlet samples and are used to determine that the drainage structure removal is a clean closure.

The clean fill STCLs apply to the paylimit sample. This data determines if the paylimit can be used for clean fill or requires treatment. The soil will be treated in the OABF if any of the contaminants tested are above the STCLs for clean fill. Additionally, if the soil fails the "twenty times" rule as defined in specification 01410, a paylimit sample will be analyzed for TCLP. If the soil passes the TCLP, it will be treated in the OABF. Any soil failing TCLP limits will be disposed off-site at a RCRA-regulated facility.

1.3 DRAINAGE STRUCTURE DESCRIPTION AND LOCATION

Drainage structure 23CDXX3 is located north of former building 3693 west of Frank Perkins Road in the FS-17 Study Area. This structure is located outside the flightline area. The drainage structure was a Leaching Well III (See Figure 1). The drainage structure was visible at the ground surface and had a depth of 11 feet. The survey coordinates are 246,740 North and 856,220.3 East.

The drainage structure was visible and had a round steel manhole cover. The structure walls were constructed of approximately one foot of brick and inner and outer corrugated metal walls. The structure bottom was not visible. A single inlet pipe, 4-inch steel, was observed entering the structure. An outlet pipe was present.

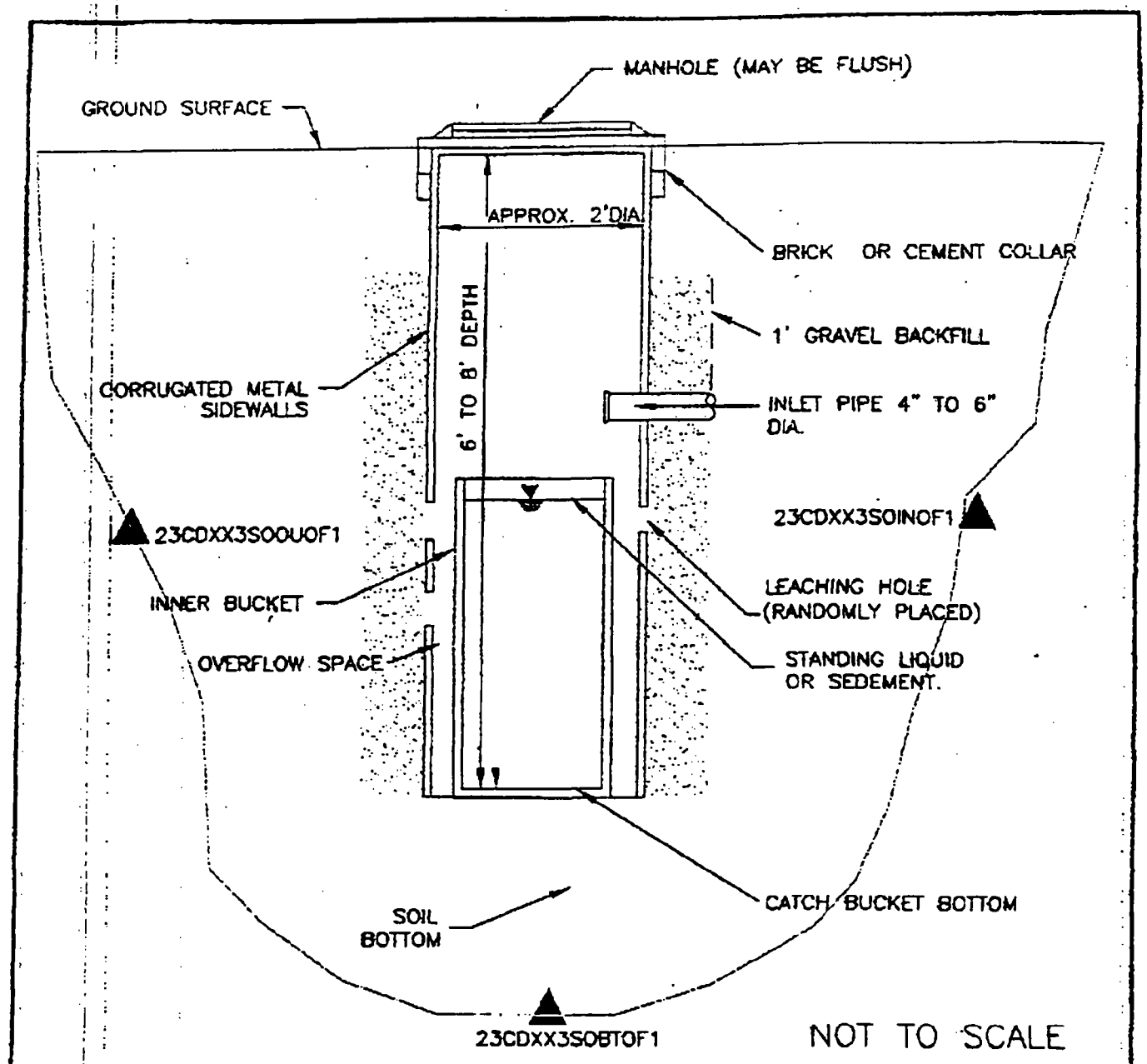
1.4 PREVIOUS INVESTIGATION HISTORY

1.4.1 FUEL SPILL 17 (FS-17) STUDY AREA

Study area FS-17 is a former World War II motor pool. The study area is located off Frank Perkins Road. Two type III leaching well structures and a french drain were identified during the previous investigations. Drainage structures 23CDXX1 and 23CDXX2 were sampled during the Phase I Sump Investigation Program conducted by ABB. At that time, eight soil borings were drilled in the FS-17 area to assess contamination.

1.4.2 PHASE I INVESTIGATION SUMMARY

At the time of ABB investigation (Sump Removal Action Program, Phase I Sump Investigation Program Work Completion Report, October 1992), drainage structure 23CDXX3 was not sampled. Results from the sampling at other sumps in the FS-17 area had TPH, benzene, copper, zinc, and pesticide detections.



▲ SAMPLE POINT

Figure 1
Otis Air National Guard Base
23CDXX3
Leaching Well Type III

Drawn By: S. LEWIS Date: 09/23/96	Jacobs Project Number: 10K79701	Drawing File Name: 23CDXX3.DWG

JACOBS ENGINEERING GROUP INC.
1300 N. 17th St., Suite 602, Arlington, Virginia 22209

2. LIQUID REMOVAL AND DISPOSAL

No liquid was removed from this drainage structure.

3. *SEDIMENT/SLUDGE REMOVAL AND DISPOSAL*

No sediment/sludge was removed from this drainage structure.

4. DRAINAGE STRUCTURE REMOVAL AND DISPOSAL

4.1 PROCEDURES USED TO REMOVE PAYLIMIT

4.1.1 EXCAVATION

On February 7, 1996, a backhoe was used to excavate and remove the drainage structure (Leaching Well III) and paylimit soils. The soil was removed and directly loaded onto dumptrucks. Approximately 20 cubic yards of soil and debris were excavated. The final excavation size was 10 feet long by 10 feet wide by 14 feet deep. The excavated soil was stored by structure in the Central Storage Area. During the removal of the paylimit approximately 15 linear feet of steel pipe was removed. Pipe remaining in the ground were plugged with concrete. Structure closure was observed by ABB Environmental, the Title II subcontractor to IRP. Photos are located in the photo log of the master copy of this document in the IRP office.

4.1.2 FIELD SCREENING

Field screening for volatile organic compounds and dust was conducted throughout the excavation activities. PID results were non-detect in the breathing zone. Mini-RAM results were also non-detect in the breathing zone. Headspace PID readings were also taken at the inlet, outlet, and bottom. The headspace readings were used as an initial determination of contamination. The headspace readings at the bottom, inlet, and outlet sample locations were all 0.0 ppm.

4.1.3 BACKFILL

The backfill used for this excavation came from an on-base source, either the former Landfill 1 common borrow pit located off Turpentine Road or paylimit soils from drainage structures with analytical results below the clean fill STCLs. Approximately 28 cubic yards of soil were used to backfill the excavation.

4.1.4 FINAL RESTORATION

A former parking lot was impacted during the removal and the area will be regraded in the Spring. No repaving is required.

4.2 ANALYTICAL RESULTS

The on-site and off-site laboratories analyzed the samples according to the Quality Assurance Plan and the laboratory specification (Section 01410 of the Specifications). All data was validated in accordance with HAZWRAP/DOE and EPA guidelines. The samples were analyzed for the volatile

compounds by EPA method 8010/8020 and EDB, the semivolatile organic compounds by EPA method 8270, pesticides and PCBs by EPA method 8080, metals by EPA method series 6000 and 7000, and TPH by EPA method 8015 modified as diesel or gasoline. The off-site laboratory has established analyte detection levels which are below the method required quantitation levels. The concentrations reported for those analytes detected below the laboratory quantitation limits are estimated and are noted as such in the following tables.

A sample was collected from the bottom, inlet, and outlet. These samples were analyzed in the on-site laboratory as part of our field screening program. When the on-site laboratory results demonstrated the excavation was clean, additional samples were sent to the off-site laboratory for confirmation. The off-site analytical detection results are summarized in Tables 4-1 through 4-3, respectively. The complete on-site and off-site analytical data are in Appendix A and B, respectively. None of the compounds detected in the bottom, inlet, and outlet samples exceeded the STCLs; therefore, structure 23CDXX3 is a clean closure.

TABLE 4-1 - Bottom Sample - 23CDXX3SOBTOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	35 mg/kg			500 mg/kg
Aluminum	1980 mg/kg			54900 mg/kg
Barium	6.0 mg/kg			3800 mg/kg
Beryllium	0.17 mg/kg			1 mg/kg
Calcium	121 mg/kg			
Chromium	3.3 mg/kg			274 mg/kg
Cobalt	1.5 mg/kg			
Copper	2.5 mg/kg			
Iron	2930 mg/kg			
Lead	4.7 mg/kg			300 mg/kg
Magnesium	453 mg/kg			
Manganese	40.3 mg/kg			274 mg/kg
Nickel	2.9 mg/kg			1100 mg/kg
Potassium	210 mg/kg			
Vanadium	5.1 mg/kg			384 mg/kg
Zinc	51.9 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	54 ug/kg	YES		45700 ug/kg
Butyl benzyl phthalate	40 ug/kg	YES		11000000 ug/kg
Chrysene	60 ug/kg	YES		87700 ug/kg

[1]STCL outside is used when the structure was located outside the flightline.

TABLE 4-2 - Inlet Sample - 23CDXX3SOINOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	70 mg/kg			500 mg/kg
Aluminum	3250 mg/kg			54900 mg/kg
Barium	5.9 mg/kg			3800 mg/kg
Beryllium	0.12 mg/kg			1 mg/kg
Calcium	118 mg/kg			
Chromium	4.4 mg/kg			274 mg/kg
Cobalt	2.4 mg/kg			
Copper	2.3 mg/kg			
Iron	3370 mg/kg			
Lead	10.8 mg/kg			300 mg/kg
Magnesium	578 mg/kg			
Manganese	52.8 mg/kg			274 mg/kg
Nickel	4.4 mg/kg			1100 mg/kg
Potassium	228 mg/kg			
Selenium	7.0 mg/kg			274 mg/kg
Vanadium	4.7 mg/kg			384 mg/kg
Zinc	39.8 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	75 ug/kg	YES		45700 ug/kg

[1] STCL outside was located used when the structure is outside the flightline.

TABLE 4-3 - Outlet Sample - 23CDXX3SOOUOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	27 mg/kg			500 mg/kg
Aluminum	1670 mg/kg			54900 mg/kg
Barium	4.4 mg/kg			3800 mg/kg
Beryllium	0.06 mg/kg			1 mg/kg
Calcium	139 mg/kg			
Chromium	0.63 mg/kg			274 mg/kg
Cobalt	1.2 mg/kg			
Copper	1.3 mg/kg			
Iron	1930 mg/kg			
Lead	7.4 mg/kg			300 mg/kg
Magnesium	307 mg/kg			
Manganese	32.0 mg/kg			274 mg/kg
Potassium	202 mg/kg			
Vanadium	2.9 mg/kg			384 mg/kg
Zinc	22.9 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	93 ug/kg	YES		45700 ug/kg
Di-n-butyl phthalate	39 ug/kg	YES		5490000 ug/kg

[1]STCL outside is used when the structure was located outside the flightline.

4.3 ANALYTICAL QA

The analytical data was validated in accordance with DOE/HWP - 65/R1: "Requirements for Quality Control of Analytical Data." The validation was a Level C DQO validation and found the data to be usable. Samples were collected from the sidewalls and bottom of the excavation for analysis by an on-site laboratory. This laboratory used gas chromatography and immunoassay techniques for the organic analyses and x-ray fluorescence (XRF) for inorganic analysis. There is good agreement between the on-site and off-site analytical data, with the exception of the PAH and barium results. The on-site laboratory measures PAHs as a total concentration while the off-site laboratory measures the concentration of individual PAHS. No PAHs were detected by the off-site laboratory. The total PAH concentrations found by the on-site laboratory were low and could result from summing the concentrations of several PAHs which are each present at below the off-site detection limit or which are not target compounds for off-site analysis. The barium concentrations reported by the on-site laboratory are approximately 30 to 75 times the corresponding off-site data. It is possible that the sample digestion process used by the off-site laboratory is not efficient for barium and this is compounded by a matrix effect. Due to the high STCL value for barium, it is unlikely barium is present in any sample from this structure at levels approaching the STCLs.

Low levels of contaminants were found in blanks associated with the SVOC analysis and the data were appropriately qualified by the laboratory. Due to blank contamination, the di-n-butyl phthalate detect in the inlet sample is considered to be a laboratory artifact. The off-site laboratory analyzed the paylimit sample for metals on an instrument which had a detection limit of 2.4 mg/kg (accounting for percent moisture) for thallium. The clean fill limit for thallium is 2 mg/kg, which is slightly lower than the instruments detection limit. Thallium was not detected in the paylimit sample. As thallium is not an expected contaminant and the paylimit was found unsuitable for clean fill because of the presence of other contaminants, the impact on data usability is assessed to be minimal. The off-site laboratory

analyzed the paylimit and bottom samples for pesticides/PCBs at a 10-fold dilution because of matrix effects. This increased the detection limits for heptachlor (2.2 µg/kg) and PCB-1221 (190 µg/kg) to above the STCLs of 1.7 and 158 µg/kg, respectively. As no other pesticides or PCBs were detected in these or any other sample from this structure, it is unlikely that these contaminants would be present and the impact of these elevated detection limits is assessed to be minimal.

4.4 SOIL FINAL DISPOSITION

The analytical results for the paylimit from this drainage structure were reviewed and are summarized in Table 4-4. Based on these results, the paylimit was stockpiled to be treated in the OABF. STCLs were exceeded for cadmium and zinc.

TABLE 4-4 - Paylimit Sample - Z3CDXX3SOPLOF1

Analyte	Results	Estimated Quantitation	Exceeds Limits	STCL Clean	TCLP Limits	20X Rule
TPH as Diesel	84 mg/kg			500 mg/kg		
Aluminum	2710 mg/kg			26400 mg/kg		
Barium	6.8 mg/kg			3800 mg/kg	100 mg/L	2000 mg/kg
Beryllium	0.13 mg/kg			1 mg/kg		
Cadmium	2.3 mg/kg		YES	1.5 mg/kg	1 mg/L	20 mg/kg
Calcium	144 mg/kg					
Chromium	3.7 mg/kg			6.8 mg/kg	5 mg/L	100 mg/kg
Cobalt	1.6 mg/kg			333 mg/kg		
Copper	6.5 mg/kg			19.3 mg/kg		
Iron	3300 mg/kg					
Lead	11.0 mg/kg			15.8 mg/kg	5 mg/L	100 mg/kg
Magnesium	379 mg/kg					
Manganese	35.1 mg/kg			274 mg/kg		
Nickel	3.7 mg/kg			955 mg/kg		
Potassium	249 mg/kg					
Selenium	7.2 mg/kg			7.8 mg/kg	1 mg/L	20 mg/kg
Vanadium	5.2 mg/kg			15.2 mg/kg		
Zinc	239 mg/kg		YES	16 mg/kg		
bis(2-Ethylhexyl) phthalate	39 ug/kg	YES		812 ug/kg		

4.5 DEBRIS FINAL DISPOSITION

The debris from this structure was decontaminated. It will be sorted into suitable and non-suitable debris. The suitable debris will be used for aggregate in the On-site Asphalt Batching Facility. The unsuitable debris will be sent to a construction landfill.

5. APPENDICES

A. ON-SITE ANALYTICAL DATA
B. OFF-SITE ANALYTICAL DATA

CLOSURE REPORT

1. INTRODUCTION

1.1 *DRAINAGE STRUCTURE REMOVAL PROGRAM*

Massachusetts Military Reservation (MMR) is listed on the U.S. Environmental Protection Agency (USEPA) National Priority List. Remedial studies and activities are currently being conducted at MMR in accordance with guidelines and procedures of the USEPA Superfund program and the National Contingency Plan (NCP). Two types of action can be initiated under the NCP: remedial actions and removal actions. Remedial actions are long-term, permanent remediation of hazardous waste sites. Removal actions are short-term actions to abate or eliminate the release of contamination. The drainage structure removal program is a removal action program.

The National Guard Bureau (NGB) evaluated the drainage structures in a separate basewide program because of the similarity in operations and contaminants. The drainage structure removal program is based on the Phase I Sump Investigation Program conducted by ABB Environmental Services Inc. (ABB) and the Phase II Sump Investigation Program conducted by Metcalf and Eddy for the NGB. ABB characterized approximately 100 drainage structures. This characterization included sampling to identify potential contaminant sources. Also during this phase an additional 161 drainage structures were identified. Fifteen of these structures were characterized by Metcalf and Eddy as a high priority.

