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Feasibility Study

for

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Old Fire Fighting Training Area
Naval Station Newport
Newport, Rhode Island

Environmental Field Activity Northeast
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298
Contract Task Order 0833

September 2002

TETRA TECH NUS, INC.

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FEASIBILITY STUDY

for

OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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10 Industrial Highway, Mail Stop #82
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Submitted by:
Tetra Tech NUS, Inc.
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406-1433

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PREPARED UNDER THE DIRECTION OF:

STEPHEN S. PARKER
PROJECT MANAGER
TETRA TECH NUS, INC.
WILMINGTON, MASSACHUSETTS

APPROVED FOR SUBMISSION BY:

JOHN J. TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS, INC.
KING OF PRUSSIA, PENNSYLVANIA

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LIST OF ACRONYMS

ACOE	U.S. Army Corps of Engineers
ARAR	Applicable or Relevant and Appropriate Requirement
AVS	Acid Volatile Sulfides
AWQC	Ambient Water Quality Criteria
BAF	Bioaccumulation Factor
bgs	below ground surface
B&RE	Brown & Root Environmental
BSAF	Biota-Sediment Accumulation Factor
CAA	Clean Air Act
CAD	Contained Aquatic Disposal
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CRDL	Contract Required Detection Limit
CTE	Central Tendency Exposure
CWA	Clean Water Act
ELUR	Environmental Land Usage Restriction
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low: NOAA Adverse Effects Benchmark Value For Sediment
ER-M	Effects Range-Median: NOAA Adverse Effects Benchmark Value For Sediment
FDA	U.S. Food and Drug Administration
FFA	Federal Facilities Interagency Agreement
FS	Feasibility Study
GRA	General Response Action
HEAST	Health Effects Summary Table
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IDL	Instrument Detection Limit

LIST OF ACRONYMS (Continued)

IEUBK	Integrated Exposure and Uptake Biokinetic Model
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LDR	Land Disposal Restriction
LTTS	Low-Temperature Thermal Stripping
MCL	Maximum Contaminant Level
NAVSTA	Naval Station
Navy	United States Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NETC	Naval Education and Training Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOEC	No Observed Effects Concentration
NORTHDIV	Northern Division
NPL	National Priorities List
O&M	Operation and Maintenance
OFFTA	Old Fire Fighting Training Area
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PDI	Pre-Design Investigation
POTW	Publicly Owned Treatment Work
PPE	Personal Protective Equipment
PRG	Preliminary Remedial Goal
PVC	Polyvinyl Chloride
RAB	Restoration Advisory Board
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act

LIST OF ACRONYMS (Continued)

RfD	Risk Reference Dose
RI	Remedial Investigation
RIDEM	Rhode Island Department of Environmental Management
RIDOT	Rhode Island Department of Transportation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPO	Representative Process Option
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SEM	Simultaneously Extracted Metal
SER	Shore Establishment Realignment Program
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TBC	To Be Considered
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TCR	Tissue Concentration Ratio
TE	Toxicity Equivalency
TEV	Toxicity Effects Value
TEV-HQ	Toxicity Effects Value - Hazard Quotient
TEQ	Toxicity Equivalency
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRC	TRC Environmental Corporation
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
URI	University of Rhode Island
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WQSV	Water Quality Screening Value

EXECUTIVE SUMMARY

OVERVIEW

This Feasibility Study (FS) describes the process used to evaluate a variety of approaches to address contaminated soil, groundwater, and marine sediment at the Old Fire Fighting Training Area at Naval Station Newport in Newport, Rhode Island. Three alternatives are presented for consideration as the Navy's cleanup strategy for the soil, three alternatives are presented for consideration for groundwater, and five alternatives are presented for consideration for the marine sediment located along the shoreline and near shore portions of the site.

This report does not recommend selection of any of the alternatives, it provides a basis for the comparison of each alternative for each media.

BACKGROUND

The Navy used the information from several studies to develop the FS. These studies included several phases of remedial investigations, a human health risk assessment, and a marine ecological risk assessment. The main findings of these investigations pertinent to this FS are summarized below.

Results of the investigations indicated that site activities have resulted in the release of both organic and inorganic contaminants. Semivolatile organic compounds, metals, and one pesticide exceeded regulatory levels for residential use of the soil at the site. For groundwater, one metal and one volatile organic exceeded the drinking water criteria at the site. For sediment, semi-volatile organic compounds and one metal exceeded concentrations protective of human health and the environment. In addition to the contaminated soil and sediment at the site, various types of debris, including granite blocks, concrete slabs, bricks, and asphalt, are present in the mounds at the site, in the subsurface, and along the shoreline.

A human health risk assessment was performed to evaluate exposure to surface soil, subsurface soil, shoreline sediment, and shellfish (lobsters, clams, and mussels). The risk assessment considered exposures under a residential scenario, recreational and visitor scenarios, and a worker scenario, as well as ingestion of shellfish taken recreationally and for subsistence. For surface soil, subsurface soil, and shoreline sediment, the cancer risks for the residential scenario were within the U.S. Environmental Protection Agency's (EPA's) target risk range of 1×10^{-4} to 1×10^{-6} but exceeded Rhode Island's acceptable risk level of 1×10^{-5}. For shellfish ingestion, the cancer risks exceeded EPA's and Rhode Island's acceptable risk levels under the subsistence fishing and lifetime recreational scenarios for

lobster, clams, and mussels, although this risk was based on the form of arsenic that may not be toxic. None of the media or exposure scenarios posed an unacceptable non-cancer risk.

A groundwater risk evaluation was performed to estimate the potential risks to human health resulting from the presence of contamination in groundwater and to provide the basis for determining appropriate remedial measures, if any, for this medium as part of the FS. The resulting estimated reasonable maximum exposure (RME) incremental cancer risks for a lifetime resident using groundwater as a potable water supply was 1.2×10^{-3}, which exceeds EPA's target risk range of 1×10^{-4} to 1×10^{-6} and RIDEM's benchmark of 1×10^{-5}. Non-carcinogenic risks for the residential child and residential adult both exceed an HI of 1.0. The evaluation was based on an implausible scenario of unrestricted residential groundwater use as the primary drinking water source for future on-site residents. While drinking and bathing uses of groundwater do not currently exist, this use is evaluated for future activities.

An ecological risk assessment was performed to assess ecological risks to the offshore environments of Coasters Harbor and Narragansett Bay from contaminants associated with the site and included exposure and effects assessments, a characterization of risk, risk synthesis, and uncertainty analysis. Sample stations were rated based on whether there is high, intermediate, and low probability for adverse risk (exposure and response measured in test organisms) to receptors present at those stations. The assessment found a high probability for adverse risk at one station along the central shoreline of the site. Intermediate probability for risk (more than one exposure and/or response noted but no correlation found) was estimated for a number of stations at the near shore area and in the harbor sediment, and low probability for adverse risk (exposure or response, but no correlation found) was estimated for the remainder of the stations.

Stations with high probability for ecological risk are those where exposure to contaminants is evident, and a direct negative effect from that exposure is also found. Stations with intermediate probability for ecological risk are those which showed evidence of exposure or effects to organisms, but these exposures and effects are not linked. Stations with low probability for risk are those that show minimal evidence of negative effects from contaminants, and no exposure-response relationships present. A baseline condition is noted if no contaminant exposure or negative effects to organisms (associated with relatively pristine conditions) are found. The baseline condition was not observed at any of the stations evaluated in this assessment, including the off-site reference stations.

AREAS AND VOLUMES

Based on current data, the area of the onshore soil to be addressed at the site is approximately 229,000 square feet (5.3 acres) and the volume of impacted soil and debris is approximately 48,500 cubic yards. This area is presented on Figure E-1. Approximately 85,013 square feet (2.0 acres) of sediment will be

addressed, corresponding to approximately 6,006 cubic yards. Of these amounts, 2,039 square feet (0.05 acre) is currently occupied by eelgrass beds. This area is presented on Figure E-2.

FEASIBILITY STUDY PROCESS

The FS identified preliminary remediation goals (PRGs) for the soil and the marine sediment at the site. PRGs are concentrations of chemicals that, if allowed to remain in the soil, groundwater, and marine sediment, are not anticipated to pose an increased risk of adverse effects to human health or the environment. Soil, groundwater, and sediment that contain concentrations of contaminants in excess of the PRGs were identified and used to delineate the areas that may require remediation or risk management.

The FS evaluated a range of options to address the soil, groundwater, and marine sediment. Current technologies were evaluated to determine if they could be effectively used to protect human health and the environment by containing, removing, or treating the contaminants and if they could be implemented in the areas where the contaminants are present. General technology options assessed were removal and or treatment of contaminated materials, on-site treatment, off-site disposal, establishing land use restrictions, restricting access to the site, and monitoring concentrations to assess any changes in site conditions and risk.

The remedial action alternatives developed to address the contaminants at the site were evaluated against seven criteria identified in the National Contingency Plan: overall protection of human health and environment, compliance with environmental laws, long-term effectiveness, reduction of toxicity through treatment, short-term effectiveness, implementability, and cost (for a 30-year period). Two additional criteria identified in the National Contingency Plan, state and public acceptance, will be evaluated in the Record of Decision following the receipt of public and regulatory comments on the Final Feasibility Study and the proposed remedial action plan.