- A total of 185 drainage structures are included in the program. One hundred sixty-five of these structures are funded for removal. Currently, Jacobs Engineering Group is under contract through the Air Force Center for Environmental Excellence for the following work under the drainage structure removal program. The scope of work includes: The removal or abandonment in place of approximately 165 existing drainage structures on the Massachusetts Military Reservation and the associated liquid and sediment contents.
- Demolition of 12 existing vehicle maintenance slabs and foundations.
- Testing soil, liquid, sludge and sediment for contamination.
- Stockpiling and treatment or disposal of excavated drainage structure debris and surrounding soil.
- Backfilling and restoring excavations as specified.
- Preparing closure reports.

The work Jacobs is performing on the drainage structure removal program is governed by the "Final Drainage Structure Removal Program Specifications", July 1995, prepared for Massachusetts Military Reservation by Metcalf and Eddy; and the approved Jacobs' Plans (Drainage Structure Removal Program Volume I - Quality Project Plan and Volume II - Remedial Action Work Plan, January 1996, prepared for Massachusetts Military Reservation). These documents detail the procedures utilized by Jacobs during the removal of drainage structures.

1.2 CLEAN-UP LEVELS

The clean-up levels for the drainage structure removal program (DSRP) are determined by the MMR specific soil target clean-up levels (STCLs) as developed by HAZWRAP and presented in their letter, "Soil Target Clean Up Levels," dated January 30, 1995. The STCLs are risk based standards. The depth utilized for the DSRP is the 2 to 15 foot depth. Additionally, the STCLs are divided into several sub-categories: inside the flightline, outside the flightline, and clean fill. The inside and outside the flightline STCLs are based upon future use as well as risk. These standards apply to the bottom, inlet, and outlet samples and are used to determine that the drainage structure removal is a clean closure.

The clean fill STCLs apply to the paylimit sample. This data determines if the paylimit can be used for clean fill or requires treatment. The soil will be treated in the OABF if any of the contaminants tested are above the STCLs for clean fill. Additionally, if the soil fails the "twenty times" rule as defined in specification 01410, a paylimit sample will be analyzed for TCLP. If the soil passes the TCLP, it will be treated in the OABF. Any soil failing TCLP limits will be disposed off-site at a RCRA-regulated facility.

1.3 DRAINAGE STRUCTURE DESCRIPTION AND LOCATION

Drainage structure 23CDXX4 is located outside the flightline area in former Building 3694, west of Frank Perkins Road, in the FS-17 Study Area. The drainage structure was a Vehicle Maintenance Pit (See Figure 1). It was visible at ground surface and had a depth of 5 feet in the manway and a depth of 8 feet in the drainage pit. This structure was immediately adjacent to and located within the same building foundation as Vehicle Maintenance Pit 23CDXX5. The survey coordinates, taken at the center point of the structure, are 246,655.2 North and 856,301.3 East.

The drainage pit area was located at the northern end of the structure. The structure bottom and walls were constructed of poured concrete with reinforcement bars. No piping was observed exiting the pit area. However, a single 4-inch steel outlet pipe was observed exiting the foundation. The outlet pipe from the foundation discharged to Leaching Well 23CDXX1.

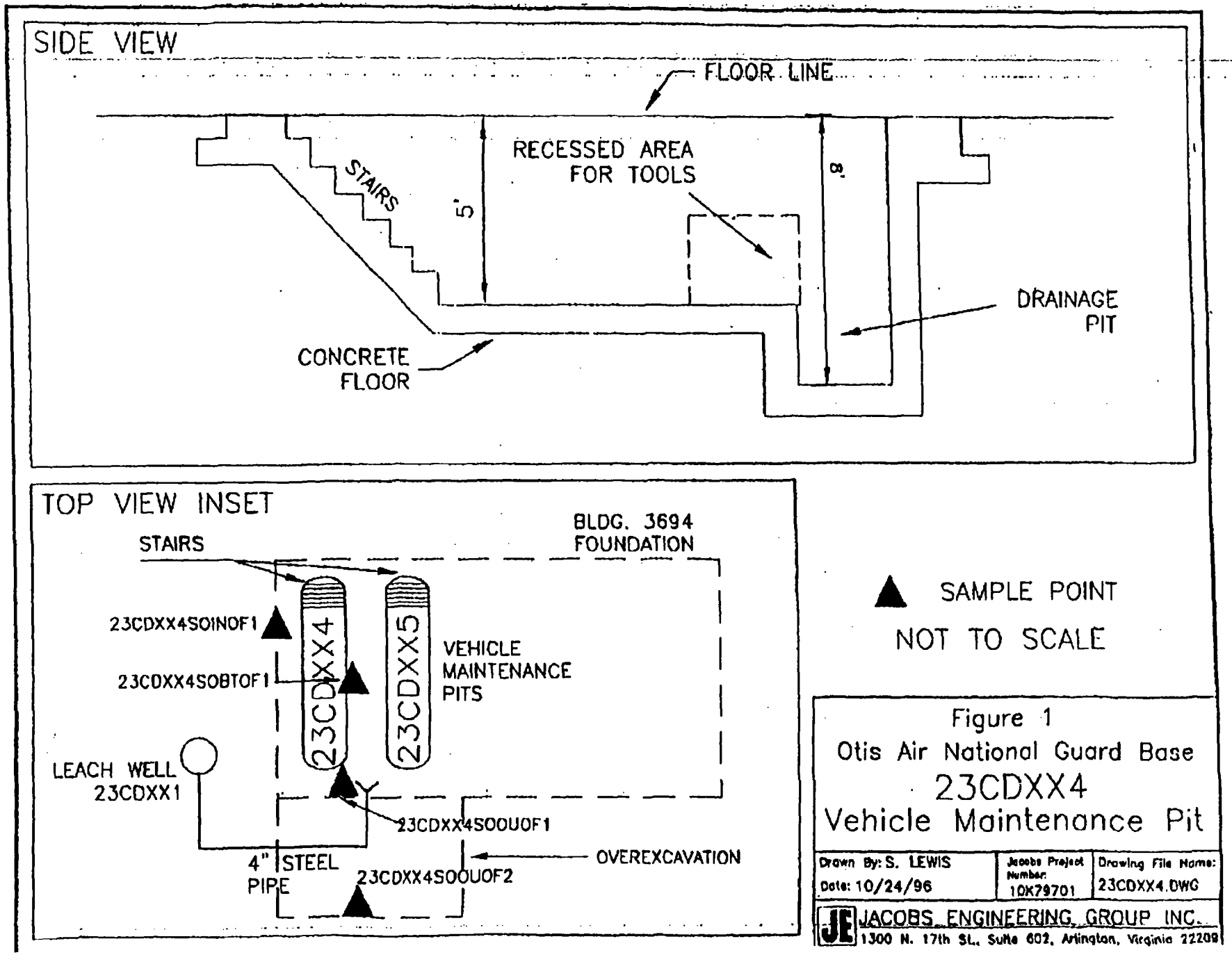
1.4 PREVIOUS INVESTIGATION HISTORY

1.4.1 FUEL SPILL 17 (FS-17) STUDY AREA

Study area FS-17 is a former World War II Motor Pool. The study area is located off Frank Perkins Road. Two type III Leaching Well structures and a French Drain were identified during the previous investigations. Drainage structures 23CDXX1 and 23CDXX2 were sampled during the Phase I Sump Investigation Program conducted by ABB. At that time, eight soil borings were drilled in the FS-17 area to assess contamination.

1.4.2 PHASE I INVESTIGATION SUMMARY

At the time of ABB investigation (Sump Removal Action Program, Phase I Sump Investigation Program Work Completion Report, October 1992), drainage structure 23CDXX4 was not sampled. Results from the sampling at other drainage structures in the FS-17 area had TPH, benzene, copper, zinc, and pesticide detections.


SIDE VIEW
FLOOR LINE
STAIRS
5'
RECESSED AREA
FOR TOOLS
8'
DRAINAGE
PIT
CONCRETE
FLOOR
TOP VIEW INSET
BLDG. 3694
FOUNDATION
STAIRS
23CDXX4SOINOF1
23CDXX4SOBTOF1
23CDXX4
23CDXX5
VEHICLE
MAINTENANCE
PITS
LEACH WELL
23CDXX1
23CDXX4SOOUOF1
4" STEEL
PIPE
23CDXX4SOOUOF2
OVEREXCAVATION
SAMPLE POINT
NOT TO SCALE
Figure 1
Otis Air National Guard Base
23CDXX4
Vehicle Maintenance Pit
Drawn By: S. LEWIS
Date: 10/24/96
Jacobs Project Number: 10K79701
Drawing File Name: 23CDXX4.DWG
JACOBS ENGINEERING GROUP INC.
1300 N. 17th St., Suite 602, Arlington, Virginia 22209

2. LIQUID REMOVAL AND DISPOSAL

No liquid was removed from this structure.

3. SEDIMENT/SLUDGE REMOVAL AND DISPOSAL

No sediment/sludge was removed from this structure. The structure was filled with soil, and construction debris which was removed as part of the paylimit.

4. DRAINAGE STRUCTURE REMOVAL AND DISPOSAL

4.1 PROCEDURES USED TO REMOVE PAYLIMIT

4.1.1 EXCAVATION

On April 4, 1996, an excavator was used to excavate and remove the drainage structure (Vehicle Maintenance Pit) and paylimit soils. A hoe-ram was used throughout the removal process for demolition of the structure. The soil was removed and directly loaded onto dump trucks. Approximately 210 cubic yards of soil and debris were excavated from former Building 3694, which included the foundation as well as structures 23CDXX4 and 23CDXX5. The final excavation size was 36-feet long by 21-feet wide by 11-feet deep. During removal of the paylimit, approximately 7 feet of 4-inch steel pipe were removed from the foundation. Pipe remaining in the ground was capped with concrete.

Structure 23CDXX4 was overexcavated on May 23, 1996. Detections of PCB-1260 were found at levels above the STCLs at the outlet sample location. An additional 41 cubic yards of material was removed. No additional foundation or piping was removed with this second excavation.

Excavated soil was stored by structure in the CSA. Structure closure was observed by ABB Environmental, the Title II subcontractor to IRP. Photos are located in the photo log of the master copy of this document in the IRP office.

4.1.2 FIELD SCREENING

Field screening for volatile organic compounds and dust was conducted throughout the excavation activities. PID results were non-detect in the breathing zone. Mini-RAM results were also non-detect in the breathing zone. Headspace PID readings were also taken at the inlet, outlet, and bottom. The headspace readings were used as an initial determination of contamination. The headspace levels were 16.1 ppm for the bottom, 0.4 ppm for the inlet, and 0.1 ppm for the outlet sample locations. The headspace level at the outlet location for the overexcavation was 0.6 ppm.

4.1.3 BACKFILL

The backfill used for this excavation came from an on-base source, either the former Landfill 1 common borrow pit located on Turpentine Road or paylimit soils from drainage structures with analytical results below the clean fill STCLs. Approximately 394 cubic yards of soil were used to backfill 23CDXX4 and 23CDXX5.

4.1.4 FINAL RESTORATION

The building foundation was removed during the excavation impacting the surrounding vegetation. The area was regraded.

4.2 *ANALYTICAL RESULTS*

The on-site and off-site laboratories analyzed the samples according to the Quality Assurance Plan and the laboratory specification (Section 01410 of the Specifications). All data was validated in accordance with HAZWRAP and DOE guidelines. The samples were analyzed for the volatile compounds utilizing EPA method 8010/8020 and EDB, the semivolatile compounds utilized EPA method 8270, pesticides and PCBs by EPA method 8080, metals by EPA method series 6000 and 7000, and TPH by EPA method 8015 modified as diesel and gasoline. The off-site laboratory has established analyte detection levels which are below the method required quantitation levels. The concentrations reported for those analytes detected below the laboratory quantitation limits are estimated and are noted as such in the following tables.

A sample was collected from the bottom, inlet, and outlet sample locations. The outlet sample was collected from a point in the sidewall closest to where the outlet pipe exited the building foundation. The inlet sample was collected from the sidewall opposite the outlet sample since there was no inlet pipe present. These samples were analyzed in the on-site laboratory as part of our field screening program. All samples were sent to the off-site laboratory for confirmation. The off-site analytical detection results for the excavation are summarized in Tables 4-1 through 4-3, respectively. Detections of PCB-1260 were reported above the STCLs for the outlet sample location. The offsite analytical results for the overexcavated outlet sample are summarized in Table 4-4. The complete on-site and off-site analytical data are in Appendix A and B, respectively. None of the compounds detected in the bottom and inlet for the intial excavation and outlet samples for the overexcavation exceeded the STCLs therefore, structure 23CDXX4 is a clean closure.

Table 4-1 - Bottom Sample 23CDXX4SOBTOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	92 mg/kg			500 mg/kg
PCB-1260	0.028 mg/kg			0.158 mg/kg
Aluminum	1550 mg/kg			54900 mg/kg
Arsenic	1.6 mg/kg			3.6 mg/kg
Barium	6.6 mg/kg			3800 mg/kg
Beryllium	0.17 mg/kg			1 mg/kg
Cadmium	0.62 mg/kg			26.4 mg/kg
Calcium	871 mg/kg			
Chromium	3.6 mg/kg			274 mg/kg
Cobalt	2.2 mg/kg			
Copper	2.1 mg/kg			
Iron	3400 mg/kg			
Lead	17.4 mg/kg			300 mg/kg
Magnesium	320 mg/kg			
Manganese	42.3 mg/kg			274 mg/kg
Nickel	2.0 mg/kg			1100 mg/kg
Potassium	143 mg/kg			
Vanadium	6.0 mg/kg			384 mg/kg
Zinc	15.4 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	270 ug/kg	YES		45700 ug/kg
Pyrene	100 ug/kg	YES		1650000 ug/kg

[1]STCL is used when the drainage structure was located outside the flightline.

Table 4–2 - Inlet Sample 23CDXX4SOINOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	75 mg/kg			500 mg/kg
Aluminum	2850 mg/kg			54900 mg/kg
Arsenic	2.6 mg/kg			3.6 mg/kg
Barium	17.9 mg/kg			3800 mg/kg
Beryllium	0.24 mg/kg			1 mg/kg
Cadmium	0.41 mg/kg			26.4 mg/kg
Calcium	1710 mg/kg			
Chromium	8.4 mg/kg			274 mg/kg
Cobalt	3.0 mg/kg			
Copper	4.3 mg/kg			
Iron	6020 mg/kg			
Lead	22.9 mg/kg			300 mg/kg
Magnesium	774 mg/kg			
Manganese	111 mg/kg			274 mg/kg
Nickel	3.5 mg/kg			1100 mg/kg
Potassium	360 mg/kg			
Vanadium	11.1 mg/kg			384 mg/kg
Zinc	24.1 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	270 ug/kg	YES		45700 ug/kg
Di-n-butyl phthalate	37 ug/kg	YES		5490000 ug/kg
Pyrene	110 ug/kg	YES		1650000 ug/kg

[1] STCL is used when the drainage structure was located outside the flightline.

Table 4-3 - Outlet Sample 23CDXX4SOOUOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	41 mg/kg			500 mg/kg
PCB-1260	0.23 mg/kg		YES	0.158 mg/kg
Aluminum	3410 mg/kg			54900 mg/kg
Arsenic	1.8 mg/kg			3.6 mg/kg
Barium	13.8 mg/kg			3800 mg/kg
Beryllium	0.19 mg/kg			1 mg/kg
Cadmium	0.76 mg/kg			26.4 mg/kg
Calcium	820 mg/kg			
Chromium	11.0 mg/kg			274 mg/kg
Cobalt	2.1 mg/kg			
Copper	8.8 mg/kg			
Iron	4700 mg/kg			
Lead	153 mg/kg			300 mg/kg
Magnesium	647 mg/kg			
Manganese	64.8 mg/kg			274 mg/kg
Nickel	3.5 mg/kg			1100 mg/kg
Potassium	299 mg/kg			
Vanadium	8.0 mg/kg			384 mg/kg
Zinc	83.7 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	160 ug/kg	YES		45700 ug/kg
Pyrene	100 ug/kg	YES		1650000 ug/kg

[1]STCL is used when the drainage structure was located outside the flightline.

Table 4-4 - Overexcavation Outlet Sample 23CDXX4SOOUOF2

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
Aluminum	1690 mg/kg			54900 mg/kg
Arsenic	1.1 mg/kg			3.6 mg/kg
Barium	4.0 mg/kg			3800 mg/kg
Beryllium	0.12 mg/kg			1 mg/kg
Calcium	115 mg/kg			
Chromium	1.6 mg/kg			274 mg/kg
Cobalt	1.8 mg/kg			
Copper	1.6 mg/kg			
Iron	2810 mg/kg			
Lead	1.6 mg/kg			300 mg/kg
Magnesium	440 mg/kg			
Manganese	54.7 mg/kg			274 mg/kg
Nickel	2.4 mg/kg			1100 mg/kg
Potassium	257 mg/kg			
Vanadium	3.4 mg/kg			384 mg/kg
Zinc	9.4 mg/kg			10000 mg/kg

4.3 ANALYTICAL QA

The analytical data were validated in accordance with DOE/HWP - 65/R1: "Requirements for Quality Control of Analytical Data." The validation was a Level C DQO validation and found the data to be usable. Samples were collected from the sidewalls and bottom of the excavation for analysis by an on-site laboratory. This laboratory used gas chromatography and immunoassay techniques for the organic analyses and x-ray fluorescence (XRF) for inorganic analysis. There is good agreement between the on-site and off-site analytical data, with the exception of PAH, TPH, 4,4'-DDT, PCB, and barium results. The on-site laboratory detected low levels of PAH in the bottom and inlet samples that were much greater than those detected in the corresponding samples by the off-site laboratory. TPH as diesel was detected in the inlet sample at much lower levels by the on-site laboratory. TPH as gasoline and 4,4'-DDT were detected in the bottom and inlet samples, respectively, by the on-site laboratory, but were not detected in the corresponding off-site samples. A low level of PCB was detected in the bottom sample only by the off-site laboratory. The impact of these disagreements between the on-site and off-site data is assessed to be minimal as all affected results were below applicable STCLs. The barium concentrations reported by the on-site laboratory are approximately 15 to 30 times the corresponding off-site data. The sample digestion process in the analytical method specified for the off-site laboratory is designed to extract the contaminants from soil matrix samples, not to enable a total soil composition analysis. The XRF technique, however, is non-selective and will detect all barium in a sample, both from contamination and soil composition.

Because of the dark color of the final pesticide extract, the inlet and outlet samples were analyzed for pesticide/PCBs at a 20-fold dilution. This resulted in minimum detection limits that were greater than the corresponding clean-fill STCL for heptachlor, toxaphene, PCB1016, PCB1221, PCB-1232, and PCB-1254. The bottom sample was also analyzed at a secondary dilution. It had no impact on data usability because the dilution did not raise the MDLs above the corresponding STCLs.

Low levels of organic and metallic analytes were detected in the rinse, method, and preparation blanks associated with the samples from this structure. This resulted in the qualification of some data as laboratory or sampling artifact. For this reason, the beryllium and bis(2-ethylhexyl) phthalate detects in all of the samples are considered to be artifacts. Each detection qualified as an artifact is below the applicable STCL and has no impact on the overall usability of the data. All other analytes detected in blanks have no effect on the data.

4.4 SOIL FINAL DISPOSITION

The analytical results for the paylimit from this drainage structure were reviewed and are summarized in Table 4-5. STCLs were not exceeded for clean fill. Based on these results the paylimit soil from this structure was used as clean fill.

Table 4-5 - Paylimit Sample 23CDXX4SOPLOF1

Analyte	Result	Estimated Quantitation	Exceeds Limits	STCL Clean	TCLP Limit	20X Rule
Aluminum	1060 mg/kg			26400 mg/kg		
Arsenic	1.3 mg/kg			3.6 mg/kg	5 mg/L	100 mg/kg
Barium	3.1 mg/kg			3800 mg/kg	100 mg/L	2000 mg/kg
Beryllium	0.15 mg/kg			1 mg/kg		
Cadmium	0.60 mg/kg			1.5 mg/kg	1 mg/L	20 mg/kg
Calcium	185 mg/kg					
Chromium	2.2 mg/kg			6.8 mg/kg	5 mg/L	100 mg/kg
Cobalt	1.2 mg/kg			333 mg/kg		
Copper	2.4 mg/kg			19.3 mg/kg		
Iron	2810 mg/kg					
Lead	1.6 mg/kg			15.8 mg/kg	5 mg/L	100 mg/kg
Magnesium	268 mg/kg					
Manganese	40.0 mg/kg			274 mg/kg		
Nickel	16.4 mg/kg			955 mg/kg		
Potassium	150 mg/kg					
Vanadium	4.1 mg/kg			15.2 mg/kg		
Zinc	7.9 mg/kg			16 mg/kg		
bis(2-Ethylhexyl) phthalate	310 ug/kg	YES		812 ug/kg		
Pyrene	94 ug/kg	YES		4690 ug/kg		

4.5 DEBRIS FINAL DISPOSITION

The debris from this structure was decontaminated. It will be sorted into suitable and non-suitable debris. The suitable debris will be used for aggregate in the OABF. The unsuitable debris will be sent to a construction debris landfill.

5. APPENDICES

A. ON-SITE ANALYTICAL DATA
B. OFF-SITE ANALYTICAL DATA

CLOSURE REPORT

1. INTRODUCTION

1.1 *DRAINAGE STRUCTURE REMOVAL PROGRAM*

Massachusetts Military Reservation (MMR) is listed on the U.S. Environmental Protection Agency (USEPA) National Priority List. Remedial studies and activities are currently being conducted at MMR in accordance with guidelines and procedures of the USEPA Superfund program and the National Contingency Plan (NCP). Two types of action can be initiated under the NCP: remedial actions and removal actions. Remedial actions are long-term, permanent remediation of hazardous waste sites. Removal actions are short-term actions to abate or eliminate the release of contamination. The drainage structure removal program is a removal action program.

The National Guard Bureau (NGB) evaluated the drainage structures in a separate basewide program because of the similarity in operations and contaminants. The drainage structure removal program is based on the Phase I Sump Investigation Program conducted by ABB Environmental Services Inc. (ABB) and the Phase II Sump Investigation Program conducted by Metcalf and Eddy for the NGB. ABB characterized approximately 100 drainage structures. This characterization included sampling to identify potential contaminant sources. Also during this phase an additional 161 drainage structures were identified. Fifteen of these structures were characterized by Metcalf and Eddy as a high priority.

- A total of 185 drainage structures are included in the program. One hundred sixty-five of these structures are funded for removal. Currently, Jacobs Engineering Group is under contract through the Air Force Center for Environmental Excellence for the following work under the drainage structure removal program. The scope of work includes: The removal or abandonment in place of approximately 165 existing drainage structures on the Massachusetts Military Reservation and the associated liquid and sediment contents.
- Demolition of 12 existing vehicle maintenance slabs and foundations.
- Testing soil, liquid, sludge and sediment for contamination.
- Stockpiling and treatment or disposal of excavated drainage structure debris and surrounding soil.
- Backfilling and restoring excavations as specified.
- Preparing closure reports.

The work Jacobs is performing on the drainage structure removal program is governed by the "Final Drainage Structure Removal Program Specifications", July 1995, prepared for Massachusetts Military Reservation by Metcalf and Eddy; and the approved Jacobs' Plans (Drainage Structure Removal Program Volume I - Quality Project Plan and Volume II - Remedial Action Work Plan, January 1996, prepared for Massachusetts Military Reservation). These documents detail the procedures utilized by Jacobs during the removal of drainage structures.

1.2 CLEAN-UP LEVELS

The clean-up levels for the drainage structure removal program (DSRP) are determined by the MMR specific soil target clean-up levels (STCLs) as developed by HAZWRAP and presented in their letter, "Soil Target Clean Up Levels," dated January 30, 1996. The STCLs are risk based standards. The depth utilized for the DSRP is the 2 to 15 foot depth. Additionally, the STCLs are divided into several sub-categories: inside the flightline, outside the flightline, and clean fill. The inside and outside the flightline STCLs are based upon future use as well as risk. These standards apply to the bottom, inlet, and outlet samples and are used to determine that the drainage structure removal is a clean closure.

The clean fill STCLs apply to the paylimit sample. This data determines if the paylimit can be used for clean fill or requires treatment. The soil will be treated in the OABF if any of the contaminants tested are above the STCLs for clean fill. Additionally, if the soil fails the "twenty times" rule as defined in specification 01410, a paylimit sample will be analyzed for TCLP. If the soil passes the TCLP, it will be treated in the OABF. Any soil failing TCLP limits will be disposed off-site at a RCRA-regulated facility.

1.3 DRAINAGE STRUCTURE DESCRIPTION AND LOCATION

Drainage structure 23CDXX5 is located outside the flightline area in former Building 3694, west of Frank Perkins Road, in the FS-17 Study Area. The drainage structure was a Vehicle Maintenance Pit (See Figure 1). It was visible at ground surface and had a depth of 5 feet in the manway and a depth of 8 feet in the drainage pit. This structure was immediately adjacent to and located within the same building foundation as Vehicle Maintenance Pit 23CDXX4. The survey coordinates are 246,665.2 North and 856,317.0 East.

The drainage pit area was located at the northern end of the structure. The structure bottom and walls were constructed of poured concrete with reinforcement bars. No piping was observed exiting the pit area itself, however, a single 4-inch steel outlet pipe was observed exiting the foundation of the structure. The outlet pipe from the foundation discharged to Leaching Well 23CDXX1.

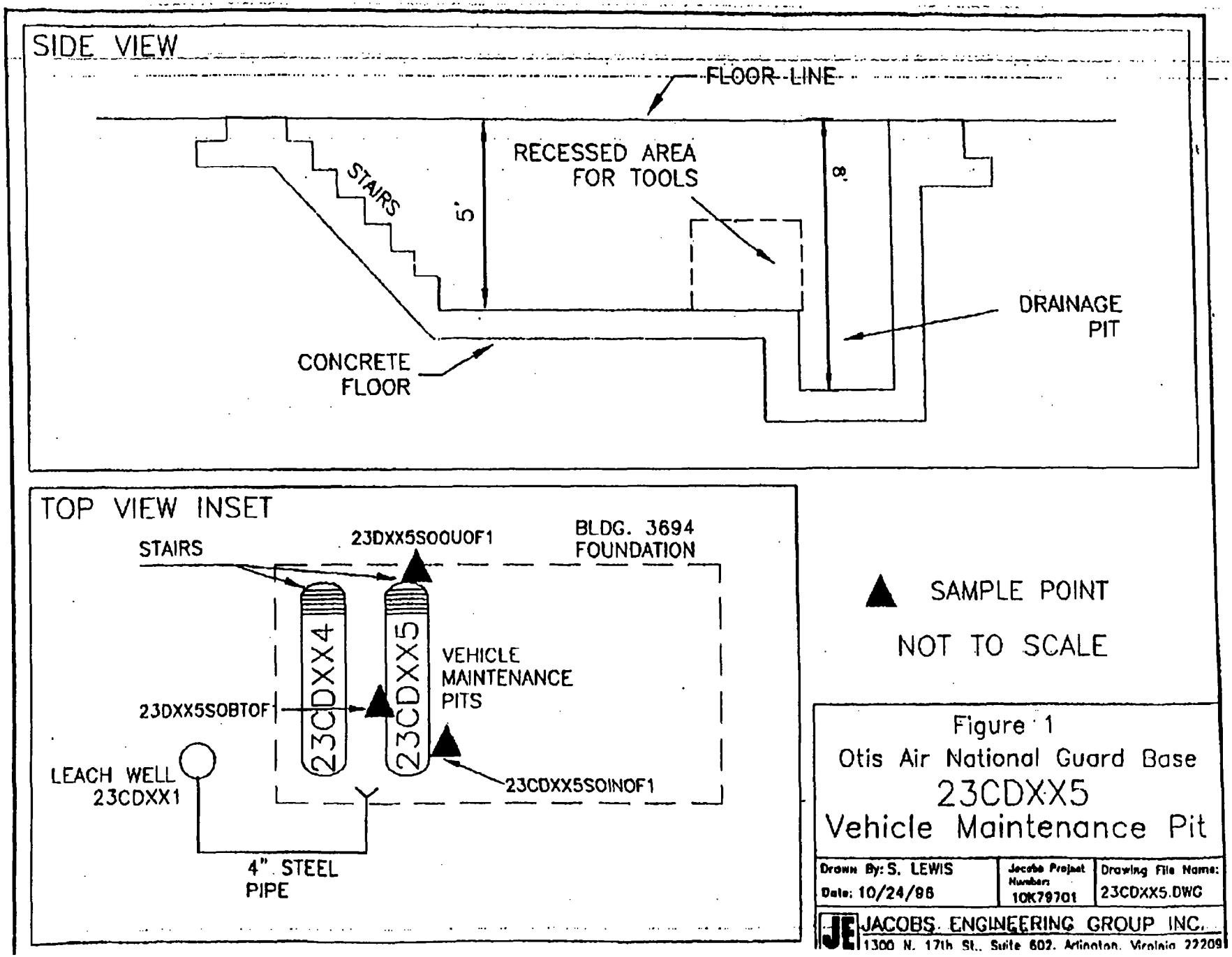
1.4 PREVIOUS INVESTIGATION HISTORY

1.4.1 FUEL SPILL 17 (FS-17) STUDY AREA

Study area FS-17 is a former World War II Motor Pool. The study area is located off Frank Perkins Road. Two type III Leaching Well structures and a French Drain were identified during the previous investigations. Drainage structures 23CDXX1 and 23CDXX2 were sampled during the Phase I Sump Investigation Program conducted by ABB. At that time, eight soil borings were drilled in the FS-17 area to assess contamination.

1.4.2 PHASE I INVESTIGATION SUMMARY

At the time of ABB investigation (Sump Removal Action Program, Phase I Sump Investigation Program Work Completion Report, October 1992), drainage structure 23CDXX5 was not sampled. Results from the sampling at other drainage structures in the FS-17 area had TPH, benzene, copper, zinc, and pesticide detections.


SIDE VIEW
FLOOR LINE
STAIRS
5'
RECESSED AREA
FOR TOOLS
8'
DRAINAGE
PIT
CONCRETE
FLOOR
TOP VIEW INSET
STAIRS
23DXX5S00U0F1
BLDG. 3694
FOUNDATION
23CDXX4
23CDXX5
VEHICLE
MAINTENANCE
PITS
23DXX5S0BT0F1
LEACH WELL
23CDXX1
23CDXX5S0IN0F1
4" STEEL
PIPE
SAMPLE POINT
NOT TO SCALE
Figure 1
Otis Air National Guard Base
23CDXX5
Vehicle Maintenance Pit
Drawn By: S. LEWIS
Date: 10/24/98
Jacobs Project Number: 10K79701
Drawing File Name: 23CDXX5.DWG
JACOBS ENGINEERING GROUP INC.
1300 N. 17th St., Suite 602, Arlington, Virginia 22209

2. LIQUID REMOVAL AND DISPOSAL

No liquid was removed from this structure.

3. SEDIMENT/SLUDGE REMOVAL AND DISPOSAL

No sediment/sludge was removed from this structure. The structure was filled with soil, and construction debris which were removed as part of the paylimit.

4. DRAINAGE STRUCTURE REMOVAL AND DISPOSAL

4.1 PROCEDURES USED TO REMOVE PAYLIMIT

4.1.1 EXCAVATION

On April 4, 1996, an excavator was used to excavate and remove the drainage structure (Vehicle Maintenance Pit) and paylimit soils. A hoe-ram was used throughout the removal process for demolition of the structure. The soil was removed and directly loaded onto dump trucks. Approximately 251 cubic yards of soil and debris were excavated from former Building 3694, which included the foundation as well as structures 23CDXX5 and 23CDXX4. The final excavation size was 36 feet long by 21 feet wide by 11 feet deep. During removal of the paylimit, approximately 7 feet of 4-inch steel pipe were removed from the foundation. Pipe remaining in the ground was capped with concrete.

Excavated soil was stored by structure in the CSA. Structure closure was observed by ABB Environmental, the Title II subcontractor to IRP. Photos are located in the photo log of the master copy of this document in the IRP office.

4.1.2 FIELD SCREENING

Field screening for volatile organic compounds and dust was conducted throughout the excavation activities. PID results were non-detect in the breathing zone. Mini-RAM results were also non-detect in the breathing zone. Headspace PID readings were also taken at the inlet, outlet, and bottom sample locations. The headspace readings were used as an initial determination of contamination. The headspace levels were 0.1 ppm for the bottom, 0.4 ppm for the inlet, and 0.0 ppm for the outlet sample locations.

4.1.3 BACKFILL

The backfill used for this excavation came from an on-base source, either the former Landfill 1 common borrow pit located on Turpentine Road or paylimit soils from drainage structures with analytical results below the clean fill STCLs. Approximately 394 cubic yards of soil were used to backfill 23CDXX5 and 23CDXX4.

4.1.4 FINAL RESTORATION

The area affected by the excavation included the former foundation and surrounding vegetation. This area was regraded.

4.2 ANALYTICAL RESULTS

The on-site and off-site laboratories analyzed the samples according to the Quality Assurance Plan and the laboratory specification (Section 01410 of the Specifications). All data was validated in accordance with HAZWRAP and DOE guidelines. The samples were analyzed for the volatile compounds utilizing EPA method 8010/8020 and EDB, the semivolatile compounds utilized EPA method 8270, pesticides and PCBs by EPA method 8080, metals by EPA method series 6000 and 7000, and TPH by EPA method 8015 modified as diesel and gasoline. The off-site laboratory has established analyte detection levels which are below the method required quantitation levels. The concentrations reported for those analytes detected below the laboratory quantitation limits are estimated and are noted as such in the following tables.

A sample was collected from the bottom, inlet, and outlet sample locations. The inlet sample was collected from the sidewall opposite the outlet sample since there was no inlet pipe present. The outlet sample was collected from the sidewall closest to the outlet pipe. These samples were analyzed in the on-site laboratory as part of our field screening program. All samples were sent to the off-site laboratory for confirmation. The off-site analytical detection results for the excavation are summarized in Tables 4-1 through 4-3, respectively. The complete on-site and off-site analytical data are in Appendix A and B, respectively. None of the compounds detected in the bottom, inlet, or outlet sample exceeded the STCLs therefore, structure 23CDXX5 is a clean closure.

Table 4-1 - Bottom Sample 23CDXX5SOBTOF1

Analyte	Results	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	6.2 mg/kg			500 mg/kg
Aluminum	1220 mg/kg			54900 mg/kg
Arsenic	3.3 mg/kg			3.6 mg/kg
Barium	3.5 mg/kg			3800 mg/kg
Beryllium	0.22 mg/kg			1 mg/kg
Cadmium	0.73 mg/kg			26.4 mg/kg
Calcium	142 mg/kg			
Chromium	3.3 mg/kg			274 mg/kg
Cobalt	1.4 mg/kg			
Copper	2.8 mg/kg			
Iron	6520 mg/kg			
Lead	2.5 mg/kg			300 mg/kg
Magnesium	460 mg/kg			
Manganese	31.3 mg/kg			274 mg/kg
Nickel	2.5 mg/kg			1100 mg/kg
Potassium	164 mg/kg			
Vanadium	12.3 mg/kg			384 mg/kg
Zinc	10 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	310 ug/kg	YES		45700 ug/kg
Pyrene	93 ug/kg	YES		1650000 ug/kg

[1] STCL is used when the drainage structure was located outside the flightline.