Remedial alternatives were developed for the three identified media at the site: the onshore area of soil, groundwater, and the marine sediment, which includes the beach and near shore area. The alternatives evaluated for the soil are (1) no action, (2) removal, treatment, and backfill, and (3) removal and disposal. The alternatives evaluated for the groundwater are (1) no action, (2) establishing environmental land use restriction and monitoring contaminant decrease after soil removal, and (3) removing the groundwater for treatment then disposal. The alternatives evaluated for the marine sediment are (1) no action, (2) limited action with long-term monitoring (established as an interim action), (3) limited removal and disposal (beach area), (4) removal and disposal option A (beach and some subtidal area), and (5) removal and disposal option B (all sediments exceeding PRGs, even those in

sensitive habitats). The FS discusses how each alternative meets the seven criteria and evaluates how well each alternative compares to the others.

SUMMARY OF SOIL ALTERNATIVES

Soil Alternative 1, a no action alternative, serves as a baseline consideration or addresses sites that do not require active remediation. This alternative assumes that no remedial action would occur. No land use restrictions would be implemented, and there would be no monitoring of conditions. Natural attenuation could reduce concentrations of chemicals to some extent, but the progress of attenuation would not be monitored. Since contaminants would remain at the site, a 5-year review would be required under law. The present worth cost of this alternative is estimated at $70,000.

Soil Alternative 2 would reduce risks by addressing contaminated soil through excavation and on-site treatment. This alternative would offer aggressive remediation through excavation and treatment by low-temperature thermal stripping and soil washing to reduce the contaminant concentrations to levels below PRGs. Low-temperature thermal stripping uses direct or indirect heating to thermally desorb or volatilize organic contaminants present in soil. Soil washing involves treating soil with wash liquids that would separate the contaminants from the soil media. Removal would involve the excavation of surface and subsurface soils using trackhoes. An estimated 48,500 cubic yards of soil and debris would be excavated and segregated for treatment or disposal. The contaminated portion of the excavated material would be treated on site. Much of the debris would fall into the category of non-hazardous waste and could be disposed of at a municipal landfill. Treated soil would be used for backfilling excavated areas. The present worth cost of this alternative is estimated at $14,192,000.

Soil Alternative 3 would reduce risks by addressing contaminated soil through excavation and disposal. This alternative would provide remediation through excavation and transportation of contaminated soil to a landfill or a treatment, storage, and disposal facility (TSDF). If the excavated soil meets the requirements for use as a daily cover for a municipal landfill, contaminated soil would be disposed of at permitted landfill; however, if the soil requires treatment, disposal at a TSDF would be preferred. An estimated 48,500 cubic yards of soil and debris would be excavated, segregated, and disposed of off site. Much of the debris would fall into the category of non-hazardous waste and could be disposed of at municipal landfill. The present worth cost of this alternative is estimated at $9,751,000.

SUMMARY OF GROUNDWATER ALTERNATIVES

Groundwater Alternative 1, a no action alternative, serves as a baseline consideration. This alternative assumes that no remedial action would occur. No land use restrictions would be implemented, and there

would be no monitoring of conditions. Natural flushing of the aquifer would reduce concentrations of chemicals to some extent, but the progress of and parameters for such attenuation would not be monitored. Since contaminants would remain at the site, 5-year reviews would be required under law. The present worth cost of this alternative is estimated at $70,000.

Groundwater Alternative 2 would be limited to institutional controls and long term monitoring. This alternative would be instituted to prevent use of groundwater for general consumption and monitor the improvement of the groundwater after the source of contaminants (soil) is removed from the site. A property use restriction would be imposed to prevent use of groundwater for public water supply. Monitoring would be conducted over time to evaluate groundwater quality. Basic groundwater models predict that petroleum-related organic compounds would be naturally flushed out of the system within 19 years, although the metals, which are, in part, natural components of the soils and bedrock, would not be flushed out for a long time. The present worth cost of this alternative is estimated at $543,000.

Groundwater Alternative 3 would address contaminated groundwater through removal and treatment of groundwater from the site. This alternative would involve installation of new extraction wells, and pumping those wells to collect the water, then treatment of that water through two processes: Ion exchange system would remove metals from the water, and a granular activated carbon system would remove the organic contaminants. Treated water could be used for aquifer recharge or be disposed of at the local POTW. An estimated 5.5 million gallons of water would be treated and disposed of over every 12 months to capture contaminants. While organic contaminants would be removed within the 30 year performance period, the metals would not be removed for a long time due to their propensity to adhere to soil particles. Groundwater monitoring would also take place during the treatment period, and 5 year reviews would be conducted to evaluate the effectiveness of the alternative. The present worth cost of this alternative is estimated at $2,128,000.

SUMMARY OF MARINE SEDIMENT ALTERNATIVES

Sediment Alternative 1, a no action alternative, would involve no remedial response activities but provides a baseline for comparison to other alternatives. Since contamination would remain and unrestricted future use of the near shore environment would be allowed, 5-year reviews of the no action decision would be required. The present worth cost of this alternative is estimated at $70,000.

Sediment Alternative 2 is a limited action alternative that has been developed to reduce exposure to humans and to monitor improvement in the sediment conditions after removal of the on-site contamination source (soils). Under this alternative, a railing-style fence and signs would be erected along the high tide line at the site to restrict people from accessing the sediments at the shoreline, thus

reducing their exposure. The sediment conditions would be monitored periodically to determine if the removal of the contaminated soils on site results in an overall reduction in contaminant concentrations in the sediment. This alternative would be implemented as an interim action, to allow reevaluation of additional necessary actions after a period of monitoring. This alternative does not provide a reduction of toxicity, mobility or volume through treatment. Because contamination would remain, 5-year reviews of the alternative would be required to evaluate the risks to human health and the environment posed by the site in the future. The present worth cost of this alternative is estimated at $653,000.

Sediment Alternative 3 was developed to reduce the on-site toxicity, mobility, and volume of contaminated beach sediment through removal and disposal. Sediment along the beach would be removed using appropriate excavation techniques and disposed of off site. This alternative does not provide a reduction of toxicity, mobility or volume through treatment. In order to provide protection against near shore sediment, long-term monitoring would be in place. The present worth cost of this alternative is estimated at $3,605,000.

Sediment Alternative 4 was developed to reduce the on-site toxicity, mobility, and volume of contaminated beach and near shore sediment through removal and disposal while providing protection to potential eelgrass beds. Sediment within the eelgrass beds would remain intact while the rest of the contaminated sediment would be removed from the beach and near shore area using appropriate excavation techniques and disposed of off site. This alternative does not provide a reduction of toxicity, mobility or volume through treatment. The eelgrass beds cover about 0.05 acres of area. Sediment associated with eelgrass beds accounts for approximately 1 percent of the volume of contaminated sediment. Because this sediment would remain, long-term monitoring and 5 year reviews would be required. The present worth cost of this alternative is estimated at $3,922,000.

Sediment Alternative 5 was developed to provide a remedial action that eliminates the on-site toxicity, mobility, and volume of contaminated marine sediment through removal and disposal. Sediment would be removed from the beach and near shore areas using appropriate excavation techniques and disposed of off site. This alternative does not provide a reduction of toxicity, mobility or volume through treatment. These areas include those presented in Alternative 4 as well as potential eelgrass beds. The present worth cost of this alternative is estimated at $4,095,000.

1.0 INTRODUCTION

This Feasibility Study (FS) report has been prepared for the Old Fire Fighting Training Area (OFFTA) site (Site 09), located at Naval Station Newport (NAVSTA Newport) in Newport, Rhode Island (formerly the Naval Education and Training Center [NETC]). The FS is submitted in fulfillment of the Remedial Investigation/Feasibility Study (RI/FS) for the site. The RI/FS was initiated by TRC Environmental Corporation (TRC) on behalf of the United States Navy (Navy) under Contract Number N62472-86-C-1282 for the Northern Division Naval Facilities Engineering Command (NORTHDIV). The RI/FS is being completed by Tetra Tech NUS, Inc. (TtNUS), formerly Brown & Root Environmental (B&RE), on behalf of the Navy under Contract Number N62472-90-D-1298 for NORTHDIV.

1.1 REPORT ORGANIZATION

This FS report has been divided into six sections, with tables and figures presented in back of the text. This section of the report, Section 1.0, provides background information on the OFFTA site, including the site location and description; site history; site geology and hydrogeology; terrestrial and marine habitats; contaminant nature and distribution in the media of concern; and the results of the site investigations and risk assessments. Section 2.0 describes the development of remediation goals, including identification of potential applicable or relevant and appropriate requirements (ARARs), media and chemicals of concern (COCs) for the FS, and development of preliminary remediation goals (PRGs) and remedial action objectives (RAOs). Section 3.0 describes the general response actions (GRAs) and presents the identification and preliminary screening of potential remedial technologies and the detailed evaluation of candidate technologies and process options. Sections 4.0, 5.0, and 6.0 describe the remedial alternative development process and provide detailed descriptions of the proposed remedial alternatives for soil, groundwater, and marine sediment, respectively. These sections also provide a detailed analysis of remedial alternatives on the basis of the evaluation criteria specified by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) 300, and a comparative analysis of the remedial alternatives.

1.2 NAVSTA NEWPORT BACKGROUND INFORMATION

NAVSTA Newport is located approximately 60 miles southwest of Boston, Massachusetts, and 25 miles south of Providence, Rhode Island. It occupies approximately 1,063 acres, with portions of the facility located in the City of Newport and Towns of Middletown, Portsmouth, and Jamestown, Rhode Island. The facility layout is long and narrow, following the western shoreline of Aquidneck Island for nearly 6 miles facing the east passage of Narragansett Bay. General location maps of the NAVSTA Newport are provided as Figures 1-1 and 1-2.

The NAVSTA Newport facility has been in use by the Navy since the era of the Civil War. During World Wars I and II, military activities at the facility increased significantly and the base provided housing for many servicemen. In subsequent peacetime years, use of on-site facilities was slowly phased out until Newport became the headquarters of the Commander Cruiser-Destroyer Force Atlantic in 1962. In April 1973, the Shore Establishment Realignment Program (SER) resulted in the reorganization of naval forces, and activity again declined. This reorganization resulted in the Navy excessing some 1,629 acres of its 2,420 acres. Portions of the facility are currently leased by the Navy to the State of Rhode Island Port Authority and Economic Development Corporation. Some of these areas are, in turn, subleased to private enterprises.

From 1974 to the present, research and development and training have been the primary activities at Newport. The base was renamed Naval Station Newport in 1998. The major commands currently located at NAVSTA Newport include the Naval Education and Training Center, Surface Warfare Officers School Command, Naval Undersea Warfare Center, and the Naval War College.

The entire NAVSTA Newport was listed on the U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) of abandoned or uncontrolled hazardous waste sites in November 1989. (The NPL listing is still under the old name of Naval Education and Training Center.) The NPL identifies those sites that pose a significant threat to human health and the environment. Several sites on the base are currently being studied by the Navy under the Department of Defense Installation Restoration Program (IRP). This program is similar to the EPA's Superfund Program authorized under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) in 1986.

A Federal Facilities Agreement (FFA) for NAVSTA Newport was signed by the Navy, the State of Rhode Island, and the EPA on March 23, 1992. The FFA outlines response action requirements under the Department of Defense IRP at NAVSTA Newport. The FFA was developed, in part, to ensure that environmental impacts associated with past and present activities at NAVSTA Newport are thoroughly investigated and remediated, as necessary.

1.3 OLD FIRE FIGHTING TRAINING AREA BACKGROUND INFORMATION

The OFFTA site is located at the northern end of Coasters Harbor Island (see Figure 1-3). The site occupies approximately 5.5 acres and is bordered by Taylor Drive to the south and is surrounded by Coasters Harbor (part of Narragansett Bay) to the east, north, and, west. The site contains a picnic area, playground, and baseball field. A one-story concrete block building (Building 144) is located along the

southern side of the site. The building and recreational facilities at the site are not currently in use. Access to the site is restricted by a chain link fence along its eastern, southern, and western sides.

Unique topographic features at the site include three soil mounds: one that is approximately 20 feet high (30 feet above mean low water) located in the center of the site, another that is approximately 6 feet high (16 feet above mean low water) located on the western side of the site, and a third smaller mound at the far west end of the site. The rest of the site is generally flat, with surface elevations ranging from 8 to 12 feet above mean low water. With the exception of the baseball infields, the site is entirely vegetated with grass. A site plan is presented as Figure 1-4.

The site was home to a Navy fire fighting training facility from World War II until 1972. During the training operations, fuel oils were ignited in various structures at the site that simulated shipboard compartments, and then extinguished by sailors. The general layout of the training facility is shown on a 1953 drawing, which details the planned design of the facility (Figure 1-5). It is not known whether the facility was constructed exactly as shown on this design drawing; however, a 1944 aerial photo of Coasters Harbor Island (Figure 1-6) confirms that the drawing is a reasonable representation of the facility at that time.

It was reported that the two buildings labeled "Carrier Compartment" on Figure 1-5 had a water/oil mixture injected into them which was set on fire for fire fighting practice. Underground piping reportedly carried the water/oil mixture to the buildings and from the buildings to the oil-water separator shown on the figure. No other known information is available concerning the prior fire fighting training operations.

The fire fighting training facility was closed in 1972. Upon closure, the training structures were reportedly demolished and buried in mounds on the site, and then the entire area was covered with topsoil. The site was then converted to a recreational area with a playground, a picnic area with an open pavilion and barbecue grills, and a baseball field. The field was dedicated on July 4, 1976, and used as a recreational area until its closure in October 1998 due to potential environmental and human health concerns.

In its 22 years of use as a recreational area, the site was used for organized activities including youth day camps, picnic functions, and little league baseball (1 year only), as well as for general recreation. A child day care center operated out of Building 144 on the site from approximately 1983 through January 1994 when it was relocated off site to a larger facility on base.

Aerial photos and facility maps for the period from 1939 through 1988 were reviewed to better evaluate the site history. Activity on the site appears to date back to approximately 1943. A 1953 facility design map (Figure 1-5) indicates the locations of structures and site features associated with fire fighting

training exercises. An aerial photo taken in May 1944 (Figure 1-6) depicts the site with structures in a similar layout to that shown on the 1953 facility design map. Based on the design map and subsequent facility condition maps, on-site structures included an administration building, hose house, two carrier compartments, smothering pit, separator pit, foam pit, simulated ship structures, suction pumps, and oil tanks.

The indexes that accompanied some of the facility conditions maps indicate that the on-site structure that was used in recent years as a day care center was once used as "wash and dressing rooms." No significant visible site changes are noted from 1944 until a 1975 aerial photo of the site, when the structures and facilities associated with the fire fighting training area are no longer evident, with exception of the "hose house" and day care center structure. As of 1987, the site appears similar to its current condition, with soil mounds visible in the central and western portions of the site and a pavilion in the east-central portion of the site.

The remedial investigation was initiated when construction activities in 1987 unearthed petroleum contaminated subsurface soil.

1.4 GEOLOGY AND HYDROGEOLOGY

This section presents a summary of the regional and site geologic and hydrogeologic features. This information is based on the RI drilling program and data from previously published literature and reports of other contractors, which are presented in the RI Report (TtNUS, 2001).

1.4.1 Regional Geology and Hydrogeology

The NAVSTA Newport site is located at the southeastern end of the Narragansett Basin. The rocks of the Narragansett Basin are non-marine sedimentary rocks of Pennsylvanian age. The bedrock at the NAVSTA Newport facility is almost entirely of the Rhode Island Formation. A few areas of thick conglomerates are present within the Rhode Island Formation. They consist of pebbles, cobbles, and boulders interbedded with sandstone and graywacke. Coasters Harbor Island (Figure 1-3) is mostly covered with this conglomerate material. Overlying the Pennsylvanian rocks of the Narragansett Basin are surficial deposits of Pleistocene sediments. These unconsolidated, glacial sediments range in thickness from 1 to 150 feet and consist of till, sand, gravel, and silt.

Many areas on Aquidneck Island, on which the NAVSTA Newport is located, obtain potable water from wells. Groundwater is obtained from the unconsolidated glacial till and outwash deposits, and from the underlying Pennsylvanian bedrock. The average depth to groundwater is 14 feet. In the NAVSTA

Newport area, glacial till deposits are typically less than 20 feet thick. Well yields in these materials range from 1 to 120 gallons per minute. Although till is considered an unconsolidated deposit, the upper limit of this well yield is likely from an outwash deposit that is well sorted and stratified. Till wells typically yield a few hundred gallons of water per day, or less than 1 gallon per minute. Bedrock well yields range from less than 1 to as much as 55 gallons per minute and are highly dependent on the presence of joints and fractures. Most groundwater is soft or moderately hard. In scattered locations, pumping has led to salt water intrusion.

1.4.2 Site Geology and Hydrogeology

The geologic and hydrogeologic conditions at the OFFTA site have been determined using data from the various site investigations. This evaluation indicates that the site is underlain by the following materials: fill, consisting of construction debris and sand and gravel; silty sand and gravel; sand and gravel; peat and silt layer; and glacial till, consisting of silt sand and gravel. The thickness of the overburden deposits range from about 6 to 27 feet thick, excluding the elevated mound areas located on the site. The data from the monitoring wells indicate that the groundwater table occurs in the overburden across most of the site, but the water table lies in the bedrock in the eastern and southeastern portions of the site.

Soil present at the OFFTA site consists of native soil as well as imported soil used as fill and top soil in the various stages of the site's development. Upon closure of the fire fighting training facility in 1972, the training structures were reportedly demolished and buried in two mounds on the site, and the entire area was covered with topsoil. The origin of the imported soil is unknown.

The native soil was produced by the combination of physical and chemical processes acting upon the glacial till and regional and local bedrock materials present, which determine the mineralogical and chemical composition of the soil. The bedrock in the area (Rhode Island Formation) contains beds of meta-anthracite and anthracite that may be associated with elevated concentrations of arsenic and beryllium. Arsenic and beryllium are trace constituents of anthracite and other coal and petroleum-related minerals. It appears that the rock is a similar type (classic metasedimentary rock type containing carbonate and sulfide minerals) to the bedrock that has been associated with elevated arsenic concentrations in groundwater in various locations throughout New England. If this rock type does contribute high levels of arsenic to groundwater, it is likely that soils generated from degradation of this material would also be anomalously high in arsenic and potentially other constituents, such as beryllium, related to the high carbon content (i.e., graphite, anthracite coal).