Table 4-2 - Inlet Sample 23CDXX5SOINOF1

Analyte	Results	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	59 mg/kg			500 mg/kg
PCB-1260	0.018 mg/kg	YES		0.158 mg/kg
Aluminum	1530 mg/kg			54900 mg/kg
Arsenic	3.2 mg/kg			3.6 mg/kg
Barium	10.2 mg/kg			3800 mg/kg
Beryllium	0.15 mg/kg			1 mg/kg
Cadmium	0.56 mg/kg			26.4 mg/kg
Calcium	2870 mg/kg			
Chromium	3.8 mg/kg			274 mg/kg
Cobalt	1.7 mg/kg			
Copper	6.7 mg/kg			
Iron	3530 mg/kg			
Lead	16.7 mg/kg			300 mg/kg
Magnesium	504 mg/kg			
Manganese	57.0 mg/kg			274 mg/kg
Nickel	2.2 mg/kg			1100 mg/kg
Potassium	206 mg/kg			
Vanadium	5.9 mg/kg			384 mg/kg
Zinc	23.3 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	530 ug/kg			45700 ug/kg
Pyrene	99 ug/kg	YES		1650000 ug/kg

[1]STCL is used when the drainage structure was located outside the flightline.

Table 4-3 - Outlet Sample 23CDXX5SOOUOF1

Analyte	Results	Estimated Quantitation	Exceeds Limits	STCL Outside[1]
TPH as Diesel	31 mg/kg			500 mg/kg
Dieldrin	0.0048 mg/kg	YES		0.133 mg/kg
PCB-1260	0.013 mg/kg	YES		0.158 mg/kg
Aluminum	1780 mg/kg			54900 mg/kg
Arsenic	2.4 mg/kg			3.6 mg/kg
Barium	16.6 mg/kg			3800 mg/kg
Beryllium	0.19 mg/kg			1 mg/kg
Cadmium	0.70 mg/kg			26.4 mg/kg
Calcium	1490 mg/kg			
Chromium	3.2 mg/kg			274 mg/kg
Cobalt	1.9 mg/kg			
Copper	2.3 mg/kg			
Iron	4940 mg/kg			
Lead	6.1 mg/kg			300 mg/kg
Magnesium	481 mg/kg			
Manganese	51.7 mg/kg			274 mg/kg
Nickel	2.7 mg/kg			1100 mg/kg
Potassium	274 mg/kg			
Vanadium	9.2 mg/kg			384 mg/kg
Zinc	13.8 mg/kg			10000 mg/kg
bis(2-Ethylhexyl) phthalate	160 ug/kg	YES		45700 ug/kg
Pyrene	97 ug/kg	YES		1650000 ug/kg

[1]STCL is used when the drainage structure was located outside the flightline.

4.3 *ANALYTICAL QA*

The analytical data were validated in accordance with DOE/HWP - 65/R1: "Requirements for Quality Control of Analytical Data." The validation was a Level C DQO validation and found the data to be usable. Samples were collected from the sidewalls and bottom of the excavation for analysis by an on-site laboratory. This laboratory used gas chromatography and immunoassay techniques for the organic analyses and x-ray fluorescence (XRF) for inorganic analysis. There is good agreement between the on-site and off-site analytical data, with the exception of total PAHs, TPH as diesel, and barium results. The on-site laboratory detected total PAHs and TPH as diesel in the bottom, inlet, and outlet samples with corresponding detections at much lower levels by the off-site laboratory. The level of total PAHs detected by the on-site laboratory could be the result of matrix interferences or the presence of non-target PAH compounds. The on-site laboratory calculates TPH as diesel from the total PAHs result, so any inaccuracies in the former results are carried over in the calculation of the latter. The barium concentrations reported by the on-site laboratory are approximately 25 to 50 times the corresponding off-site data. This is caused by differences in analytical methodology. The sample digestion process in the analytical method specified for the off-site laboratory is designed to extract the contaminants from soil matrix samples, not to enable a total soil composition analysis. The XRF technique, however, is non-selective and will detect all barium in a sample, both from contamination and soil composition.

The inlet sample from this structure was analyzed at a tenfold dilution for pesticides/PCBs. This caused the method detection limits (MDLs) for heptachlor and PCB-1221 to be raised above the applicable STCLs. The impact on the data is considered minimal as these are not expected contaminants. The paylimit and outlet samples were also analyzed at secondary dilutions. There is no impact on data usability for these samples as no compound MDLs were raised above the applicable STCLs.

Low levels of organic and metallic analytes were detected in the method and preparation blanks associated with the samples from this structure. For this reason, bis(2-ethylhexyl) phthalate is considered an artifact in all samples and beryllium is considered an artifact in the bottom, inlet, and outlet samples. Each detection qualified as an artifact is below the applicable STCL and has no impact on the overall usability of the data. All other analytes detected in blanks have no effect on the data.

The preparation blank had a negative value reported for selenium. This negative value indicates a downward baseline drift for this element for all samples from this structure. Review of the data indicates that although there is a possibility of false negatives, it is highly unlikely that selenium is present above applicable STCLs in any sample from this structure.

4.4 SOIL FINAL DISPOSITION

The analytical results for the paylimit from this drainage structure were reviewed and are summarized in Table 4-4. The STCLs was exceeded for zinc in structure 23CDXX5. On a case by case basis, if zinc is the only exceedence, a waiver will be given to the clean fill standard. This decision is based on discussions between the NGB IRP and the regulatory agencies. A Request For Information was made when the analytical results were received. Jacobs was directed to use the paylimit as clean fill.

Table 4-4 - Paylimit Sample 23CDXX5SOPLOF1

Analyte	Results	Estimated Quantitation	Exceeds Limits	STCL Clean	TCLP Limit	20X Rule
TPH as Diesel	14 mg/kg			500 mg/kg		
Aluminum	1710 mg/kg			26400 mg/kg		
Arsenic	4.2 mg/kg		YES	3.6 mg/kg	5 mg/L	100 mg/kg
Barium	7.9 mg/kg			3800 mg/kg	100 mg/L	2000 mg/kg
Beryllium	0.29 mg/kg			1 mg/kg		
Cadmium	1.0 mg/kg			1.5 mg/kg	1 mg/L	20 mg/kg
Calcium	274 mg/kg					
Chromium	4.4 mg/kg			6.8 mg/kg	5 mg/L	100 mg/kg
Cobalt	1.9 mg/kg			333 mg/kg		
Copper	2.6 mg/kg			19.3 mg/kg		
Iron	8840 mg/kg					
Lead	5.8 mg/kg			15.8 mg/kg	5 mg/L	100 mg/kg
Magnesium	546 mg/kg					
Manganese	63.6 mg/kg			274 mg/kg		
Nickel	2.6 mg/kg			955 mg/kg		
Potassium	203 mg/kg					
Vanadium	14.5 mg/kg			15.2 mg/kg		
Zinc	15.2 mg/kg			16 mg/kg		
bis(2-Ethylhexyl) phthalate	530 ug/kg			812 ug/kg		
Pyrene	97 ug/kg	YES		4690 ug/kg		

4.5 DEBRIS FINAL DISPOSITION

The debris from this structure was decontaminated. It will be sorted into suitable and non-suitable debris. The suitable debris will be used for aggregate in the OABF. The unsuitable debris will be sent to a construction debris landfill.

5. APPENDICES

A. ON-SITE ANALYTICAL DATA
B. OFF-SITE ANALYTICAL DATA

SUMP NO. 08CDXX1

ABB ENVIRONMENTAL SERVICES, INC
MMR; DRAINAGE STRUCTURE REMOVAL PROGRAM
FIELD EXCAVATION DATA SHEET

ABB-ES PROJECT NO. 8742-03 Date: 7/17/96

ABB-ES Field Rep: JEN

Structure number and location: 08CDXX1, CORNER OF LEEE AND WEAVER RDS. FS-19

Type of Structure: VALVE AND PUMP PIT ADJACENT TO FORMER BLDG.

Depth to bottom of structure: 8' Structure dimension: 12' X 6' X 4'

Inlet location, depth, and diameter: STRUCTURE HAD BEEN PREVIOUSLY DISTURBED AND

Outlet location, depth, and diameter: PIPING REMOVED COULD NOT BE CERTAIN WHERE PIPES ORIGINALLY ENTERED OR EXITED

Excavation Dimensions: 12' X 12' X 15' Length of pipe removed: N/A

Sample locations and head space results:

Pay Limit:	FROM EXCAVATED SOILS	Head space:	N/A PPM
Inlet:	W, 10' BGS	Head space:	0.0 PPM
Outlet:	E, 10' BGS	Head space:	0.0 PPM
Bottom:	15'	Head space:	0.0 PPM

Sump contents and action taken: STAINED SOILS WERE MIXED WITH EXCAVATED SOILS.

Non associated utilities encountered:

Notes:

On-site lab: N/A

Off-site lab: Confirmatory Samples passed STCL'S
Pay Limit soils Failed Clean Fill STCLS and will either be treated by OABF or disposed-of-off-site

(See laboratory data sheets by JEG in project file)

Sample ID	Analyte	Results	Unit	EX_LIMIT	stcl_inside	stcl_outside	stcl_clean	fed_reg	20Xrule
08CDXX1SOBTOF1	TPH as Diesel-	5.6	MG/KG		1200	500			
08CDXX1SOBTOF1	4,4'-DDT-	0.023	MG/KG		90	6.28			
08CDXX1SOBTOF1	Dieldrin-	0.013	MG/KG		2	.133			
08CDXX1SOBTOF1	Aluminum	1470	MG/KG		58200	54900			
08CDXX1SOBTOF1	Arsenic	1.6	MG/KG		11.6	3.6			
08CDXX1SOBTOF1	Barium	5.2	MG/KG		4070	3800			
08CDXX1SOBTOF1	Beryllium	0.10	MG/KG		4.73	1			
08CDXX1SOBTOF1	Calcium	206	MG/KG						
08CDXX1SOBTOF1	Chromium	1.9	MG/KG		1160	274			
08CDXX1SOBTOF1	Cobalt	1.2	MG/KG						
08CDXX1SOBTOF1	Copper	2.7	MG/KG						
08CDXX1SOBTOF1	Iron	2590	MG/KG						
08CDXX1SOBTOF1	Lead	21.3	MG/KG		1000	300			
08CDXX1SOBTOF1	Magnesium	341	MG/KG						
08CDXX1SOBTOF1	Manganese	50.9	MG/KG		8140	274			
08CDXX1SOBTOF1	Nickel	2.3	MG/KG		1160	1100			
08CDXX1SOBTOF1	Potassium	94.9	MG/KG						
08CDXX1SOBTOF1	Vanadium	3.7	MG/KG		407	384			
08CDXX1SOBTOF1	Zinc	26.6	MG/KG		10000	10000			
08CDXX1SOINOF1	TPH as Diesel-	250	MG/KG		1200	500			
08CDXX1SOINOF1	4,4'-DDT-	0.021	MG/KG		90	6.28			
08CDXX1SOINOF1	Dieldrin-	0.014	MG/KG		2	.133			
08CDXX1SOINOF1	Aluminum	2630	MG/KG		58200	54900			
08CDXX1SOINOF1	Arsenic	2.3	MG/KG		11.6	3.6			
08CDXX1SOINOF1	Barium	7.7	MG/KG		4070	3800			
08CDXX1SOINOF1	Beryllium	0.13	MG/KG		4.73	1			
08CDXX1SOINOF1	Cadmium	1.3	MG/KG		27.3	26.4			
08CDXX1SOINOF1	Calcium	442	MG/KG						
08CDXX1SOINOF1	Chromium	4.0	MG/KG		1160	274			
08CDXX1SOINOF1	Cobalt	1.8	MG/KG						
08CDXX1SOINOF1	Copper	5.6	MG/KG						
08CDXX1SOINOF1	Iron	4480	MG/KG						
08CDXX1SOINOF1	Lead	36.5	MG/KG		1000	300			
08CDXX1SOINOF1	Magnesium	479	MG/KG						
08CDXX1SOINOF1	Manganese	59.3	MG/KG		8140	274			
08CDXX1SOINOF1	Nickel	2.9	MG/KG		1160	1100			
08CDXX1SOINOF1	Potassium	93.3	MG/KG						
08CDXX1SOINOF1	Vanadium	6.5	MG/KG		407	384			
08CDXX1SOINOF1	Zinc	113	MG/KG		10000	10000			

Sample ID	Analyte	Results	Unit	EX_LIMIT	stcl_inside	stcl_outside	stcl_clean	fed_reg	20Xrule
08CDXX1SOINOF1	Benzo(a)Anthracene	78	UG/KG		27900	5000			
08CDXX1SOINOF1	Benzo(b)Fluoranthene	130	UG/KG		27900	5000			
08CDXX1SOINOF1	Benzo(g,h,i)Perylene	77	UG/KG		2330000	5000			
08CDXX1SOINOF1	bis(2-Ethylhexyl)Phthala	200	UG/KG		1160000	45700			
08CDXX1SOINOF1	Chrysene	83	UG/KG		400000	87700			
08CDXX1SOINOF1	Fluoranthene	91	UG/KG		10000000	2200000			
08CDXX1SOINOF1	Indeno(1,2,3-cd)Pyrene	57	UG/KG		27900	5000			
08CDXX1SOINOF1	Phenanthrene	92	UG/KG		2330000	2200000			
08CDXX1SOINOF1	Pyrene	220	UG/KG		10000000	1650000			
08CDXX1SOINOF1 RE	Anthracene	110	UG/KG		10000000	10000000			
08CDXX1SOINOF1 RE	Benzo(a)Anthracene	410	UG/KG		27900	5000			
08CDXX1SOINOF1 RE	Carbazole	140	UG/KG		1020000	32000			
08CDXX1SOINOF1 RE	Chrysene	410	UG/KG		400000	87700			
08CDXX1SOINOF1 RE	Phenanthrene	430	UG/KG		2330000	2200000			
08CDXX1SOINOF1 RE	Pyrene	1700	UG/KG		10000000	1650000			
08CDXX1SOOUOF1	TPH as Diesel-	72	MG/KG		1200	500			
08CDXX1SOOUOF1	4,4'-DDE-	0.0031	MG/KG		90	6.28			
08CDXX1SOOUOF1	4,4'-DDT-	0.24	MG/KG		90	6.28			
08CDXX1SOOUOF1	Aluminum	853	MG/KG		58200	54900			
08CDXX1SOOUOF1	Arsenic	1.8	MG/KG		11.6	3.6			
08CDXX1SOOUOF1	Barium	2.6	MG/KG		4070	3800			
08CDXX1SOOUOF1	Beryllium	0.12	MG/KG		4.73	1			
08CDXX1SOOUOF1	Calcium	79.3	MG/KG						
08CDXX1SOOUOF1	Chromium	1.5	MG/KG		1160	274			
08CDXX1SOOUOF1	Cobalt	0.62	MG/KG						
08CDXX1SOOUOF1	Copper	1.9	MG/KG						
08CDXX1SOOUOF1	Iron	3140	MG/KG						
08CDXX1SOOUOF1	Lead	9.0	MG/KG		1000	300			
08CDXX1SOOUOF1	Magnesium	167	MG/KG						
08CDXX1SOOUOF1	Manganese	31.8	MG/KG		8140	274			
08CDXX1SOOUOF1	Nickel	1.3	MG/KG		1160	1100			
08CDXX1SOOUOF1	Potassium	58.2	MG/KG						
08CDXX1SOOUOF1	Vanadium	5.4	MG/KG		407	384			
08CDXX1SOOUOF1	Zinc	33.0	MG/KG		10000	10000			

Sample ID	Analyte	Results	Unit	EX_LIMIT	stcl_inside	stcl_outside	stcl_clean	fed_reg	20Xrule
08CDXX1SOPLOF1	TPH as Diesel-	13	MG/KG				500		
08CDXX1SOPLOF1	4,4'-DDD-	0.0054	MG/KG				2.41		
08CDXX1SOPLOF1	4,4'-DDT-	0.90	MG/KG	YES			.25		
08CDXX1SOPLOF1	Aluminum	1790	MG/KG				26400		
08CDXX1SOPLOF1	Arsenic	1.8	MG/KG				3.6	5	100
08CDXX1SOPLOF1	Barium	6.0	MG/KG				3800	100	2000
08CDXX1SOPLOF1	Beryllium	0.12	MG/KG				1		
08CDXX1SOPLOF1	Calcium	288	MG/KG						
08CDXX1SOPLOF1	Chromium	2.2	MG/KG				6.8	5	100
08CDXX1SOPLOF1	Cobalt	1.4	MG/KG				333		
08CDXX1SOPLOF1	Copper	3.1	MG/KG				19.3		
08CDXX1SOPLOF1	Iron	3130	MG/KG						
08CDXX1SOPLOF1	Lead	20.1	MG/KG	YES			15.8	5	100
08CDXX1SOPLOF1	Magnesium	533	MG/KG						
08CDXX1SOPLOF1	Manganese	90.9	MG/KG				274		
08CDXX1SOPLOF1	Nickel	2.2	MG/KG				955		
08CDXX1SOPLOF1	Potassium	112	MG/KG						
08CDXX1SOPLOF1	Vanadium	4.1	MG/KG				15.2		
08CDXX1SOPLOF1	Zinc	33.2	MG/KG	YES			16		
08CDXX1SOPLOFD	TPH as Diesel-	11	MG/KG				500		
08CDXX1SOPLOFD	4,4'-DDD-	0.0091	MG/KG				2.41		
08CDXX1SOPLOFD	4,4'-DDT-	0.74	MG/KG	YES			.25		
08CDXX1SOPLOFD	Aluminum	1450	MG/KG				26400		
08CDXX1SOPLOFD	Arsenic	1.4	MG/KG				3.6	5	100
08CDXX1SOPLOFD	Barium	15.5	MG/KG				3800	100	2000
08CDXX1SOPLOFD	Beryllium	0.12	MG/KG				1		
08CDXX1SOPLOFD	Calcium	240	MG/KG						
08CDXX1SOPLOFD	Chromium	2.1	MG/KG				6.8	5	100
08CDXX1SOPLOFD	Cobalt	1.8	MG/KG				333		
08CDXX1SOPLOFD	Copper	3.9	MG/KG				19.3		
08CDXX1SOPLOFD	Iron	2470	MG/KG						
08CDXX1SOPLOFD	Lead	17.9	MG/KG	YES			15.8	5	100
08CDXX1SOPLOFD	Magnesium	374	MG/KG						
08CDXX1SOPLOFD	Manganese	59.9	MG/KG				274		
08CDXX1SOPLOFD	Nickel	1.6	MG/KG				955		
08CDXX1SOPLOFD	Potassium	124	MG/KG						
08CDXX1SOPLOFD	Vanadium	3.2	MG/KG				15.2		
08CDXX1SOPLOFD	Zinc	36.3	MG/KG	YES			16		