The bedrock at the site has been described as a conglomerate. The bedrock may contain localized units of sandstone. In addition, the conglomerate is believed to be in contact with the Rhode Island

Formation. The Rhode Island Formation consists of metaconglomerates and metasandstones, as well as schist, carbonaceous schist, and graphite. The bedrock in the central portion of the site was blasted as part of the development of the site. The blasting may have increased the fracture density in the bedrock in the areas of blasting and resulted in localized areas of higher hydraulic conductivity.

The groundwater elevations indicate that the groundwater at the site in general flows toward Narragansett Bay and Coasters Harbor located to the north to northwest and the east to northeast of the site, respectively. The depth to groundwater ranges from 4 to 9 feet below ground surface (bgs). Further review of the groundwater maps indicates that locally the groundwater flow can be impacted by groundwater recharge events such as rainstorms. This change in the groundwater flow pattern is believed to be caused by the presence of relatively impermeable paved areas on the site and adjacent to the site. These paved areas reduce the rate of groundwater recharge compared to the unpaved areas of the site.

A tidal influence study indicates that a tidal influence is felt along the shoreline in both the overburden and bedrock aquifers, but this influence does not extend beyond the shoreline.

The vertical groundwater gradients observed at monitoring well clusters indicate that both upward and downward vertical gradients were observed during the investigation (TtNUS, 2001). The vertical gradients in the upgradient monitoring well cluster MW-6 vary seasonally in response to changes in seasonal recharge events. The direction and magnitude of the vertical gradients in the shoreline well clusters MW-2 and MW-11 appear to be influenced by the changes in surface water elevations caused by the tides.

The horizontal groundwater gradients at the site were greater in the central and eastern portions of the site. The western portion of the site had a smaller gradient compared to the eastern portions of the site. This smaller gradient is due to the greater thickness of the overburden at this location.

The hydraulic conductivity of the overburden and bedrock aquifers was estimated using slug tests. This testing indicated that the hydraulic conductivity in the bedrock ranged from 0.61 feet per day at MW-6R (bedrock well) to 120 feet per day at MW-11S (overburden well). The well screen at MW-11S is set in fill material that includes construction debris and is not considered to be representative of the natural deposits. Hydraulic conductivity in the natural overburden deposits at the site ranges from 0.74 to 41 feet per day. The higher values are associated with the sand and gravel deposits at the site, and the lower values are associated with the silty sandy gravels. The highest bedrock hydraulic conductivity measured was at monitoring well MW-8. This well is located in the area of the site where blasting was conducted as part of the site development activities.

The estimated average linear groundwater velocity at the site ranged from 0.39 feet per day to 3.1 feet per day. The higher values were calculated for the western portion of the site where the hydraulic conductivity of the overburden is greatest.

The overall conclusions regarding the site hydrogeology are as follows:

- Groundwater flows from the site and any potential source areas toward Narragansett Bay and Coasters Harbor.
- The groundwater flow rate is higher in the overburden compared to the bedrock aquifer.
- The groundwater migrates at the site at an estimated rate of between 145 feet per year (0.39 feet per day) and 1,131 feet per year (3.1 feet per day). At this rate of groundwater movement, it is estimated that groundwater from the upgradient side of the site would discharge into the surface water within 1 to 2 years or sooner. The actual time would depend on the location of the release relative to the surface water and the actual groundwater velocity.

1.5 TERRESTRIAL HABITATS

In 1976, OFFTA was converted from a training facility to a maintained recreational area called Katy Field. After the fire fighting activities ceased and the facility was demolished, the site was covered by a layer of topsoil ranging from 0.5 to 2 feet in depth. A playground, a picnic area with an open pavilion and barbecue grills, and a baseball field were constructed on the property. The terrestrial habitat of the OFFTA property is a maintained (i.e., mowed) grass lawn. The lawn extends north to the shoreline but is not found around the baseball infield, some of the playground areas, and areas otherwise occupied by buildings or pavement. A few trees, Austrian black pines and red cedars, are growing on the property (SAIC, 2000). In November 1998, the property was enclosed with a chain-link fence, and the recreational facility was closed.

The gravel and cobble shoreline to the north shows signs of erosion from wave action. Stone and construction debris have been placed in this area in an effort to retain the bank and reduce erosion. Construction debris includes granite blocks, concrete slabs, bricks, and asphalt.

In 1994, surveys conducted by Menzie-Cura & Associates, Inc., identified habitats and wildlife in the vicinity of OFFTA. The methods and detailed results of those surveys are reported in the Menzie-Cura & Associates 1994 report (SAIC, 2000).

1.6 MARINE HABITATS

The marine habitat discussion presented in this section is based on data collected during the marine Ecological Risk Assessment (ERA) for the OFFTA. Refer to the Ecological Risk Assessment Report (SAIC, 2000) for complete details.

Coasters Harbor is a shallow cove connected to the East Passage of Narragansett Bay. The harbor is open at each end, north and south of Coasters Harbor Island. A wide mouth faces west at the north end of the island, and a narrow opening at the head faces south at the south end of the island. The depth of the harbor at the mouth is approximately 20 feet at mean low water. At the head, the depth of the harbor is approximately 3 feet at mean low water. A tidal difference of approximately 3.5 feet has been recorded for Coasters Harbor. Circulation patterns and energies within the harbor are dominated by the tides and wind-driven flow. Hydrographic studies performed in 1996 indicate that water enters and exits at both the west and south openings and does not show a consistent directional flow pattern (Kincaid, Ellis, and DeLeo, 1996).

The estuarine system in the vicinity of OFFTA primarily includes subtidal environments, sand- or silt-substrate, with some eelgrass. The dominant taxa in the silty, subtidal, infaunal communities (less than 60 percent sand content) of Coasters Harbor included the bivalve *Nucula proxima*, *oligochaetes* species (aquatic worms), and the arthropod *Microdeutopsis*. The sandy, intertidal, infaunal communities (greater than 70 percent sand content) were found north of Coasters Harbor. Organisms and species that numerically dominated the benthic community at sandy intertidal stations included the snail *Littorina littorea*, the blue mussel *Mytilus edulis*, and, to a lesser extent, *oligochaetes* (SAIC, 2000).

The infaunal benthic, epibenthic, and pelagic communities in Coasters Harbor represent important marine habitats. Infaunal benthic communities exist within sediment depositional areas. Epibenthic communities exist on sediment depositional areas. Pelagic communities exist within the open water. Species within some of these communities are highlighted below.

The blue mussel is an epibenthic species. This species is a locally abundant and ecologically important filter-feeding bivalve found in subtidal and intertidal habitats. It is an important food source for fish, birds, starfish, and occasionally humans (SAIC, 2000). In the ERA this species was identified as a target receptor in the intertidal environment. Blue mussels in Coasters Harbor were considered surrogates for epibenthic species that are potentially exposed to water-borne and particulate-bound contaminants, which presumably originate from OFFTA.

The lobster (*Homarus americanus*) is also an epibenthic species. This species is locally abundant and an ecologically and economically important subtidal crustacean which feeds opportunistically as a scavenger. It is an important food source for fish and humans (SAIC, 2000). In the ERA this species was identified as a target epibenthic receptor in the subtidal environment. Lobsters in Coasters Harbor are potentially exposed to bulk sediment and water-borne contaminants, which presumably originate from OFFTA.

Hard clams (*Mercenaria mercenaria/Pitar morrhuana*) represent infaunal benthic species. These bivalve filter feeders are locally abundant, ecologically and economically important, and they provide a food source for birds and occasionally humans. In the ERA these species were identified as target receptors in the subtidal environment. *Mercenaria mercenaria* was used in the ERA as an indicator species for infaunal bivalves. Hard clams in Coasters Harbor are potentially exposed to bulk sediment and porewater contaminants, which presumably originate from OFFTA. In Narragansett Bay, *Mercenaria mercenaria* is an important commercial species for Rhode Island.

Cunner (*Tautogolabrus adspersus*) are pelagic finfish species. These species are locally abundant and ecologically important estuarine fish, which feed opportunistically upon both plants and animals (SAIC, 2000). They may serve as an important food source for birds and other fish. In the ERA these species were identified as target receptors in the pelagic community. Cunner were considered a surrogate for other pelagic fish species potentially exposed to contaminants in bulk sediment and the water column, which presumably originate from OFFTA.

Other species found during field investigations of the marine environment include oysters and bay scallops. Both of these bivalves are epibenthic and very important, both commercially and ecologically. Their presence in this area shows evidence of overall good health of the epibenthic environment in the subtidal areas. The benthic community is ecologically important and serves as a major food source for birds and fish, as well as for benthic and epibenthic invertebrates. As a whole, this community is potentially exposed to bulk sediment and water-borne contaminants, which presumably originate from OFFTA.

Note that the Rhode Island Department of Environmental Management (RIDEM) has designated the area of Narragansett Bay along the NAVSTA Newport shoreline, including Coasters Harbor, as a shellfish closure area due to known or potential sewage discharges in the area. However, the effectiveness of the ban for preventing shellfishing is uncertain, and the ban applies only to a few species of shellfish (bivalves only); it does not apply to lobster or finfish.

1.7 NATURE AND EXTENT OF CONTAMINATION

Results of the investigations indicated that site activities have resulted in the release of both organic and inorganic contaminants. A summary of the nature and extent of site contamination follows. A few volatile organic compounds (VOCs) were detected in surface soil, subsurface soil, and shoreline sediment at low concentrations below RIDEM residential soil criteria. VOCs were also detected in groundwater at concentrations below RIDEM criteria, although benzene exceeded its maximum contaminant level (MCL) promulgated under the Safe Drinking Water Act.

Semivolatile organic compounds (SVOCs) were detected in all media across the site. The most prevalent detected SVOCs were polynuclear aromatic hydrocarbons (PAHs). PAHs were detected at their highest concentrations in surface and subsurface soil and groundwater sample locations adjacent to Coasters Harbor. PAHs were also detected in all shoreline sediment locations, marine sediment stations, and storm water samples. The highest concentrations in marine sediment were detected at sampling stations nearest the shore in the vicinity of the central portion of the site. Only non-carcinogenic PAHs were detected in storm water samples. PAHs were detected in biota samples from all sampling stations. In clam tissue samples, the highest concentrations were detected in samples northwest of the site and at the reference station. In blue mussel tissue samples, the highest concentrations were detected in samples near the shore east of the site and at the reference station. In lobster tissue samples, the highest concentrations were detected in samples from a distant area opposite the central portion of the site. In fish tissue samples, the highest concentrations were detected in samples nearest the shore in the vicinity of the central portion of the site. Concentrations of PAHs in surface soil, subsurface soil, and shoreline sediment exceeded RIDEM Residential Direct Exposure Criteria for soil. Other SVOCs, other than PAHs, were detected infrequently and in low concentrations in surface soil and subsurface soil; none of these exceeded RIDEM Residential Direct Exposure Criteria for soil. They were also detected in groundwater at concentrations below RIDEM criteria. However, 2-methylnaphthalene, dibenzofuran, and naphthalene exceeded the EPA Region IX screening levels.

Pesticides were detected in surface soil and subsurface soil across the site, in storm water, marine sediment, and in biota samples. Only one pesticide, endrin, was detected in groundwater. All pesticide concentrations were low. Among biota, the highest pesticide concentrations were detected in lobster. The highest marine sediment pesticide concentrations were detected offshore east of the site.

Polychlorinated biphenyls (PCBs) were detected infrequently in surface and subsurface soil at concentrations below RIDEM Residential Direct Exposure Criteria for soil. PCBs were detected frequently in biota tissue samples. In clam tissue samples, the highest concentrations were detected in samples offshore near the central portion of the site. In blue mussel tissue samples, the highest

concentrations were detected in samples near the shore in the vicinity of the central portion of the site. In lobster tissue samples, the highest concentrations were detected in samples from a distant area opposite the central portion of the site. In fish tissue samples, the highest concentrations were detected in samples in the nearshore area at the west end of the site. The fish tissues were found to contain higher concentrations of PBCs relative to other organisms.

Metals were detected throughout the site. Many are the result of the natural breakdown of soils and the parent bedrock and are naturally occurring in low concentrations. Concentrations of metals in site soil and groundwater were compared to site-specific background or upgradient samples. In general, metals were detected in higher concentrations on site. In surface soil the metals detected most frequently at concentrations greater than background were arsenic, magnesium, and potassium. Arsenic, beryllium, lead, and manganese in surface soil exceeded the RIDEM Residential Direct Exposure Criteria for soil. The highest concentrations of arsenic were detected in surface soil from the central portion of the site. In subsurface soil the metals detected most frequently at concentrations greater than background were barium, calcium, copper, lead, potassium, and zinc. Arsenic, antimony, beryllium, lead, and manganese in subsurface soil exceeded the RIDEM Residential Direct Exposure Criteria for soil. The highest concentrations of arsenic were detected in subsurface soil from the central portion of the site. The Navy's background study showed that on Coasters Harbor Island background arsenic concentrations are higher in the subsurface soils than in the surface soils. The elevated arsenic concentrations in the Coasters Harbor Island soils may be attributable to the composition of the local and regional bedrock formations and the shallow depth of bedrock and glacial till in the area (TtNUS, 2000).

A background soil investigation was conducted on the overburden soils on Coasters Harbor Island. This investigation evaluated soil conditions across the island, and samples from two depths were analyzed for selected metals including arsenic. This investigation found elevated levels of arsenic on undeveloped portions of the island, at varying depths. Higher concentrations were found in samples directly above bedrock, and none were found to be below the RIDEM direct exposure criteria for soils at residential property. Average background concentrations were measured at 5.5 mg/kg for surface and 42.8 mg/kg for subsurface soils. The investigation resulted in a negotiated background soil concentration for arsenic being established at 6.2 mg/kg.

Concentrations of metals in site groundwater were compared to upgradient samples. In groundwater the metals detected most frequently at concentrations greater than upgradient groundwater samples were calcium, iron, magnesium, potassium, and sodium. Lead exceeded its MCL concentration; all other metals in groundwater were below their respective MCLs. Arsenic, barium, cadmium, chromium, lead, manganese, vanadium, and zinc exceeded the EPA Region IX screening levels. The highest concentrations of metals were detected in samples from the north and central portions of the site. Nickel

and copper concentrations in storm water samples exceeded marine ambient water quality criteria (AWQC).

Metal concentrations detected in shoreline sediment were comparable to surface soil samples. Arsenic, beryllium, lead, and manganese in shoreline sediment exceeded the RIDEM Residential Direct Exposure Criteria for soil. (Because there are no sediment benchmarks against which to compare, the shoreline sediment samples, which are directly accessible when walking on the shore, were compared with soil standards.) No spatial pattern was evident for metals in marine sediment samples. Metals detected in biota samples revealed no relative differences between samples and no differences from reference stations, with the exception of silver concentrations in lobster. Concentrations of silver in lobster tissue samples obtained from the western boundary of the study area were greater than other areas.

All surface soil samples analyzed for dioxins detected low dioxin concentrations toxicity equivalency (TEQ) well below the accepted dioxin residential clean-up goal of 1 ug/kg.

1.8 FATE AND TRANSPORT

Spills and leaks of petroleum-based fuels and deposition of fuel combustion byproducts have introduced a wide range of petroleum hydrocarbons into the OFFTA site soil. Over the many years since fire fighting training activities have ceased, most of the volatile and soluble petroleum hydrocarbons have apparently partitioned to the vapor phase or dissolved phase and have been degraded or transported off site, leaving behind a relatively insoluble and recalcitrant petroleum residue. The much less soluble and volatile PAHs are still present at high concentrations in the soil in the central portion of the site. These contaminants will continue to leach into the groundwater, but the solubility and adsorptive properties of these contaminants should keep groundwater PAH concentrations low. The migration of these contaminants into the nearshore sediment is not expected to be significant. Further discussion on this groundwater to sediment pathway is presented in Appendix A. As stated in the RI Report, the PAHs in the nearshore marine sediment likely originated from off-site as well as on-site sources.

Some of the arsenic and chromium in the OFFTA soil and groundwater may be naturally occurring. The near neutral pH and low dissolved oxygen content of the groundwater enhance the mobility of arsenic. By contrast, the presence of organic carbon in the soil zone and reducing conditions in the aquifer reduce the mobility of chromium in both environments. Off-site sources are probably a major contributor to the high chromium concentrations observed in marine sediment.

Lead concentrations in soil samples were often much higher than those in background samples, indicating the presence of lead contamination in the site soil. The lead appears to be immobilized by

mineral solubility constraints and adsorption to soil organic matter, clay minerals, and metal oxyhydroxides. The lead in the marine sediment probably originated from both on-site and off-site sources.

1.9 HUMAN HEALTH RISK ASSESSMENT

The Baseline Human Health Risk Assessment (HHRA) evaluated exposure to surface soil, subsurface soil, shoreline sediment, and shellfish (lobsters, clams, and mussels). Although finfish samples were collected at the site, the fish collected are not an edible species, and it is believed that the shellfish ingestion would pose a higher and thus more conservative risk. This risk assessment considered exposures under a CERCLA residential scenario, a recreational scenario (considered a limit restricted recreational scenario under RIDEM's regulations), a visitor scenario, and a worker scenario, as well as ingestion of shellfish taken recreationally and for subsistence. Summaries of the risks and hazards resulting from soil, sediment, and groundwater are presented in Tables 1-1, 1-2 and 1-3, respectively. The EPA's target risk range is 1×10^{-4} to 1×10^{-6}, and RIDEM's benchmark is 1×10^{-5}.

For surface soil, the cancer risks under the residential, recreational, and worker scenarios were 2.5×10^{-5}, 5.4×10^{-6}, and below 1×10^{-6}, respectively. For subsurface soil, cancer risks under the residential and worker scenarios were 4.0×10^{-5} and 1.4×10^{-6}, respectively. No recreational exposures were calculated for subsurface soil. Non-cancer risks for surface and subsurface soil under all scenarios did not exceed 1.0 for any target organ group.

EPA has reevaluated reference values for dioxin and related compounds, and this reassessment is in review. EPA has requested that in the meantime, site data be evaluated by comparing the dioxin toxicity equivalency factor (TEQ) for the site data to the published oral slope factor of 1.5×10^{-5} $(mg/kg/day)^{-1}$, and also the proposed slope factor of 1.0×10^{-6} $(mg/kg/day)^{-1}$. Because this proposed value was not provided during the development of the Remedial Investigation for the OFFTA site, the risk assessment was performed using the older, published value. However, in completion of this FS, the dioxin data has been reviewed in accordance with the EPA request, and it is noted that while dibenzofurans were detected at very low concentrations in the surface soil at the site, 2,3,7,8-TCDD (dioxin) was not, providing a maximum TEQ value of 0.0164 ug/kg. With such a low dioxin TEQ, dioxin and its related dibenzofuran compounds would not be selected as COPCs. Thus if the risk assessment was redone using the proposed dioxin slope factor, there would be no change to the findings already published.