TEST CODE :SPH_0C1 JOB NUMBER :9601.536
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : JG-4000 OTIS AIR FORCE BASE
RESULTS IN DRY WEIGHT %SOLIDS : 96 %
TEST NAME : 8010 VOA +EDB (JE) UNITS : UG/KG
SAMPLE ID LAB : EE-96-48224 MATRIX : SOLID
SAMPLE ID CLIENT: 08CDXX1SOBTOF1 DATE RECEIVED : 07/24/96
SDG # : 48222 DATE ANALYZED : 07/25/96
DILUTION FACTOR : 1.0

SAMPLE VOLUME: 5.0 g

PARAMETER	RESULTS	Q	QNT. LIMIT
Dichlorodifluoromethane	ND		5.2
Chloromethane	ND		5.2
Vinyl chloride	ND		1.0
Bromomethane	ND		0.52
Chloroethane	ND		0.83
Trichlorofluoromethane	ND		0.62
1,1-Dichloroethene	ND		0.52
Methylene chloride	ND		2.6
trans-1,2-Dichloroethene	ND		0.52
1,1-Dichloroethane	ND		0.52
cis-1,2-Dichloroethene	ND		0.52
Chloroform	ND		5.2
1,1,1-Trichloroethane	ND		0.52
Carbon tetrachloride	ND		0.52
1,2-Dichloroethane	ND		0.52
Trichloroethene	ND		1.0
1,2-Dichloropropane	ND		3.1
Bromodichloromethane	ND		2.1
2-Chloroethylvinylether	ND		2.1
cis-1,3-Dichloropropene	ND		0.73
trans-1,3-Dichloropropene	ND		1.6
1,1,2-Trichloroethane	ND		0.52
Tetrachloroethene	ND		2.1
Dibromochloromethane	ND		0.52
Chlorobenzene	ND		0.83
Bromoform	ND		0.52
1,1,2,2-Tetrachloroethane	ND		5.2
1,3-Dichlorobenzene	ND		0.83
1,4-Dichlorobenzene	ND		0.83
1,2-Dichlorobenzene	ND		0.83
Ethylene dibromide	ND		1.0

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
X = EXCEEDS CALIBRATION LIMIT
N = ANALYTE WAS NOT CONFIRMED BY ALTERNATE PROCEDURE
A = PHENOMENON OF METHODOLOGY WITH ACID PRESERVATION

TEST CODE :SPA_0C1 JOB NUMBER :9601.536
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : JG-4000 OTIS AIR FORCE BASE
RESULTS IN DRY WEIGHT %SOLIDS : 96 %
TEST NAME : 8020 VOA (JE) UNITS : UG/KG
SAMPLE ID LAB : EE-96-48224 MATRIX : SOLID
SAMPLE ID CLIENT: 08CDXX1SOBTOF1 DATE RECEIVED : 07/24/96
SDG # : 48222 DATE ANALYZED : 07/25/96
DILUTION FACTOR : 1.0

SAMPLE VOLUME: 5.0 g

PARAMETER	RESULTS	Q	QNT. LIMIT
MTBE	ND		1.6
Benzene	ND		0.62
Toluene	ND		10
Ethylbenzene	ND		10
Chlorobenzene	ND		1.4
1,3-Dichlorobenzene	ND		1.4
1,4-Dichlorobenzene	ND		1.2
1,2-Dichlorobenzene	ND		1.2
Total Xylenes	ND		10

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
X = EXCEEDS CALIBRATION LIMIT
N = ANALYTE WAS NOT CONFIRMED BY ALTERNATE PROCEDURE
A = PHENOMENON OF METHODOLOGY WITH ACID PRESERVATION

1B
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

081BTOF1

Lab Name: E & E INC. Contract:

Lab Code: EANDE Case No.: 536 SAS No.: SDG No.: 48222

Matrix: (soil/water) SOIL Lab Sample ID: 48224

Sample wt/vol: 30.0 (g/mL) G Lab File ID: B0508

Level: (low/med) LOW Date Received: 07/24/96

% Moisture: 4 decanted: (Y/N) N Date Extracted: 07/24/96

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 07/26/96

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH:

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
108-95-2	Phenol	340	U
111-44-4	bis(2-Chloroethyl)Ether	340	U
95-57-8	2-Chlorophenol	340	U
541-73-1	1,3-Dichlorobenzene	340	U
106-46-7	1,4-Dichlorobenzene	340	U
95-50-1	1,2-Dichlorobenzene	340	U
95-48-7	2-Methylphenol	340	U
108-60-1	2,2'-oxybis(1-Chloropropane)	340	U
106-44-5	4-Methylphenol	340	U
621-64-7	N-Nitroso-Di-n-Propylamine	340	U
67-72-1	Hexachloroethane	340	U
98-95-3	Nitrobenzene	340	U
78-59-1	Isophorone	340	U
88-75-5	2-Nitrophenol	340	U
105-67-9	2,4-Dimethylphenol	340	U
111-91-1	bis(2-Chloroethoxy)Methane	340	U
120-83-2	2,4-Dichlorophenol	340	U
120-82-1	1,2,4-Trichlorobenzene	340	U
91-20-3	Naphthalene	340	U
106-47-8	4-Chloroaniline	340	U
87-68-3	Hexachlorobutadiene	340	U
59-50-7	4-Chloro-3-Methylphenol	340	U
91-57-6	2-Methylnaphthalene	340	U
77-47-4	Hexachlorocyclopentadiene	340	U
88-06-2	2,4,6-Trichlorophenol	340	U
95-95-4	2,4,5-Trichlorophenol	1700	U
91-58-7	2-Chloronaphthalene	340	U
88-74-4	2-Nitroaniline	1700	U
131-11-3	Dimethylphthalate	340	U
208-96-8	Acenaphthylene	340	U
606-20-2	2,6-Dinitrotoluene	340	U
99-09-2	3-Nitroaniline	1700	U
83-32-9	Acenaphthene	340	U
51-28-5	2,4-Dinitrophenol	1700	U
100-02-7	4-Nitrophenol	1700	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

081BTOF1

Lab Name: E & E INC. Contract:

Lab Code: EANDE Case No.: 536 SAS No.: SDG No.: 48222

Matrix: (soil/water) SOIL Lab Sample ID: 48224

Sample wt/vol: 30.0 (g/mL) G Lab File ID: B0508

Level: (low/med) LOW Date Received: 07/24/96

% Moisture: 4 decanted: (Y/N) N Date Extracted: 07/24/96

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 07/26/96

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH:

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
132-64-9	Dibenzofuran	340	U
121-14-2	2,4-Dinitrotoluene	340	U
84-66-2	Diethylphthalate	340	U
7005-72-3	4-Chlorophenyl-phenylether	340	U
86-73-7	Fluorene	340	U
100-01-6	4-Nitroaniline	1700	U
534-52-1	4,6-Dinitro-2-methylphenol	1700	U
86-30-6	N-Nitrosodiphenylamine (1)	340	U
101-55-3	4-Bromophenyl-phenylether	340	U
118-74-1	Hexachlorobenzene	340	U
87-86-5	Pentachlorophenol	1700	U
85-01-8	Phenanthrene	340	U
120-12-7	Anthracene	340	U
86-74-8	Carbazole	340	U
84-74-2	Di-n-Butylphthalate	340	U
206-44-0	Fluoranthene	340	U
92-87-5	Benzidine	1700	U
129-00-0	Pyrene	340	U
85-68-7	Butylbenzylphthalate	340	U
91-94-1	3,3'-Dichlorobenzidine	690	U
56-55-3	Benzo(a)Anthracene	340	U
218-01-9	Chrysene	340	U
117-81-7	bis(2-Ethylhexyl)Phthalate	340	U
117-84-0	Di-n-Octyl Phthalate	340	U
205-99-2	Benzo(b)Fluoranthene	340	U
207-08-9	Benzo(k)Fluoranthene	340	U
50-32-8	Benzo(a)Pyrene	340	U
193-39-5	Indeno(1,2,3-cd)Pyrene	340	U
53-70-3	Dibenz(a,h)Anthracene	340	U
191-24-2	Benzo(g,h,i)Perylene	340	U
65-85-9	Benzoic Acid	1700	U
100-51-6	Benzyl Alcohol	340	U

(1) - Cannot be separated from Diphenylamine

TEST CODE :SP&PCB1 JOB NUMBER :9601.536
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : JG-4000 OTIS AIR FORCE BASE
RESULTS IN DRY WEIGHT %SOLIDS : 96 %
TEST NAME : PESTICIDE-PCB UNITS : MG/KG
SAMPLE ID LAB : EE-96-48224 MATRIX : SOLID
SAMPLE ID CLIENT: 08CDXX1SOBTOF1 DATE RECEIVED : 07/24/96
SDG # : 48222 DATE ANALYZED : 07/26/96
DILUTION FACTOR : 2.0
SAMPLE VOLUME: 30 g DATE EXTRACTED: 07/24/96
FINAL VOLUME: 10 mL INJECTION VOLUME: 2.0 uL

PARAMETER	RESULTS	Q	QNT. LIMIT
Aldrin	ND		0.002
alpha-BHC	ND		0.002
beta-BHC	ND		0.002
gamma-BHC (Lindane)	ND		0.002
delta-BHC	ND		0.002
Chlordane	ND		0.017
4,4'-DDD	ND		0.004
4,4'-DDE	ND		0.004
4,4'-DDT	0.023		0.010
Dieldrin	0.013		0.004
Endosulfan I	ND		0.004
Endosulfan II	ND		0.004
Endosulfan sulfate	ND		0.010
Endrin	ND		0.004
Endrin aldehyde	ND		0.010
Heptachlor	ND		0.002
Heptachlor epoxide	ND		0.002
Toxaphene	ND		0.10
Methoxychlor	ND		0.033
PCB-1016	ND		0.042
PCB-1221	ND		0.042
PCB-1232	ND		0.042
PCB-1242	ND		0.042
PCB-1248	ND		0.042
PCB-1254	ND		0.042
PCB-1260	ND		0.042

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
X = EXCEEDS CALIBRATION LIMIT
N = ANALYTE WAS NOT CONFIRMED BY ALTERNATE PROCEDURE
A = PHENOMENON OF METHODOLOGY WITH ACID PRESERVATION

TEST CODE :SCTPH 1 JOB NUMBER :9601.536
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : JG-4000 OTIS AIR FORCE BASE
RESULTS IN DRY WEIGHT %SOLIDS : 96 %
TEST NAME : TPH AS DIESEL UNITS : MG/KG
SAMPLE ID LAB : EE-96-48224 MATRIX : SOLID
SAMPLE ID CLIENT: 08CDXX1SOBTOF1 DATE RECEIVED : 07/24/96
SDG # : 48222 DATE ANALYZED : 07/26/96
DILUTION FACTOR : 1.0
SAMPLE VOLUME: 25 g DATE EXTRACTED: 07/24/96
FINAL VOLUME: 1.0 mL INJECTION VOLUME: 2.0 uL

PARAMETER	RESULTS	Q	QNT. LIMIT
TPH as Diesel	5.6		5.2

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
X = EXCEEDS CALIBRATION LIMIT
N = ANALYTE WAS NOT CONFIRMED BY ALTERNATE PROCEDURE
A = PHENOMENON OF METHODOLOGY WITH ACID PRESERVATION

TEST CODE :SPPH 1 JOB NUMBER :9601.536
ELAP ID : 10486

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : JG-4000 OTIS AIR FORCE BASE
RESULTS IN DRY WEIGHT %SOLIDS : 96 %
TEST NAME : TPH AS GASOLINE UNITS : MG/KG
SAMPLE ID LAB : EE-96-48224 MATRIX : SOLID
SAMPLE ID CLIENT: 08CDXX1SOBTOF1 DATE RECEIVED : 07/24/96
SDG # : 48222 DATE ANALYZED : 07/25/96
DILUTION FACTOR : 1.0

SAMPLE VOLUME: 7.0 g
FINAL VOLUME: 10 mL INJECTION VOLUME: 100 uL

PARAMETER	RESULTS	Q	QNT. LIMIT
TPH as Gasoline	ND		5.2

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
X = EXCEEDS CALIBRATION LIMIT
N = ANALYTE WAS NOT CONFIRMED BY ALTERNATE PROCEDURE
A = PHENOMENON OF METHODOLOGY WITH ACID PRESERVATION

U.S. EPA - CLP

1
INORGANIC ANALYSES DATA SHEET

EPA SAMPLE NO.

48224

Lab Name: ECOLOGY_AND_ENVIRONMENT__ Contract: _____

Lab Code: EANDE_ Case No.: 9601.536 SAS No.: _____ SDG No.: 48222_

Matrix (soil/water): SOIL_ Lab Sample ID: 48224

Level (low/med): LOW__ Date Received: 07/24/96

% Solids: _96.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum_	1470			P
7440-36-0	Antimony_	6.1	U		P
7440-38-2	Arsenic__	1.6			P
7440-39-3	Barium__	5.2	B		P
7440-41-7	Beryllium	0.10	B		P
7440-43-9	Cadmium__	0.27	U		P
7440-70-2	Calcium__	206	B		P
7440-47-3	Chromium_	1.9			P
7440-48-4	Cobalt___	1.2	B		P
7440-50-8	Copper___	2.7			P
7439-89-6	Iron____	2590			P
7439-92-1	Lead____	21.3			P
7439-95-4	Magnesium	341	B		P
7439-96-5	Manganese	50.9			P
7439-97-6	Mercury__	0.02	U		CV
7440-02-0	Nickel___	2.3	B		P
7440-09-7	Potassium	94.9	B		P
7782-49-2	Selenium_	0.43	U		P
7440-22-4	Silver___	0.22	U		P
7440-23-5	Sodium___	73.4	U		P
7440-28-0	Thallium_	0.31	U		P
7440-62-2	Vanadium_	3.7	B		P
7440-66-6	Zinc____	26.6			P
	Cyanide__				NR

Color Before: _____ Clarity Before: _____ Texture: SD____

Color After: Y_____ Clarity After: C_____ Artifacts: YES___

Comments:

CLIENT_SAMPLE_ID:__08CDXX1SOBTOF1

FORM I - IN ILM03.0

APPENDIX G

1999 LABORATORY DATA SHEETS

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ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	ALUMINUM (TOTAL)	ND	192	317	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	BARIUM (TOTAL)	15.4	0.3	20	UG/L	J
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	BERYLLIUM (TOTAL)	ND	0.66	6.5	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	CALCIUM (TOTAL)	3250	28.1	500	UG/L	
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	CHROMIUM (TOTAL)	ND	3.6	8.5	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	COBALT (TOTAL)	ND	3.4	5	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	COPPER (TOTAL)	ND	23.6	42	UG/L	UJ
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	IRON (TOTAL)	ND	113	145	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	MAGNESIUM (TOTAL)	2420	21.8	500	UG/L	
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	MANGANESE (TOTAL)	6.3	0.3	10	UG/L	J
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	NICKEL (TOTAL)	ND	0.89	20	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	SODIUM (TOTAL)	9610	98.8	500	UG/L	
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C200.7	ZINC (TOTAL)	ND	6.7	20	UG/L	U
23MW0001	23MW0001-01	1/21/99	80.39	C245.2	MERCURY (TOTAL)	ND	0.047	0.29	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	ALUMINUM (TOTAL)	ND	22	100	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	BARIUM (TOTAL)	14.8	0.3	20	UG/L	J
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	BERYLLIUM (TOTAL)	ND	0.51	6.5	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	CALCIUM (TOTAL)	4200	28.1	500	UG/L	
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	CHROMIUM (TOTAL)	ND	3.3	8.5	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	COBALT (TOTAL)	ND	0.6	5	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	COPPER (TOTAL)	ND	7	42	UG/L	UJ
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	IRON (TOTAL)	ND	10.5	145	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	MAGNESIUM (TOTAL)	1780	21.8	500	UG/L	
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	MANGANESE (TOTAL)	6.5	0.3	10	UG/L	J
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	NICKEL (TOTAL)	ND	3.7	20	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	POTASSIUM (TOTAL)	867	46.3	1500	UG/L	J
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	SODIUM (TOTAL)	8030	98.8	500	UG/L	
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	THALLIUM (TOTAL)	7	2.5	10	UG/L	J
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C200.7	ZINC (TOTAL)	ND	4.8	20	UG/L	U
23MW0003	23MW0003-01	1/21/99	84.93	C245.2	MERCURY (TOTAL)	ND	0.081	0.29	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	ALUMINUM (TOTAL)	ND	58.7	317	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	ANTIMONY (TOTAL)	ND	6.2	15.5	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	ARSENIC (TOTAL)	3.4	1.9	5	UG/L	J
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	BARIUM (TOTAL)	14	0.3	20	UG/L	J
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	BERYLLIUM (TOTAL)	ND	0.58	6.5	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	CALCIUM (TOTAL)	4030	28.1	500	UG/L	
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	CHROMIUM (TOTAL)	ND	3.4	8.5	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	COBALT (TOTAL)	ND	2.2	5	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	COPPER (TOTAL)	ND	3.2	42	UG/L	UJ
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	IRON (TOTAL)	ND	77.1	145	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	MAGNESIUM (TOTAL)	1720	21.8	500	UG/L	
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	MANGANESE (TOTAL)	5.9	0.3	10	UG/L	J
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	NICKEL (TOTAL)	ND	2.2	20	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	POTASSIUM (TOTAL)	722	46.3	1500	UG/L	J
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	SILVER (TOTAL)	ND	0.62	10	UG/L	UJ
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	SODIUM (TOTAL)	7720	98.8	500	UG/L	
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	THALLIUM (TOTAL)	7.9	2.5	10	UG/L	J
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	VANADIUM (TOTAL)	ND	1.7	10	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C200.7	ZINC (TOTAL)	ND	4.7	20	UG/L	U
23MW0003	23MW0003-01F	1/21/99	84.93	C245.2	MERCURY (TOTAL)	ND	0.099	0.29	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	ALUMINUM (TOTAL)	ND	61.4	317	UG/L	U