For shoreline sediment (sediment collected from the area between mean high water and mean low water), the cancer risks under the residential and recreational (shoreline visitor) scenarios were 2.2×10^{-5}

and 1.6 x 10^{-6}, respectively. Non-cancer risks for shoreline sediment did not exceed 1.0 for any target organ group. Subtidal sediment was not evaluated under the human health risk scenarios.

For shellfish ingestion, the cancer risks exceeded the risk range of 1 x 10^{-4} to 1 x 10^{-6} under the subsistence fishing and lifetime recreational scenarios for lobster, clams, and mussels. The primary contributor to these risks is arsenic, and other contributors include PCBs, PAHs, mercury, cadmium, and chromium as calculated from analytical results. Non-cancer risk exceeded 1.0 under the subsistence fishing scenario for lobster, clams, and mussels. The target organs and the principal COPCs contributing to the non-cancer risk were skin (arsenic and PCBs), CNS (mercury), kidney (cadmium and chromium), and eye (PCBs). Although the total non-cancer risk exceeded 1.0 under the child and adult recreational scenarios for lobster, clams, and mussels, the risks did not exceed an HI of 1.0 for any target organ group for any of these scenarios except child exposure to clams. For that scenario, one target organ, skin, exhibited an HI greater than 1.0, for which the principal COPCs contributing to the non-cancer risk were arsenic and PCBs.

Note that the subsistence fishing scenario is not likely to exist and is unlikely in the future because of the unsubstantiated assumption that all of the fisherman's catch would be obtained continually from waters adjacent to the OFFTA site, and because there are no local cultures (such as Native Americans) involved in subsistence fishing in this limited area.

Arsenic is present in fish and shellfish tissue in the organic form of arsenobetanine, which is non-toxic. The risk calculations are performed based on the presence of this arsenic in its inorganic form. Therefore, the risk values for seafood ingestion from this site are biased high and could be overestimated by as much as a factor of 10. In addition, the exposure scenarios used for the risk assessment, particularly the use of subsistence fishing, are biased high, and it is highly unlikely that exposures to the degree used for risk estimation could effectively be achieved.

A groundwater risk evaluation was performed to estimate the potential risks to human health resulting from the presence of contamination in groundwater and to provide the basis for determining appropriate remedial measures, if any, for this medium as part of the FS. The resulting estimated reasonable maximum exposure (RME) incremental cancer risks for a lifetime resident exposed to groundwater was 1.2 x 10^{-3}, which exceeds EPA's target risk range of 1 x 10^{-4} to 1 x 10^{-6} and RIDEM's benchmark of 1 x 10^{-5}. Non-carcinogenic risks for the residential child and residential adult both exceed an HI of 1.0, indicating the need to segregate groundwater risks according to target organ. For the residential child receptor, the target organs exceeding 1.0 and the principal COPCs contributing to noncancer risk were: CNS (HI of 43 - manganese), skin and vascular system (HI of 12.4 - arsenic), kidney (HI of 2.7 - barium, cadmium, chromium, and dibenzofuran), weight loss (HI of 2.3 - naphthalene and 2-methylnaphthalene,

and blood (HI of 1.3 - benzene and zinc). The evaluation was based on the scenario of unrestricted residential groundwater use as the primary drinking water source for future on-site residents. This scenario is unlikely based on the groundwater classification, the salinity of groundwater at the site, and the availability of nearby alternative potable water supplies.

Drinking and bathing uses of groundwater are currently not present, and the proximity to the ocean and salinity measured in the groundwater indicates that groundwater use as a water supply is implausible at the site. However, this scenario is used in this study for comparison purposes.

1.10 ECOLOGICAL RISK ASSESSMENT

The ERA (SAIC, 2000) was performed to assess ecological risks to the offshore environments of Coasters Harbor and Narragansett Bay from contaminants associated with OFFTA and included exposure and effects assessments, a characterization of risk, risk synthesis, and uncertainty analysis.

Risks were identified by stations based on summaries of each weight of evidence, focusing on the exposure (contaminants present) correlated to effects (reproduction and growth inhibitions, etc). Stations were rated from these summaries to exhibit properties where there is high, intermediate, and low probability for adverse risk to receptors present at those stations.

The assessment found a high probability for adverse risk at one station (Station 5), close to the outfall at the central shoreline of the site, likely from PAHs and metals present at this area. Intermediate probability for risk was estimated for a number of stations at the nearshore area and in the harbor sediment, including one reference station south of Coasters Harbor, but because a clear exposure-response relationship was not found, it is not certain that stresses to test organisms are from site contaminants present, or from other sources or factors. Low probability for adverse risk was estimated for the remainder of the stations, including one reference station and the nearshore stations more exposed to rough water conditions. The observed risks at these stations are considered acceptable from an ecological perspective. A baseline condition associated with relatively pristine conditions was not observed at any of the site or reference stations evaluated in this assessment.

Ecological risks have been qualitatively evaluated. According to RIDEM's National Heritage Program (RIDEM, 1994), rare plants or animals or ecologically significant natural communities are not present in the vicinity of the OFFTA site. In addition, RIDEM conducted an endangered species survey of several Navy facilities including NAVSTA Newport in 1989 (RIDEM, 1989). At that time, the potential for any rare species to occur at NAVSTA Newport was considered extremely low. Little habitat is available for rare species in the area of NAVSTA Newport because of heavy development throughout much of the

area, particularly the on shore portions of Coasters Harbor Island, the location of the OFFTA site. Based on this information, threatened and endangered species are not likely to be of concern at the on-shore portions of the OFFTA site.

However the marine portions of the site are of more ecological significance. Eelgrass beds not previously identified by RIDEM were found on the northwest section of the study area. There is a healthy subtidal community in the subtidal area near the site, as documented during eelgrass surveys conducted by the Navy in July and November 2001. Both Kemps Ridley and Loggerhead turtles are known to be present in Narragansett Bay.

2.0 DEVELOPMENT OF REMEDIATION OBJECTIVES

This section presents the initial steps in developing remedial alternatives to address the human health and ecological concerns identified at OFFTA and to comply with all applicable regulations. The process includes:

- Identifying ARARs and other environmental criteria that must be considered in developing RAOs (Section 2.1).

- Developing media-specific RAOs that are protective of human health and the environment and comply with ARARs. RAOs may specify COCs, exposure pathways and receptors, and preliminary remediation goals (PRGs) that identify potentially acceptable contaminant levels or ranges of levels for each exposure route (Section 2.2).

- Developing initial estimates of areas or volumes of media that should be addressed by the remedial alternatives (Section 2.3).

After these steps are completed, GRAs that will satisfy the site-specific RAOs can be formulated, and applicable technologies identified and evaluated. GRA development and technology identification, screening, and evaluation are presented in Section 3.0.

2.1 ARARs AND TBCs

ARARs and guidance to be considered (TBCs) are the regulatory and non-regulatory environmental criteria that must be considered while planning and implementing remedial actions. This section summarizes what constitutes ARARs and TBCs, and the various types of ARARs that must be considered in the FS.

ARARs are promulgated federal and state environmental and facility siting requirements that are determined to be legally applicable or relevant and appropriate to the hazardous substances, remedial actions, or other circumstances at a CERCLA site. The two categories of requirements are defined below.

- Applicable Requirements - Section 300.5 of the NCP defines applicable requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws

that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site."

- Relevant and Appropriate Requirements - Section 300.5 of the NCP defines relevant and appropriate requirements as "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

The NCP Section 300.430(E) states that on-site remedial actions at CERCLA sites must meet ARARs unless there are grounds for invoking a waiver. A waiver is required if ARARs cannot be achieved.

TBCs are non-promulgated criteria, advisories, and guidance issued by the federal or state governments. Along with ARARs, TBCs may be used to develop the remedial action alternatives necessary to protect human health and the environment.

ARARs and TBCs are further divided into three categories: chemical-specific, location-specific, and action-specific. These categories are briefly discussed in Sections 2.1.1 through 2.1.3.

2.1.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in numerical values that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. In general, chemical-specific requirements are set for a single chemical or a closely related group of chemicals. These requirements do not consider the mixture of chemicals. A set of chemical-specific ARARs and TBCs that may be applied to the OFFTA site is presented in Table 2-1.

2.1.2 Location-Specific ARARs and TBCs

Location-specific ARARs and TBCs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they are in specific areas. The general types of location-specific requirements that may be applied to the OFFTA site include coastal zone, water resources, and floodplain regulations. Potential location-specific ARARs and TBCs for the OFFTA site are presented in Table 2-2.

2.1.3 Action-Specific ARARs and TBCs

Action-specific ARARs and TBCs are usually technology- or activity-based requirements or limitations on actions taken with respect to managing hazardous substances, pollutants, or contaminants. These requirements generally focus on actions taken to remediate, handle, treat, transport, or dispose of hazardous substances, pollutants, or contaminants. These action-specific requirements determine how a selected alternative must be implemented. A set of potential action-specific ARARs and TBCs for the OFFTA site are presented in Table 2-3. However, action-specific ARARs can be unique to different alternatives evaluated and thus may be modified for each alternative later in this FS.

2.2 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES

RAOs consist of medium-specific goals for protecting human health and the environment. The RAOs specify the media and COCs, exposure pathways and receptors, and acceptable contaminant levels or range of levels for each exposure pathway. By specifying both an exposure pathway and target contaminant level(s), the RAOs permit development of a range of alternatives that may achieve protectiveness by reducing exposure to contaminated media or reducing contaminant concentrations.

The following sections present the major components of the RAO development process: identification of the media of concern, identification of the chemicals of potential concern (COPCs) for each medium, development of PRGs, identification of COCs, and formulation of RAOs. Section 2.2.1 identifies the media of concern. Sections 2.2.2, 2.2.3, and 2.2.4 and their subsections then present the COPCs, PRGs, COCs, and RAOs for each selected medium.

2.2.1 Identification of Media of Concern

The media of concern are identified based on the results of site investigations, the site-specific HHRA and marine ERA, the Groundwater Risk Evaluation (TtNUS, 2002a; included as Appendix B in this document), and an evaluation of compliance with chemical-specific ARARs. Site investigations documented in the RI Report have identified soil and sediment as potential media of concern. Shellfish are an indirect medium of concern, as it is assumed that they continue to be affected by sediment contaminants. Groundwater was not identified as a medium of concern in the RI Report; however, further evaluation has been performed in the Groundwater Risk Evaluation (TtNUS, 2002a) and has identified groundwater as a medium of concern. Surface water was not selected as a medium of concern because there is no surface water at the site other than Narragansett Bay, which was not investigated during the RI. There are no continuing releases of contaminants to the air, and therefore air was not selected a medium of concern.

A brief discussion of each investigated medium is provided below.

Soil

During the various OFFTA site investigations, a total of 80 surface soil samples and 56 subsurface soil samples (excluding duplicates) were collected. Analyses performed on these samples include VOCs, SVOCs, pesticides/PCBs, metals, dioxins/furans, and TPH, although not all analyses were performed on all samples.

As presented in the RI Report (TtNUS, 2001), the estimated reasonable maximum exposure (RME) incremental cancer risks for a lifetime resident exposed to surface soil and subsurface soil were 2.5×10^{-5} and 4.0×10^{-5}, respectively. Both values are within EPA's target risk range of 1×10^{-4} to 1×10^{-6} but slightly greater than the 1×10^{-5} benchmark used by RIDEM. Non-carcinogenic risks for the residential child and residential adult did not exceed an HI of 1.0 for any target group for surface or subsurface soil. Both carcinogenic and non-carcinogenic risks were below EPA's risk range for recreational receptors and excavation workers. The concentrations of contaminants are above the State's standards for unrestricted residential/recreational use of the site. Chemical-specific RIDEM standards were also exceeded at the site.

The estimated percentage of children exposed to subsurface soil that are predicted to exhibit a blood lead level above 10 µg/dL is 18.6 percent. This exceeds EPA's protective level cutoff of 5 percent and indicates that adverse effects cannot be ruled out from lead exposure to residential children under these conditions.

Sediment

Marine sediment samples were collected from the intertidal area (the area between high tide and low tide, also referred to as the beach area), the nearshore area (just beyond the low-tide line), and offshore area.

Five beach sediment samples were collected approximately midway between the mean low water and mean high water along the shoreline. The samples were all collected from the 0- to 0.5-foot depth interval and analyzed for VOCs, SVOCs, and metals. These samples were used in the HHRA to evaluate potential risk to people walking or playing along the shoreline.

Twenty-three sampling stations, located in Coasters Harbor, both immediately adjacent to and in the wider area surrounding the site were established for marine sediment (both nearshore and offshore) and

biota sampling. Sediment and biota collected from these samples were used in the marine ERA to evaluate potential ecological risk.

Standards for contaminants in sediment are not set forth by state or federal government; therefore, the contaminants in sediment are evaluated as described in Section 7 of the RI Report (TtNUS, 2001).

Elevated levels of SVOCs and metals were found in both the beach and the marine sediment. Elevated levels of pesticides/PCBs were also found in the marine sediment.

As presented in the RI Report (TtNUS, 2001), the estimated RME cancer risk for a lifetime resident and a shoreline visitor exposed to sediment were 2.2×10^{-5} and 1.1×10^{-6}, respectively. The lifetime resident value is within EPA's target risk range of 1×10^{-4} to 1×10^{-6} but slightly greater than the 1×10^{-5} benchmark used by RIDEM. Non-carcinogenic risks for the adult and child residents and visitors did not exceed an HI of 1.0 for any target organ.

Shellfish

Natural populations of blue mussels, hard clams, cunner fish, and lobster were collected at a subset of the marine sediment sampling stations during the ERA and analyzed for SVOCs, pesticides/PCBs, and metals. These samples were used in the HHRA to evaluate potential risk from the ingestion of shellfish.

Standards for some contaminants in biota are set forth by the U.S. Food and Drug Administration (FDA). SVOCs, pesticides/PCBs, and metals were found in the biota samples; however, all detected concentrations of contaminants in biota tested at the site were below FDA action levels.

For shellfish ingestion, the cancer risks exceeded the risk range of 1×10^{-4} to 1×10^{-6} under the primary subsistence fishing and lifetime recreation scenarios for lobster, clams, and mussels. Additionally, noncancer risks were exceeded for subsistence and recreational shellfish ingestion scenarios. However, these were exceeded due to the total arsenic concentrations measured in the shellfish samples. The risk calculations were performed based on the presumption that this arsenic was present in its inorganic form. The FDA reports that 80-90% of the arsenic present in shellfish is present as arsenobetanine, which is not toxic. The resulting overestimate of risk is accounted for during the development of the PRGs and RAOs, described with other uncertainties in the shellfish ingestion scenarios, presented later in this section.

Shellfish are an indirect medium of concern and only provide contaminant exposures to humans by virtue of collecting those contaminants from the sediments. Therefore, the risks to persons ingesting shellfish will be mitigated as necessary by addressing sediment.

Groundwater

While a total of 34 groundwater samples (excluding duplicates) were collected during the various OFFTA site investigations, only unfiltered groundwater data from the 1997 Phase III investigation were utilized in the OFFTA Groundwater Risk Evaluation (TtNUS, 2002a) (see Appendix B). The 13 unfiltered samples from the 1997 investigation, collected using the low-flow sampling method, are considered indicative of the actual groundwater conditions as the sampling method prevents suspended solids from biasing the metals data.

The OFFTA groundwater risk evaluation presents risks resulting primarily from ingestion and inhalation pathways based on the standard residential scenario (unrestricted residential groundwater use as the primary drinking water source for future on-site residents). This standard residential scenario, applied to be protective of all potential uses of groundwater, does not currently exist and is implausible for the OFFTA site based on the GB groundwater classification, the salinity of groundwater at the site, and the availability of nearby alternative potable water supplies. The estimated reasonable maximum exposure (RME) incremental cancer risks for a lifetime resident exposed to groundwater was 1.2×10^{-3}, which exceeds EPA's target risk range of 1×10^{-4} to 1×10^{-6} and RIDEM's benchmark of 1×10^{-5}. Non-carcinogenic risks for the residential child and residential adult both exceed an HI of 1.0. Under unrestricted future residential use conditions, other secondary types of residential contact with groundwater are conceivable – for example, contact with groundwater associated with lawn or garden sprinklers, car washing, swimming pools, etc. The probable risks associated with secondary residential exposure pathways, which involve predominantly dermal exposures with less frequent exposures, are likely to be significantly lower and may be less than EPA benchmarks.

A comparison of maximum detected groundwater contaminant concentrations in the 1997 data set to MCLs presented in the groundwater risk evaluation revealed that only benzene and lead exceeded their respective MCLs promulgated under the Safe Drinking Water Act.

A groundwater to sediment pathway analysis was performed to evaluate the extent to which groundwater transfers site-related contaminants to the shoreline and marine sediments (see Appendix A). The analysis compared several VOCs, SVOCs, and metals present in the groundwater beneath the OFFTA site to concentrations in soil and sediment. The analysis concluded that contaminants present in the

OFFTA groundwater do not appear to represent a present or future threat to shoreline and nearshore sediment quality.

2.2.2 Medium of Concern: Soil

For each medium of concern, the remaining components of the RAO development process will be completed: identification of the COPCs, development of PRGs, identification of the COCs, and formulation of RAOs. The following subsections present these elements for soil.

For the purposes of this feasibility study, site soil is defined as the unconsolidated materials that are present within and above the water table to the boundaries of the site (west, east, and south boundaries) and/or to the high tide line (north boundary).

2.2.2.1 Identification of Chemicals of Potential Concern in Soil

COPCs for soil were identified in the RI Report (TtNUS, 2001). These COPCs were selected primarily based on the maximum concentration exceeding the associated risk-based concentration (RBC) based on a target cancer risk of 1×10^{-6} or a non-cancer hazard quotient (HQ) of 0.1. The RBCs used for comparison were obtained from the EPA Region 3 listing for residential soil exposure (with RBCs based on non-cancer effects adjusted from an HQ of 1.0 to an HQ of 0.1 to protect against the possibility of additive toxic effects from multiple chemicals). However, the COPC selection in the RI did not consider the Direct Exposure Criteria or the Leachability Criteria from the RIDEM Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases, DEM-DSR-01-93, or more commonly known by its short title, Remediation Regulations. Examination of the soil database indicated that there would be several chemicals that had not been selected as COPCs that exceeded the RIDEM Residential Direct Exposure Criteria. Therefore, the COPC selection process has been reconsidered for the purposes of this FS.