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	BARIUM (TOTAL)	11.9	0.3	20	UG/L	J
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	BERYLLIUM (TOTAL)	ND	0.37	6.5	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	CALCIUM (TOTAL)	2520	28.1	500	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	CHROMIUM (TOTAL)	13	0.6	5	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	COBALT (TOTAL)	ND	2.6	5	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	COPPER (TOTAL)	ND	0.8	5	UG/L	UJ
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	IRON (TOTAL)	160	15.6	100	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	MAGNESIUM (TOTAL)	1930	21.8	500	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	MANGANESE (TOTAL)	14.3	0.3	10	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	NICKEL (TOTAL)	18.6	1.4	20	UG/L	J
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	SILVER (TOTAL)	ND	0.91	10	UG/L	UJ
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	SODIUM (TOTAL)	6830	98.8	500	UG/L	
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	VANADIUM (TOTAL)	ND	0.56	10	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C200.7	ZINC (TOTAL)	ND	4.4	93	UG/L	U
23MW0005	23MW0005-01	1/21/99	84.8	C245.2	MERCURY (TOTAL)	ND	0.082	0.29	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	ALUMINUM (TOTAL)	ND	22	100	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	BARIUM (TOTAL)	9.6	0.3	20	UG/L	J
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	BERYLLIUM (TOTAL)	ND	0.32	6.5	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	J
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	CALCIUM (TOTAL)	3490	28.1	500	UG/L	
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	CHROMIUM (TOTAL)	ND	6.2	8.5	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	COBALT (TOTAL)	5.4	0.6	5	UG/L	
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	COPPER (TOTAL)	ND	4.5	42	UG/L	UJ
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	IRON (TOTAL)	ND	41.8	145	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	MAGNESIUM (TOTAL)	2360	21.8	500	UG/L	

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	MANGANESE (TOTAL)	9.2	0.3	10	UG/L	J
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	NICKEL (TOTAL)	ND	4.5	20	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	SODIUM (TOTAL)	10200	98.8	500	UG/L	
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C200.7	ZINC (TOTAL)	ND	6.5	20	UG/L	U
23MW0006	23MW0006-01	1/21/99	85.1	C245.2	MERCURY (TOTAL)	ND	0.078	0.29	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	ALUMINUM (TOTAL)	ND	44	317	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	BARIUM (TOTAL)	10.2	0.3	20	UG/L	J
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	BERYLLIUM (TOTAL)	ND	0.57	6.5	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	CALCIUM (TOTAL)	3810	28.1	500	UG/L	
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	CHROMIUM (TOTAL)	ND	4.5	8.5	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	COBALT (TOTAL)	ND	0.6	5	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	COPPER (TOTAL)	ND	16.4	42	UG/L	UJ
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	IRON (TOTAL)	ND	16.5	145	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	MAGNESIUM (TOTAL)	2480	21.8	500	UG/L	
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	MANGANESE (TOTAL)	4.3	0.3	10	UG/L	J
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	NICKEL (TOTAL)	ND	2.2	20	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	SODIUM (TOTAL)	6800	98.8	500	UG/L	
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C200.7	ZINC (TOTAL)	ND	6.3	20	UG/L	U
23MW0007	23MW0007-01	1/21/99	82.2	C245.2	MERCURY (TOTAL)	ND	0.074	0.29	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	ALUMINUM (TOTAL)	ND	55.7	317	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	ANTIMONY (TOTAL)	ND	7.7	15.5	UG/L	U

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	BARIUM (TOTAL)	7.9	0.3	20	UG/L	J
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	BERYLLIUM (TOTAL)	ND	0.26	6.5	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	CALCIUM (TOTAL)	2080	28.1	500	UG/L	
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	CHROMIUM (TOTAL)	ND	1.7	8.5	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	COBALT (TOTAL)	ND	0.82	5	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	COPPER (TOTAL)	96	0.8	5	UG/L	J
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	IRON (TOTAL)	ND	48.4	145	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	MAGNESIUM (TOTAL)	1150	21.8	500	UG/L	
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	MANGANESE (TOTAL)	3.9	0.3	10	UG/L	J
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	NICKEL (TOTAL)	ND	1.4	20	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	SODIUM (TOTAL)	11600	98.8	500	UG/L	
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C200.7	ZINC (TOTAL)	ND	6.6	20	UG/L	U
08AE0009	08AE0009-01	1/22/99	65.4	C245.2	MERCURY (TOTAL)	ND	0.14	0.8	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	ALUMINUM (TOTAL)	ND	22	100	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	BARIUM (TOTAL)	7.2	0.3	20	UG/L	J
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	BERYLLIUM (TOTAL)	ND	0.21	6.5	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	CALCIUM (TOTAL)	1980	28.1	500	UG/L	
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	CHROMIUM (TOTAL)	ND	2	8.5	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	COBALT (TOTAL)	ND	0.6	5	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	COPPER (TOTAL)	ND	0.8	5	UG/L	UJ
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	IRON (TOTAL)	ND	17	145	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	MAGNESIUM (TOTAL)	1080	21.8	500	UG/L	
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	MANGANESE (TOTAL)	3.6	0.3	10	UG/L	J

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	NICKEL (TOTAL)	ND	1.4	20	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	SODIUM (TOTAL)	11400	98.8	500	UG/L	
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
08AE0009	08AE0009-01FD	1/22/99	65.4	C200.7	ZINC (TOTAL)	14.9	1.9	20	UG/L	J
08AE0009	08AE0009-01FD	1/22/99	65.4	C245.2	MERCURY (TOTAL)	ND	0.19	0.8	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	ALUMINUM (TOTAL)	ND	45.5	317	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	ANTIMONY (TOTAL)	ND	7.8	15.5	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	BARIUM (TOTAL)	13.1	0.3	20	UG/L	J
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	BERYLLIUM (TOTAL)	ND	0.28	6.5	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	CALCIUM (TOTAL)	2830	28.1	500	UG/L	J
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	CHROMIUM (TOTAL)	ND	3.2	8.5	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	COBALT (TOTAL)	ND	2	5	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	COPPER (TOTAL)	ND	2	42	UG/L	UJ
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	IRON (TOTAL)	ND	41.8	145	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	MAGNESIUM (TOTAL)	1300	21.8	500	UG/L	
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	MANGANESE (TOTAL)	3.3	0.3	10	UG/L	J
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	NICKEL (TOTAL)	ND	0.97	20	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	POTASSIUM (TOTAL)	ND	46.3	1500	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	SODIUM (TOTAL)	17600	98.8	500	UG/L	J
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	VANADIUM (TOTAL)	ND	1.3	10	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C200.7	ZINC (TOTAL)	ND	8.2	20	UG/L	U
08MW0001	08MW0001-01	1/22/99	63.15	C245.2	MERCURY (TOTAL)	ND	0.12	0.8	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	ALUMINUM (TOTAL)	ND	113	317	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	BARIUM (TOTAL)	17.7	0.3	20	UG/L	J
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	BERYLLIUM (TOTAL)	ND	0.45	6.5	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	CALCIUM (TOTAL)	4770	28.1	500	UG/L	
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	CHROMIUM (TOTAL)	ND	2.6	8.5	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	COBALT (TOTAL)	ND	0.6	5	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	COPPER (TOTAL)	62.3	0.8	5	UG/L	J
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	IRON (TOTAL)	ND	21.8	145	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	MAGNESIUM (TOTAL)	2560	21.8	500	UG/L	
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	MANGANESE (TOTAL)	13.8	0.3	10	UG/L	
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	NICKEL (TOTAL)	ND	1.4	20	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	POTASSIUM (TOTAL)	744	46.3	1500	UG/L	J
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	SODIUM (TOTAL)	31100	98.8	500	UG/L	
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	THALLIUM (TOTAL)	ND	2.5	10	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	VANADIUM (TOTAL)	ND	1	10	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C200.7	ZINC (TOTAL)	ND	6.4	20	UG/L	U
08MW0002	08MW0002-01	1/22/99	67.56	C245.2	MERCURY (TOTAL)	ND	0.1	0.8	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	ALUMINUM (TOTAL)	ND	75.5	317	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	ANTIMONY (TOTAL)	ND	12.9	15.5	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	ARSENIC (TOTAL)	2.6	1.9	5	UG/L	J
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	BARIUM (TOTAL)	28.2	0.3	20	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	BERYLLIUM (TOTAL)	ND	0.44	6.5	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	CALCIUM (TOTAL)	4190	28.1	500	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	CHROMIUM (TOTAL)	ND	2.4	8.5	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	COBALT (TOTAL)	7.2	0.6	5	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	COPPER (TOTAL)	ND	7.4	42	UG/L	UJ
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	IRON (TOTAL)	ND	83.9	145	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	MAGNESIUM (TOTAL)	2340	21.8	500	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	MANGANESE (TOTAL)	10.3	0.3	10	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	NICKEL (TOTAL)	ND	1.8	20	UG/L	U

ATTACHMENT B

Table 3
FS-17/19 Groundwater Sampling Results

Location	Sample ID	Date	Depth (feet)	Test	Analyte	Result	Detection Limit	Reporting Limit	Units	Qual
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	POTASSIUM (TOTAL)	697	46.3	1500	UG/L	J
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	UJ
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	UJ
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	SODIUM (TOTAL)	20200	98.8	500	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	THALLIUM (TOTAL)	13.3	2.5	10	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	VANADIUM (TOTAL)	ND	3	10	UG/L	U
08MW0003	08MW0003-01	1/22/99	65.4	C200.7	ZINC (TOTAL)	26.1	1.9	20	UG/L	
08MW0003	08MW0003-01	1/22/99	65.4	C245.2	MERCURY (TOTAL)	ND	0.15	0.8	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	ALUMINUM (TOTAL)	43.3	22	100	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	ANTIMONY (TOTAL)	ND	1.9	5	UG/L	UJ
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	ARSENIC (TOTAL)	ND	1.9	5	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	BARIUM (TOTAL)	24.5	0.3	20	UG/L	
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	BERYLLIUM (TOTAL)	ND	0.4	1	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	CADMIUM (TOTAL)	ND	0.4	1	UG/L	UJ
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	CALCIUM (TOTAL)	4020	28.1	500	UG/L	
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	CHROMIUM (TOTAL)	0.9	0.6	5	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	COBALT (TOTAL)	3	0.6	5	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	COPPER (TOTAL)	ND	0.8	5	UG/L	UJ
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	IRON (TOTAL)	ND	15.6	100	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	LEAD (TOTAL)	ND	1.1	2	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	MAGNESIUM (TOTAL)	2420	21.8	500	UG/L	
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	MANGANESE (TOTAL)	11.1	0.3	10	UG/L	
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	NICKEL (TOTAL)	2	1.4	20	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	POTASSIUM (TOTAL)	1150	46.3	1500	UG/L	J
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	SELENIUM (TOTAL)	ND	2.7	5	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	SILVER (TOTAL)	ND	0.8	10	UG/L	U
08MW0004	08MW0004-02	3/1/99	67.65	C200.7	SODIUM (TOTAL)	9100	98.8	500	UG/L	

J = estimated data point
U = nondetect
UJ = estimated nondetect

ATTACHMENT C

Data Summary Report

FS-17 and FS-19

1999

Data Validation Summary

ATTACHMENT C

Data Summary Report

TABLE OF CONTENTS

1.0 SAMPLE COLLECTION....C-1

2.0 SAMPLE IDENTIFICATION....C-1

3.0 ANALYTICAL PARAMETERS....C-4

4.0 DATA ASSESSMENT....C-5

4.1 LABORATORY QUALITY CONTROL....C-6

4.1.1 Holding Times and Preservation....C-6

4.1.2 Instrument Calibration....C-7

4.1.3 Laboratory Blanks....C-9

4.1.4 Matrix Spikes....C-16

4.1.5 Laboratory Replicates....C-16

4.1.6 Laboratory Control Samples....C-17

4.1.7 Surrogates....C-18

4.1.8 Internal Standards....C-18

4.2 FIELD QUALITY CONTROL....C-18

4.2.1 Field Blanks....C-18

4.2.2 Field Duplicates....C-19

5.0 CORRECTIVE ACTION AND RESOLUTION....C-19

6.0 CONCLUSIONS....C-20

Tables

Table 2-1 Sample Identification Cross-Reference and Analyses....C-2

Table 4-1 Calibration Noncompliance Summary....C-7

Table 4-2 Laboratory Blank Sample Qualification Summary....C-9

Table 4-3 Negative Blank Summary....C-15

Table 4-4 LCS/LCSD Noncompliant Samples....C-17

Table 4-5 Qualified Due to EB or TB Samples....C-18

Table 6-1 Percent Completeness Summary....C-20

ACRONYMS AND ABBREVIATIONS

AFCEE	U.S. Air Force Center for Environmental Excellence
CLP	Contract Laboratory Program
DQO	data quality objective
EB	equipment blank
EDB	ethylene dibromide
EPA	Environmental Protection Agency
FD	field duplicates
ID	identification number
IS	internal standard
LCS	laboratory control spike
LCSD	laboratory control spike duplicates
MMR	Massachusetts Military Reservation
MS	matrix spike
MSD	matrix spike duplicate
PARCC	precision, accuracy, representativeness, comparability, and completeness
QC	Quality Control
QPP	Quality Program Plan
RPD	relative percent difference
TB	trip blank
VOC	volatile organic compound

(intentionally blank)

1.0 SAMPLE COLLECTION

Jacobs Engineering Group Inc. collected and evaluated data from a total of 36 monitoring well locations to obtain sufficient data to meet the objectives of several sampling tasks associated with Delivery Order 11, Mod 1. Samples were collected on January 21 and 22, 1999, February 2, 3, 4, 5, 8, 10, 11, 16 and 24, 1999 and March 1, 8 and 10, 1999 and were submitted to Quanterra Environmental Services in Tampa, Florida and/or Quanterra Environmental Services in Knoxville, Tennessee for analysis. Field quality control (QC) samples were also collected and submitted for analysis at the frequency indicated in the MMR QPP (AFCEE, 1998) and included field duplicate (FD) samples, equipment blanks (EBs), trip blanks (TBs) and matrix spike/matrix spike duplicate (MS/MSD) samples. The actual analyses performed on each sample are listed in Table 2-1 of this appendix. All data was reviewed in accordance with MMR project-specific data review guidelines, which are defined in the technical procedure MMR TECH-055 Analytical Chemistry Data Review (AFCEE 1998).

Samples were validated either at Level D (i.e., EPA Level IV) after a review of summary forms and raw data, or Level C (i.e., EPA Level III) after a review of the summary form information only. Field and laboratory QC sample results were evaluated as part of both the Level C and Level D reviews. The results of the QC samples and the data review are summarized in Section 4.0 of this appendix.

2.0 SAMPLE IDENTIFICATION

Table 2-1 lists the native and field duplicate samples and associated field quality control samples which were collected and analyzed as part of this sampling event. Each Jacobs chain-of-custody control number is cross-referenced with location identification (Loc ID), sample number, date sampled, and the analyses performed on each sample. Data completeness (location IDs and requested analyses) was verified against the chain-of-custody forms during the data review process. All chain-of-

custody forms are maintained in project files by the data management group at Jacobs MMR.

TABLE 2-1
Sample Identification Cross-Reference and Analyses

Site	Location ID	Sample Number	Type	Date	VOC	EDB	SVOC	Metals	Control Number
	FIELDQC	012199-EB2-501	EB	01/21/99				X	MM-J014701
FS-17/FS-19	23MW0001	23MW0001-01	N1	01/21/99				X	MM-J014501
FS-17/FS-19	23MW0003	23MW0003-01	N1	01/21/99				X	MM-J014503
FS-17/FS-19	23MW0003	23MW0003-01FD	FD1	01/21/99				X	MM-J014504
FS-17/FS-19	23MW0005	23MW0005-01	N1	01/21/99				X	MM-J014601
FS-17/FS-19	23MW0006	23MW0006-01	N1	01/21/99				X	MM-J014603
FS-17/FS-19	23MW0007	23MW0007-01	N1	01/21/99				X	MM-J014604
FS-17/FS-19	08AE0009	08AE0009-01	N1	01/22/99				X	MM-J014902
FS-17/FS-19	08AE0009	08AE0009-01FD	FD1	01/22/99				X	MM-J014903
FS-17/FS-19	08MW0001	08MW0001-01	N1	01/22/99				X	MM-J014801
FS-17/FS-19	08MW0001	08MW0001-01	LR	01/22/99				X	MM-J014801
FS-17/FS-19	08MW0002	08MW0002-01	N1	01/22/99				X	MM-J014802
FS-17/FS-19	08MW0003	08MW0003-01	N1	01/22/99				X	MM-J014803
	FIELDQC	020299-TB2-501	TB	02/02/99	X				MM-J015001
CS-1	07MW0001	07MW0001-01	N1	02/02/99		X			MM-J015002
CS-1	07MW0001	07MW0001-01	N1	02/02/99	X				MM-J015003
CS-1	07MW0002	07MW0002-01	N1	02/02/99		X			MM-J015004
CS-1	07MW0002	07MW0002-01	N1	02/02/99	X				MM-J015005
	FIELDQC	020399-EB1-501	EB	02/03/99		X			MM-J015301
	FIELDQC	020399-EB1-501	EB	02/03/99	X				MM-J015302
	FIELDQC	020399-TB1-501	TB	02/03/99	X				MM-J015101
CS-1	07MW0003	07MW0003-01	N1	02/03/99		X			MM-J015102
CS-1	07MW0003	07MW0003-01	N1	02/03/99	X				MM-J015103
CS-1	07MW0004	07MW0004-01	N1	02/03/99		X			MM-J015104
CS-1	07MW0004	07MW0004-01	N1	02/03/99	X				MM-J015105
CS-1	07MW0004	07MW0004-01FD	FD1	02/03/99		X			MM-J015106
CS-1	07MW0004	07MW0004-01FD	FD1	02/03/99	X				MM-J015107
CS-1	07MW0005	07MW0005-01	N1	02/03/99		X			MM-J015201
CS-1	07MW0005	07MW0005-01	N1	02/03/99	X				MM-J015202
CS-1	07MW0007	07MW0007-01	N1	02/03/99		X			MM-J015203
CS-1	07MW0007	07MW0007-01	N1	02/03/99	X				MM-J015204
	FIELDQC	020499-TB1-501	TB	02/04/99	X				MM-J015401
CS-2	05MW0001	05MW0001-01	N1	02/04/99				X	MM-J015601
CS-2	05MW0001	05MW0001-01	N1	02/04/99		X			MM-J015501
CS-2	05MW0001	05MW0001-01	N1	02/04/99	X				MM-J015502
CS-2	05MW0002	05MW0002-01	N1	02/04/99				X	MM-J015602
CS-2	05MW0002	05MW0002-01	N1	02/04/99		X			MM-J015503
CS-2	05MW0002	05MW0002-01	N1	02/04/99	X				MM-J015504
CS-2	05MW0003	05MW0003-01	N1	02/04/99				X	MM-J015603
CS-2	05MW0003	05MW0003-01	N1	02/04/99		X			MM-J015505
CS-2	05MW0003	05MW0003-01	N1	02/04/99	X				MM-J015506
CS-1	07MW0008	07MW0008-01	N1	02/04/99		X			MM-J015402

TABLE 2-1
Sample Identification Cross-Reference and Analyses

Site	Location ID	Sample Number	Type	Date	VOC	EDB	SVOC	Metals	Control Number
CS-1	07MW0008	07MW0008-01	N1	02/04/99	X				MM-J015403
CS-1	07MW0014	07MW0014-01	N1	02/04/99		X			MM-J015404
CS-1	07MW0014	07MW0014-01	N1	02/04/99	X				MM-J015405
	FIELDQC	020599-TB1-501	TB	02/05/99	X				MM-J015701
CS-6	26MW0001	26MW0001-01	N1	02/05/99	X				MM-J015702
CS-6	26MW0001	26MW0001-01	N1	02/05/99			X		MM-J015801
CS-6	26MW0001	26MW0001-01	N1	02/05/99				X	MM-J015802
CS-6	26MW0001	26MW0001-01FD	FD1	02/05/99	X				MM-J015703
CS-6	26MW0001	26MW0001-01FD	FD1	02/05/99			X		MM-J015803
CS-6	26MW0001	26MW0001-01FD	FD1	02/05/99				X	MM-J015804
CS-6	26MW0002	26MW0002-01	N1	02/05/99	X				MM-J015704
CS-6	26MW0002	26MW0002-01	N1	02/05/99			X		MM-J015805
CS-6	26MW0002	26MW0002-01	N1	02/05/99				X	MM-J015806
	FIELDQC	020899-EB1-501	EB	02/08/99		X			MM-J016301
	FIELDQC	020899-EB1-501	EB	02/08/99	X				MM-J016302
	FIELDQC	020899-EB1-501	EB	02/08/99				X	MM-J016401
	FIELDQC	020899-TB1-501	TB	02/08/99	X				MM-J015901
CS-3	22MW0002	22MW0002-01	N1	02/08/99		X			MM-J015902
CS-3	22MW0002	22MW0002-01	N1	02/08/99	X				MM-J015903
CS-3	22MW0002	22MW0002-01	N1	02/08/99			X		MM-J016001
CS-3	22MW0002	22MW0002-01	N1	02/08/99				X	MM-J016002
CS-3	22MW0002	22MW0002-01	LR	02/08/99				X	MM-J016002
CS-3	22MW0003	22MW0003-01	N1	02/08/99		X			MM-J015904
CS-14	98MW0001	98MW0001-10	N1	02/08/99		X			MM-J016101
CS-14	98MW0001	98MW0001-10	N1	02/08/99	X				MM-J016102
CS-14	98MW0001	98MW0001-10	N1	02/08/99				X	MM-J016201
CS-3	22MW0004	22MW0004-01	N1	02/10/99		X			MM-J016501
CS-3	SDW0315-0082	SDW0315-0082-01	N1	02/10/99		X			MM-J016502
CS-2 (USCG)	46MW0004	46MW0004-01	N1	02/11/99		X			MM-J016603
CS-2 (USCG)	46MW0005	46MW0005-01	N1	02/11/99		X			MM-J016604
	FIELDQC	021699-TB1-501	TB	02/16/99	X				MM-J016901
CS-14	98MW0002	98MW0002-01	N1	02/16/99		X			MM-J016902
CS-14	98MW0002	98MW0002-01	N1	02/16/99	X				MM-J016903
CS-14	98MW0002	98MW0002-01	N1	02/16/99				X	MM-J017001
	FIELDQC	022499-TB1-501	TB	02/24/99	X				MM-J017101
CS-1	07MW0006	07MW0006-01	N1	02/24/99		X			MM-J017102
CS-1	07MW0006	07MW0006-01	N1	02/24/99	X				MM-J017103
CS-2 (USCG)	46MW0001	46MW0001-01	N1	02/24/99		X			MM-J017106
FS-17/FS-19	08MW0004	08MW0004-02	N1	03/01/99				X	MM-J017201
	FIELDQC	030898-EB2-501	EB	03/08/99				X	MM-J017701
	FIELDQC	030898-EB2-501	EB	03/08/99		X			MM-J017601
	FIELDQC	030898-EB2-501	EB	03/08/99	X				MM-J017602
	FIELDQC	030899-TB3-501	TB	03/08/99	X				MM-J017301
CS-14	98MW0003	98MW0003-02	N1	03/08/99				X	MM-J017501
CS-14	98MW0003	98MW0003-02	N1	03/08/99		X			MM-J017401
CS-14	98MW0003	98MW0003-02	N1	03/08/99	X				MM-J017402
	FIELDQC	031099-TB1-501	TB	03/10/99	X				MM-J017801

TABLE 2-1
Sample Identification Cross-Reference and Analyses

Site	Location ID	Sample Number	Type	Date	VOC	EDB	SVOC	Metals	Control Number
CS-8	04MW0001	04MW0001-02	N1	03/10/99				X	MM-J017901
CS-8	04MW0001	04MW0001-02	N1	03/10/99		X			MM-J017802
CS-8	04MW0001	04MW0001-02	N1	03/10/99	X				MM-J017803
CS-8	04MW0002	04MW0002-03	N1	03/10/99				X	MM-J017902
CS-8	04MW0002	04MW0002-03	N1	03/10/99		X			MM-J017804
CS-8	04MW0002	04MW0002-03	N1	03/10/99	X				MM-J017805
CS-8	04MW0002	04MW0002-03FD	FD1	03/10/99				X	MM-J017903
CS-8	04MW0002	04MW0002-03FD	FD1	03/10/99		X			MM-J017806
CS-8	04MW0002	04MW0002-03FD	FD1	03/10/99	X				MM-J017807

VOC = Volatile Organic Compounds
EDB = Ethylene dibromide
SVOC = Semi volatile Organic Compounds
Metal = metals (total)
N1 = native samples
FD1 = field duplicate sample
LR = Lab Replicate
EB = equipment blank
TB = trip blank

3.0 ANALYTICAL PARAMETERS

All samples were analyzed according to established EPA methods specified in the MMR QPP by analytical laboratories under subcontract to perform work for the plume response program at MMR.

Data quality was measured by five parameters: precision, accuracy, representativeness, completeness, and comparability (PARCC). The goals set for each of these parameters are referred to as the Data Quality Objectives (DQOs). Actual sample and quality control results are compared to the project DQOs to determine whether quality objectives were met for the sampling event.

Precision is defined as the degree of agreement between measurements. Sampling precision was evaluated by comparing the results of field duplicate sample pairs. Analytical precision was evaluated by comparing the results between laboratory duplicates, such as Laboratory Control Sample (LCS) and Laboratory Control Sample Duplicate (LCSD), and MS/MSD samples.

Accuracy is defined as the degree to which the calculated value represents the true value. Sampling accuracy was evaluated using matrix spike results. Analytical accuracy was evaluated using laboratory control sample results.

Representativeness reflects the ability to collect a sample that, when analyzed or measured, reflects the in situ conditions of the sample. Representativeness is measured by how well the sample collection event followed the proposed investigation so as to provide results that accurately depict the media and environmental conditions being evaluated. Documentation of field events, by collecting samples in appropriate sample containers, ensuring proper sample preservation techniques and following established chain-of-custody procedures, confirms that suitable protocols were followed and the analytical data collected will be representative of the contaminant levels at the site.

Completeness is a measure of the amount of valid, usable data obtained from the sampling event compared to the amount of data that was expected under normal conditions. Results that are rejected (coded R) by the data review process may be disqualified from application to the intended use of the data. Qualified data will be used to the extent possible.

Comparability is a measure of how well the subject data set parallels related data sets. Samples collected and analyzed during this sampling event are comparable because standardized sampling and analytical protocols were used. In addition, the results are reported in units consistent with CLP and other EPA methods.

4.0 DATA ASSESSMENT

This section discusses data that was found to be noncompliant with established quality control (QC) requirements. Qualification of results was based on review of laboratory and field QC data and is discussed below.

The following qualifiers were applied to the data during the review process:

U - The analyte was analyzed but was not detected. The associated numerical value is a quantitation limit.

J - The analyte was detected, and the reported concentration is an estimated value.

UJ - The analyte is not detected and the reporting limit is an estimated value.

R - The analyte value is rejected; result is unusable.

CLP method-specific qualifiers used by the laboratory to designate noncompliant values have been either accepted or replaced with one of the above data qualifiers.

4.1 LABORATORY QUALITY CONTROL

Laboratory QC was achieved by using established EPA analytical methods for analyzing field samples. A review of the results of method-specific laboratory QC established the quality of the data. Laboratory QC data which is reviewed in this process includes: sample holding times and preservation, instrument calibration data, laboratory blank contamination, MS/MSD analyses, laboratory replicate samples, LCS/LCSD results, surrogate recoveries, and internal standard area counts.

4.1.1 Holding Times and Preservation

When samples are analyzed beyond their respective holding times, positive results are suspected to be biased low, and non-detected results are suspected to be false negatives. Similarly, when samples are received by the laboratory with insufficient preservation or with a cooler temperature greater than six degrees Celsius, positive results are suspected to be biased low, and non-detected results are suspected to be false negatives. These results are generally rejected.

All samples collected as part of these sampling tasks met holding time and preservation requirements.

4.1.2 Instrument Calibration

Several samples were analyzed in batches that did not meet either initial or continuing calibration criteria for some volatile organic compounds (VOCs). The samples, affected compounds, and data review qualifiers are listed in Table 4-1.

TABLE 4-1
Calibration Noncompliance Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
04MW0001	04MW0001-02	03/10/99	1,2-DIBROMO-3-CHLOROPROPANE	R
04MW0001	04MW0001-02	03/10/99	ACETONE	R
04MW0001	04MW0001-02	03/10/99	METHYL ETHYL KETONE (2-BUTANONE)	R
04MW0002	04MW0002-03	03/10/99	1,2-DIBROMO-3-CHLOROPROPANE	R
04MW0002	04MW0002-03FD	03/10/99	1,2-DIBROMO-3-CHLOROPROPANE	R
04MW0002	04MW0002-03	03/10/99	ACETONE	R
04MW0002	04MW0002-03FD	03/10/99	ACETONE	R
04MW0002	04MW0002-03	03/10/99	METHYL ETHYL KETONE (2-BUTANONE)	R
04MW0002	04MW0002-03FD	03/10/99	METHYL ETHYL KETONE (2-BUTANONE)	R
05MW0001	05MW0001-01	02/04/99	1,2-DIBROMO-3-CHLOROPROPANE	R
05MW0001	05MW0001-01	02/04/99	ACETONE	R
05MW0002	05MW0002-01	02/04/99	1,2-DIBROMO-3-CHLOROPROPANE	R
05MW0002	05MW0002-01	02/04/99	ACETONE	R
05MW0003	05MW0003-01	02/04/99	1,2-DIBROMO-3-CHLOROPROPANE	R
05MW0003	05MW0003-01	02/04/99	ACETONE	R
07MW0001	07MW0001-01	02/02/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0001	07MW0001-01	02/02/99	ACETONE	R
07MW0002	07MW0002-01	02/02/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0002	07MW0002-01	02/02/99	ACETONE	R
07MW0003	07MW0003-01	02/03/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0003	07MW0003-01	02/03/99	ACETONE	R
07MW0004	07MW0004-01	02/03/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0004	07MW0004-01FD	02/03/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0004	07MW0004-01	02/03/99	ACETONE	R
07MW0004	07MW0004-01FD	02/03/99	ACETONE	R
07MW0005	07MW0005-01	02/03/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0005	07MW0005-01	02/03/99	ACETONE	R

TABLE 4-1
Calibration Noncompliance Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
07MW0006	07MW0006-01	02/24/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0006	07MW0006-01	02/24/99	ACETONE	R
07MW0006	07MW0006-01	02/24/99	METHYL ETHYL KETONE (2-BUTANONE)	R
07MW0007	07MW0007-01	02/03/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0007	07MW0007-01	02/03/99	ACETONE	R
07MW0008	07MW0008-01	02/04/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0008	07MW0008-01	02/04/99	ACETONE	R
07MW0014	07MW0014-01	02/04/99	1,2-DIBROMO-3-CHLOROPROPANE	R
07MW0014	07MW0014-01	02/04/99	ACETONE	R
22MW0002	22MW0002-01	02/08/99	1,2-DIBROMO-3-CHLOROPROPANE	R
22MW0002	22MW0002-01	02/08/99	ACETONE	R
22MW0002	22MW0002-01	02/08/99	METHYL ETHYL KETONE (2-BUTANONE)	R
26MW0001	26MW0001-01	02/05/99	1,2-DIBROMO-3-CHLOROPROPANE	R
26MW0001	26MW0001-01FD	02/05/99	1,2-DIBROMO-3-CHLOROPROPANE	R
26MW0001	26MW0001-01	02/05/99	ACETONE	R
26MW0001	26MW0001-01FD	02/05/99	ACETONE	R
26MW0001	26MW0001-01	02/05/99	METHYL ETHYL KETONE (2-BUTANONE)	R
26MW0001	26MW0001-01FD	02/05/99	METHYL ETHYL KETONE (2-BUTANONE)	R
26MW0002	26MW0002-01	02/05/99	1,2-DIBROMO-3-CHLOROPROPANE	R
26MW0002	26MW0002-01	02/05/99	ACETONE	R
26MW0002	26MW0002-01	02/05/99	METHYL ETHYL KETONE (2-BUTANONE)	R
98MW0001	98MW0001-10	02/08/99	1,2-DIBROMO-3-CHLOROPROPANE	R
98MW0001	98MW0001-10	02/08/99	ACETONE	R
98MW0001	98MW0001-10	02/08/99	METHYL ETHYL KETONE (2-BUTANONE)	R
98MW0002	98MW0002-01	02/16/99	1,2-DIBROMO-3-CHLOROPROPANE	R
98MW0002	98MW0002-01	02/16/99	ACETONE	R
98MW0002	98MW0002-01	02/16/99	METHYL ETHYL KETONE (2-BUTANONE)	R
98MW0003	98MW0003-02	03/08/99	1,2-DIBROMO-3-CHLOROPROPANE	R
98MW0003	98MW0003-02	03/08/99	ACETONE	R
98MW0003	98MW0003-02	03/08/99	METHYL ETHYL KETONE (2-BUTANONE)	R

R = Rejected data point

The analytical results for three volatile compounds in associated samples were rejected as a result of noncompliant calibrations. Acetone, methyl-ethyl-ketone, and 1,2-dibromo-3-chloropropane have poor purge efficiencies and, therefore, commonly have initial or continuing calibration response factors (RFs) of less than the acceptance criterion of 0.05. Method OLC02.1 has not set the minimum RF criterion for these compounds. However, data validation guidelines require qualification for all compounds with initial or continuing calibration RFs of less than 0.05. Based on this criterion, nondetected results for acetone, methyl-ethyl-ketone and 1,2-dibromo-3-chloropropane in associated samples, were rejected (coded R).

Initial and continuing calibration criteria were acceptable for all of the ethylene dibromide (EDB), SVOCs, and total metals analyses.

4.1.3 Laboratory Blanks

Laboratory blanks are prepared and analyzed along with each batch of field samples. Laboratory blanks exhibiting contamination are evaluated against their associated (same analytical batch) field samples to determine if a laboratory condition attributed to positive detects in the field samples. Usually, positive results in the field samples that are less than five times the highest associated laboratory blank level are considered nondetect and qualified with the "U" flag. For common laboratory contaminants—acetone, 2-butanone and methylene chloride—the action level is ten times the highest associated laboratory blank level.

Table 4-2 lists the field samples that were qualified based on laboratory blank contamination. Only metals results were qualified.

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
04MW0001	04MW0001-02	03/10/99	CHROMIUM (TOTAL)	U

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
04MW0001	04MW0001-02	03/10/99	COBALT (TOTAL)	U
04MW0001	04MW0001-02	03/10/99	NICKEL (TOTAL)	U
04MW0001	04MW0001-02	03/10/99	SILVER (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	ALUMINUM (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	ALUMINUM (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	CHROMIUM (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	CHROMIUM (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	IRON (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	IRON (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	MERCURY (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	MERCURY (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	NICKEL (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	NICKEL (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	SILVER (TOTAL)	U
04MW0002	04MW0002-03FD	03/10/99	SILVER (TOTAL)	U
04MW0002	04MW0002-03	03/10/99	ZINC (TOTAL)	U
05MW0001	05MW0001-01	02/04/99	ALUMINUM (TOTAL)	U
05MW0001	05MW0001-01	02/04/99	COPPER (TOTAL)	UJ
05MW0001	05MW0001-01	02/04/99	MERCURY (TOTAL)	U
05MW0001	05MW0001-01	02/04/99	POTASSIUM (TOTAL)	U
05MW0001	05MW0001-01	02/04/99	ZINC (TOTAL)	U
05MW0002	05MW0002-01	02/04/99	ALUMINUM (TOTAL)	U
05MW0002	05MW0002-01	02/04/99	MANGANESE (TOTAL)	U
05MW0002	05MW0002-01	02/04/99	MERCURY (TOTAL)	U
05MW0002	05MW0002-01	02/04/99	POTASSIUM (TOTAL)	U
05MW0002	05MW0002-01	02/04/99	ZINC (TOTAL)	U
05MW0003	05MW0003-01	02/04/99	BERYLLIUM (TOTAL)	U
05MW0003	05MW0003-01	02/04/99	MERCURY (TOTAL)	U
05MW0003	05MW0003-01	02/04/99	SILVER (TOTAL)	U
05MW0003	05MW0003-01	02/04/99	ZINC (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	ALUMINUM (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	ANTIMONY (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	BERYLLIUM (TOTAL)	U

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
08AE0009	08AE0009-01FD	01/22/99	BERYLLIUM (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	CHROMIUM (TOTAL)	U
08AE0009	08AE0009-01FD	01/22/99	CHROMIUM (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	COBALT (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	IRON (TOTAL)	U
08AE0009	08AE0009-01FD	01/22/99	IRON (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	MERCURY (TOTAL)	U
08AE0009	08AE0009-01FD	01/22/99	MERCURY (TOTAL)	U
08AE0009	08AE0009-01	01/22/99	ZINC (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	ALUMINUM (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	ANTIMONY (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	BERYLLIUM (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	CHROMIUM (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	COBALT (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	COPPER (TOTAL)	UJ
08MW0001	08MW0001-01	01/22/99	IRON (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	MERCURY (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	NICKEL (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	VANADIUM (TOTAL)	U
08MW0001	08MW0001-01	01/22/99	ZINC (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	ALUMINUM (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	BERYLLIUM (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	CHROMIUM (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	IRON (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	MERCURY (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	NICKEL (TOTAL)	U
08MW0002	08MW0002-01	01/22/99	ZINC (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	ALUMINUM (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	ANTIMONY (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	BERYLLIUM (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	CHROMIUM (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	COPPER (TOTAL)	UJ
08MW0003	08MW0003-01	01/22/99	IRON (TOTAL)	U

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
08MW0003	08MW0003-01	01/22/99	MERCURY (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	NICKEL (TOTAL)	U
08MW0003	08MW0003-01	01/22/99	VANADIUM (TOTAL)	U
22MW0002	22MW0002-01	02/08/99	POTASSIUM (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	ALUMINUM (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	BERYLLIUM (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	CHROMIUM (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	COBALT (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	COPPER (TOTAL)	UJ
23MW0001	23MW0001-01	01/21/99	IRON (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	MERCURY (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	NICKEL (TOTAL)	U
23MW0001	23MW0001-01	01/21/99	ZINC (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	ALUMINUM (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	ANTIMONY (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	BERYLLIUM (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	BERYLLIUM (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	CHROMIUM (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	CHROMIUM (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	COBALT (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	COPPER (TOTAL)	UJ
23MW0003	23MW0003-01FD	01/21/99	COPPER (TOTAL)	UJ
23MW0003	23MW0003-01	01/21/99	IRON (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	IRON (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	MERCURY (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	MERCURY (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	NICKEL (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	NICKEL (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	SILVER (TOTAL)	UJ
23MW0003	23MW0003-01FD	01/21/99	VANADIUM (TOTAL)	U
23MW0003	23MW0003-01	01/21/99	ZINC (TOTAL)	U
23MW0003	23MW0003-01FD	01/21/99	ZINC (TOTAL)	U
23MW0005	23MW0005-01	01/21/99	ALUMINUM (TOTAL)	U

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
23MW0005	23MW0005-01	01/21/99	BERYLLIUM (TOTAL)	U
23MW0005	23MW0005-01	01/21/99	COBALT (TOTAL)	U
23MW0005	23MW0005-01	01/21/99	MERCURY (TOTAL)	U
23MW0005	23MW0005-01	01/21/99	SILVER (TOTAL)	UJ
23MW0005	23MW0005-01	01/21/99	VANADIUM (TOTAL)	U
23MW0005	23MW0005-01	01/21/99	ZINC (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	BERYLLIUM (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	CHROMIUM (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	COPPER (TOTAL)	UJ
23MW0006	23MW0006-01	01/21/99	IRON (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	MERCURY (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	NICKEL (TOTAL)	U
23MW0006	23MW0006-01	01/21/99	ZINC (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	ALUMINUM (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	BERYLLIUM (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	CHROMIUM (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	COPPER (TOTAL)	UJ
23MW0007	23MW0007-01	01/21/99	IRON (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	MERCURY (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	NICKEL (TOTAL)	U
23MW0007	23MW0007-01	01/21/99	ZINC (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	ALUMINUM (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	ALUMINUM (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	ANTIMONY (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	BERYLLIUM (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	BERYLLIUM (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	COPPER (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	COPPER (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	IRON (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	IRON (TOTAL)	U
26MW0001	26MW0001-01	02/05/99	MANGANESE (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	MANGANESE (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	MERCURY (TOTAL)	U

TABLE 4-2
Laboratory Blank Sample Qualification Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
26MW0001	26MW0001-01	02/05/99	POTASSIUM (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	POTASSIUM (TOTAL)	U
26MW0001	26MW0001-01FD	02/05/99	SILVER (TOTAL)	U
26MW0002	26MW0002-01	02/05/99	ALUMINUM (TOTAL)	U
26MW0002	26MW0002-01	02/05/99	MANGANESE (TOTAL)	U
26MW0002	26MW0002-01	02/05/99	MERCURY (TOTAL)	U
26MW0002	26MW0002-01	02/05/99	POTASSIUM (TOTAL)	U
98MW0002	98MW0002-01	02/16/99	ALUMINUM (TOTAL)	U
98MW0002	98MW0002-01	02/16/99	ZINC (TOTAL)	U
98MW0003	98MW0003-02	03/08/99	CHROMIUM (TOTAL)	U
98MW0003	98MW0003-02	03/08/99	MERCURY (TOTAL)	U
98MW0003	98MW0003-02	03/08/99	ZINC (TOTAL)	U

U = Undetected result
UJ = Estimated non-detect

The following metals were detected in one or more laboratory blanks: aluminum, beryllium, chromium, cobalt, copper, iron, manganese, mercury, nickel, potassium, silver, antimony, vanadium and zinc. Aluminum, beryllium, chromium, copper, iron, mercury and zinc were the most prevalent contaminants. The reporting limits (RL) listed in the methodology are often much greater than the actual instrument detection limits (IDL) for an analyte. The lab is required to report all results to the IDL. Thus, the blanks frequently contain low levels of analytes that fall between the IDL and the RL. Associated sample data has been evaluated based on these blank levels. Positive results less than five times the blank levels should be considered false positives and have been qualified as nondetected (U).

All laboratory blanks accompanying the analyses for EDB, SVOC, and VOC were free of contamination.

Results for several metals were qualified as estimated (coded J or UJ) due to negative laboratory blank values. The qualified samples and affected metals results are

summarized in Table 4-3; these positive and nondetected results are potentially biased low.

TABLE 4-3
Negative Blank Summary

Location	Sample ID	Sample Date	Analyte	Qualifier
04MW0001	04MW0001-02	03/10/99	COPPER (TOTAL)	UJ
04MW0001	04MW0001-02	03/10/99	IRON (TOTAL)	UJ
05MW0001	05MW0001-01	02/04/99	LEAD (TOTAL)	UJ
05MW0002	05MW0002-01	02/04/99	COPPER (TOTAL)	UJ
05MW0002	05MW0002-01	02/04/99	LEAD (TOTAL)	UJ
05MW0003	05MW0003-01	02/04/99	COPPER (TOTAL)	UJ
05MW0003	05MW0003-01	02/04/99	LEAD (TOTAL)	UJ
08AE0009	08AE0009-01	01/22/99	SILVER (TOTAL)	UJ
08AE0009	08AE0009-01FD	01/22/99	SILVER (TOTAL)	UJ
08MW0001	08MW0001-01	01/22/99	SILVER (TOTAL)	UJ
08MW0002	08MW0002-01	01/22/99	SILVER (TOTAL)	UJ
08MW0003	08MW0003-01	01/22/99	SILVER (TOTAL)	UJ
08MW0004	08MW0004-02	03/01/99	ANTIMONY (TOTAL)	UJ
08MW0004	08MW0004-02	03/01/99	COBALT (TOTAL)	J
08MW0004	08MW0004-02	03/01/99	COPPER (TOTAL)	UJ
22MW0002	22MW0002-01	02/08/99	COPPER (TOTAL)	J
22MW0002	22MW0002-01	02/08/99	LEAD (TOTAL)	J
23MW0001	23MW0001-01	01/21/99	SILVER (TOTAL)	UJ
23MW0003	23MW0003-01	01/21/99	SILVER (TOTAL)	UJ
23MW0006	23MW0006-01	01/21/99	SILVER (TOTAL)	UJ
23MW0007	23MW0007-01	01/21/99	SILVER (TOTAL)	UJ
26MW0001	26MW0001-01	02/05/99	LEAD (TOTAL)	UJ
26MW0001	26MW0001-01FD	02/05/99	LEAD (TOTAL)	J
26MW0002	26MW0002-01	02/05/99	COPPER (TOTAL)	UJ
26MW0002	26MW0002-01	02/05/99	LEAD (TOTAL)	UJ
98MW0001	98MW0001-10	02/08/99	COPPER (TOTAL)	J
98MW0001	98MW0001-10	02/08/99	LEAD (TOTAL)	UJ
98MW0003	98MW0003-02	03/08/99	COPPER (TOTAL)	UJ

J = Estimated value
UJ = Estimated non detect

4.1.4 Matrix Spikes

Matrix spike (MS) analyses are required for all methods. Matrix spike duplicate (MSD) analyses are required for organic methods. The results from these QC tests are evaluated in the review process. Spiked analytes must have recoveries in the MS/MSD samples that meet established percent recovery criteria. The MS/MSD percent recoveries must be comparable and must meet established RPD criteria. If any spiked analyte falls outside the recovery or RPD criteria, the results for that analyte in the parent sample is qualified as estimated (UJ or J). In cases where recoveries of spiked analytes are extremely low (<10%), the result in the parent sample is rejected.

MS/MSD percent recoveries and RPD were within acceptance criteria for all samples in this data set.

4.1.5 Laboratory Replicates

Laboratory replicates, which are analyzed with inorganic samples, are used to evaluate analytical precision. Analytical precision is evaluated by comparing the difference between the results when either one or both of the sample and sample replicate results are greater than or equal to five times the RL. When an analyte from a laboratory replicate did not meet acceptance criteria, the result in the parent sample was qualified as estimated (J) for that analyte.

The result for copper in the sample collected from location 22MW0002 was qualified as estimated (coded J) due to laboratory replicate differences. All other laboratory replicate RPDs were within pre-established criteria, exhibiting good laboratory precision.

4.1.6 Laboratory Control Samples

LCS and LCSD samples were required for all analyses under the laboratory subcontract. A review of the calculated percent recoveries of the spiked analytes and the calculated RPD between the LCS and the LCSD results provides information on the analytical accuracy and precision, respectively. Table 4-4 summarizes the results that were qualified based on LCS/LCSD criteria.

TABLE 4-4
LCS/LCSD Noncompliant Samples

Location	Sample ID	Sample Date	Analyte	Qualifier
08AE0009	08AE0009-01	01/22/99	COPPER (TOTAL)	J
08AE0009	08AE0009-01FD	01/22/99	COPPER (TOTAL)	UJ
08AE0009	08AE0009-01	01/22/99	SELENIUM (TOTAL)	UJ
08AE0009	08AE0009-01FD	01/22/99	SELENIUM (TOTAL)	UJ
08MW0001	08MW0001-01	01/22/99	SELENIUM (TOTAL)	UJ
08MW0001	08MW0001-01	01/22/99	SELENIUM (TOTAL)	UJ
08MW0002	08MW0002-01	01/22/99	COPPER (TOTAL)	J
08MW0002	08MW0002-01	01/22/99	SELENIUM (TOTAL)	UJ
08MW0003	08MW0003-01	01/22/99	SELENIUM (TOTAL)	UJ
23MW0001	23MW0001-01	01/21/99	SELENIUM (TOTAL)	UJ
23MW0003	23MW0003-01	01/21/99	SELENIUM (TOTAL)	UJ
23MW0003	23MW0003-01FD	01/21/99	SELENIUM (TOTAL)	UJ
23MW0005	23MW0005-01	01/21/99	COPPER (TOTAL)	UJ
23MW0005	23MW0005-01	01/21/99	SELENIUM (TOTAL)	UJ
23MW0006	23MW0006-01	01/21/99	SELENIUM (TOTAL)	UJ
23MW0007	23MW0007-01	01/21/99	SELENIUM (TOTAL)	UJ

UJ = Estimated nondetect
J = Estimated result

The results for copper and selenium in nine samples were qualified as estimated (coded J or UJ) due to noncompliant RPD values.

4.1.7 Surrogates

Surrogate spike compounds were added to each sample undergoing organic analyses to provide information for evaluating accuracy and to assess method performance and extraction efficiency. If surrogate recoveries did not meet pre-established criteria, the sample results should be considered estimated, indicating probable bias in the results.

Surrogate recoveries were acceptable for all VOC and EDB analyses in this sample set. Qualifications were not required.

4.1.8 Internal Standards

Internal standard area counts for the VOC analyses were within method acceptance criteria. Qualifications were not required.

4.2 FIELD QUALITY CONTROL

Field QC samples were collected to help assess analytical data quality. Field QC samples consisted of EBs, TBs and field duplicate (FD) samples.

4.2.1 Field Blanks

Field blanks consisted of trip blanks (TBs), analyzed for VOC only, and equipment blanks (EBs). Nine TBs were shipped and analyzed with these samples. Three EBs were collected on January 21, 1999 and February 3 and February 8, 1999 and submitted for total metals, EDB and VOC analyses. During data review, sample data may be qualified based on TB and EB results when the analyte result in the associated sample is less than five times (10 times for common laboratory contaminants) the results in the TB or EB. Samples which were qualified based on either TB or EB levels are summarized in Table 4-5.

TABLE 4-5
Qualified Due to EB or TB Samples

Location	Sample ID	Sample Date	Analyte	Qualifier
04MW0001	04MW0001-02	03/10/99	TETRACHLOROETHYLENE(PCE)	U
98MW0001	98MW0001-10	02/08/99	BERYLLIUM (TOTAL)	U
98MW0001	98MW0001-10	02/08/99	IRON (TOTAL)	U
98MW0001	98MW0001-10	02/08/99	MANGANESE (TOTAL)	U
98MW0001	98MW0001-10	02/08/99	MERCURY (TOTAL)	U
98MW0001	98MW0001-10	02/08/99	ZINC (TOTAL)	U

U = Undetected result

The results for PCE in one groundwater sample and five analytes in another sample were qualified as nondetected due to levels in associated EBs. In general, the field blanks show minimum contamination, which reflected good sampling procedures.

4.2.2 Field Duplicates

A total of five field duplicates (FD) samples were collected with the native samples. Four FD samples were submitted for total metals analysis; three FD for VOC analysis; two FD for EDB analysis; and one FD for SVOC analysis with the samples in this data set. FD results were evaluated during the data review process by comparing the native sample results to the duplicate sample results and calculating a Relative Percent Difference (RPD). If the RPD is greater than 30 percent for aqueous samples, the positive sample results above the reporting limits, in both the native sample and the field duplicate, are qualified as estimated (coded J).

The metals results in all native and FD sample pairs were comparable, reflecting good sampling and analytical techniques. Target analytes were not detected in any of the other FD sample pairs. Qualifications were not required.

5.0 CORRECTIVE ACTION AND RESOLUTION

If necessary, corrective actions affecting analytical data for this sampling event were performed by the laboratory. When required by the methodology or the MMR QPP, the laboratory may have reanalyzed samples that did not meet QC criteria.

Corrective actions or resampling were not required for any of the field samples collected under this investigation.

6.0 CONCLUSIONS

PARCC goals were met for the samples collected for these sampling tasks. Eight separate sampling tasks are included in this Data Summary Report. Four out of 41 planned groundwater samples were not collected because the wells could not be located and one well was not sampled because it was damaged. The remaining field samples and field QC samples were collected in accordance with the MMR QPP and were submitted and reported for the requested analyses. Completeness goals were met for all analyses. The percent completeness for these analyses are presented in Table 6-1.

TABLE 6-1
Percent Completeness Summary

Analysis	Percent Complete
VOCs	95 %
EDB	100 %
Total Metals	100 %

A total of 46 VOC data points were rejected, based on calibration noncompliance, resulting in a completeness goal of 95 percent for the analysis of all Target Compound List VOCs by method OLC02.1. The 46 rejected data points were for acetone, methyl ethyl ketone, and 1,2-dibromo-3-chloropropane; these compounds are not considered contaminants of concern in this investigation.

In summary, project goals for precision, accuracy, representativeness, completeness and comparability were met for all groundwater samples that were collected.