For many remedial sites under the authority of CERCLA, the COPCs are determined using the same methodology as used in the OFFTA RI Report – screening against RBC tables. Once the list of COPCs is determined, site-specific RBCs are calculated for each of the chemicals and may include several exposure pathways, including direct exposure and leachability. These site-specific RBCs, as well as other considerations such as background concentrations, quantitation limits, and ARARs, are used to develop PRGs for each chemical. A comparison of the PRGs is made against the database, and any chemical with a concentration exceeding its PRG is selected as a COC. Any soil above PRGs will require remediation or risk management.

This primarily risk-based process for selecting COPCs, PRGs, and COCs, which is common at CERCLA sites, will still be used in this FS. However, a second parallel process that considers the requirements of the RIDEM Remediation Regulations will also be used to select COPCs, PRGs, and COCs. For each process, a list of COPCs requiring further consideration will be developed; these lists will subsequently be combined to form a comprehensive list of COPCs requiring further consideration. PRGs will be selected for the combined list by using the more conservative value from each process and then making any substitutions for background concentrations, quantitation limits, and ARARs. The two processes, termed Risk-Based COPC Selection and RIDEM-Based COPC Selection for purposes of this FS, are described in the following sections.

Risk-Based COPC Selection

As previously mentioned, COPCs for soil were identified in the RI Report. The Navy Interim Final Policy on the Use of Background Chemical Levels requires the initial screening to be comparison to risk-based benchmarks followed by a screening comparison to background. These COPCs were selected primarily based on the maximum concentration exceeding the associated Region 3 RBC for residential soil exposure based on a target cancer risk of 1×10^{-6} or a non-cancer HQ of 0.1. These COPCs are retained for further consideration. A qualitative risk evaluation of those chemicals that were screened out is provided in the HHRA.

According to Navy Policy, baseline risk assessments should not be conducted on chemicals that are present at levels less than background chemical levels. In some cases, there may be risks associated with chemical levels below background levels. This risk is outside the scope of the Navy's Environmental Restoration Program, but it should be communicated to our stakeholders. Elevated chemicals that were lower than background levels and screened out due to background considerations in the data evaluation step of the baseline risk assessment should be compared to the appropriate risk-based benchmark concentrations. The results should be documented in the Risk Characterization section of the baseline risk assessment report.

The HHRA presented in the RI Report indicated that higher-than-acceptable risk might occur through future on-site residential exposures to soil. A summary of the risk assessment results is presented in Table 1-1. The pathways that generate the greatest risk are the lifetime resident direct exposure to soil for carcinogens and the child resident direct exposure to soil for non-carcinogens. Therefore, the assumptions used in these scenarios were used to calculate site-specific RBCs. The list of COPCs and associated site-specific RBCs are presented in Tables 2-4 and 2-5 for surface soil and subsurface soil, respectively. The tables also include detection frequency and maximum detected concentrations. A chemical was selected as a COPC requiring further evaluation if its maximum detected concentration

exceeded the RBC for either carcinogenic or non-carcinogenic risk. The site-specific RBCs are based on a risk of 1×10^{-6} for carcinogens and an HQ of 1.0 for non-carcinogens. A check of the cumulative risk from all chemicals left in the soil is performed later in the process to determine if it exceeds 1×10^{-5} for carcinogens and a hazard index (HI) of 1.0.

Essential nutrients were not considered as COPCs, including calcium, chloride, magnesium, potassium, and sodium. In addition, several specific metals (aluminum, cobalt, copper, and iron) were excluded from consideration as COPCs because these substances have only provisional toxicity criteria, based on risk assessment guidance from EPA Region I (EPA, 1999). Therefore, these common minerals/essential nutrients were not considered as inorganic COPCs.

RIDEM-Based COPC Selection

Because the COPC selection in the RI did not consider the Direct Exposure Criteria or the Leachability Criteria from the RIDEM Remediation Regulations, the COPC selection process has been reconsidered. To broaden the list of COPCs, a conservative approach was taken to identify all chemicals detected in the soil as COPCs. These chemicals are listed in Tables 2-6 and 2-7 for surface and subsurface soil, respectively. As with the Risk-Based Selection, essential nutrients were not considered as COPCs, including calcium, chloride, magnesium, potassium, and sodium. Aluminum, cobalt, copper, and iron were also excluded from consideration as COPCs because of the lack of finalized toxicity criteria.

The Remediation Regulations provide the methodology for determining remedial objectives for soil. The soil objectives are broken into two components: Direct Exposure Criteria and Leachability Criteria. The Direct Exposure Criteria can be applied to either residential or industrial/commercial scenarios, and the Leachability Criteria is applied depending on the classification of the underlying groundwater. For the OFFTA site, residential reuse is assumed for the direct exposure route, and the groundwater beneath the site is classified GB. GB groundwater is designated as not suitable for public or private drinking water use.

The Remediation Regulations divide the Direct Exposure Criteria and Leachability Criteria into Method Requirements. Method 1 Soil Objectives are published in tables in the regulation, and site concentrations are compared directly to these numbers. If no Method 1 Soil Objective has been promulgated for a specific chemical, then a Method 2 Soil Objective is calculated for the site using the prescribed method and assumptions provided in the regulation. For direct exposure, the Method 2 calculations are the same as those for the Method 1, but for the leachability calculations, Method 2 allows for the consideration of limited site-specific information. The regulations also provide for Method

3 objectives, which are calculated using highly site-specific information; however, no Method 3 objectives have been calculated for the OFFTA site.

Many of the chemicals detected at OFFTA have Method 1 Objectives listed in the tables. For those chemicals not listed, Method 2 Direct Exposure Criteria were calculated for use in the screening process. These calculations are presented in Appendix C.

The list of RIDEM-Based COPCs and associated criteria for Residential Direct Exposure and GB Leachability are presented in Tables 2-6 and 2-7 for surface soil and subsurface soil, respectively. The tables also include detection frequency and maximum detected concentrations. Chemicals exceeding either the direct exposure criteria or leachability criteria are retained as COPCs requiring further consideration.

Combined List of COPCs

The screening process resulted in two sets of COPCs (Risk-Based and RIDEM-Based) which are combined to form a comprehensive list of COPCs requiring further consideration. Table 2-8 presents the combined list and a summary of the selection.

2.2.2.2 Development of Preliminary Remediation Goals for Soil

PRGs are developed to determine the degree of remediation necessary to protect human health and the environment. PRGs can be developed based on chemical-specific ARARs, when available, or risk-based factors. The PRGs must be protective of each of the principal receptors identified at the site (future residents for the soil at OFFTA), and they should be reasonable and practical to implement.

As with the selection of COPCs, PRGs were developed using both a risk-based approach and a RIDEM-based approach. In addition, chemical-specific ARARs and TBCs, inorganic background concentrations, and analytical detection limits are considered in developing PRGs. Each of these methods used in developing the PRGs is discussed below. Table 2-9 presents the candidate list of PRG numerical values identified for each COPC in soil requiring further consideration.

Risk-Based PRGs: The RBCs calculated for the risk-based COPC selection were used as the risk-based PRGs. PRGs for carcinogens were based on a risk of 1×10^{-6} for carcinogens and an HQ of 1.0 for non-carcinogens, with the more conservative of the two being chosen as the risk-based PRG.

RIDEM-Based PRGs: The lower of the Residential Direct Exposure Criteria and GB Leachability Criteria was used as the RIDEM-based PRG for each chemical.

Chemical-Specific ARARs/TBCs: Candidate PRGs for three chemicals are determined by guidance and TBCs. These chemicals are Aroclor-1254, lead, and 2,3,7,8-TCDD. EPA's OSWER Directive 9355.4-01, *A Guide on Remedial Actions at Superfund Sites with PCB Contamination* (August 1990) recommends an acceptable soil action level of 1 mg/kg PCBs for residential sites. For lead, a value of 400 mg/kg has been established for residential areas based on the Lead-Uptake/Bio-Kinetic Model, Version 0.4, developed by EPA's Office of Health and Environmental Assessment. OSWER Directive 9200.4-26, *Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites* (April 13, 1998) provides guidance in establishing cleanup levels for dioxins. A concentration of 1 µg/kg of dioxins (as 2,3,7,8-TCDD TE) has been established for soil involving future residential exposure scenarios.

Background Concentrations: Because they are naturally present in soil, some inorganics may be present in the background areas not affected by past site activities or releases at concentrations higher than risk-based PRGs or RIDEM remediation standards. Because it may not be reasonable or possible to remediate the site soil to concentrations lower than levels naturally present in the area soil, background concentrations may be considered as PRGs for inorganic contaminants. The background concentration values (95 percent upper tolerance levels), based on data from undisturbed locations on Coasters Harbor Island sampled during February 2000 for the Background Soil Investigation Report (TtNUS, 2000), were calculated and are included in Table 2-9. The background concentration value for arsenic was calculated by RIDEM and is based on the same dataset.

In the background study conducted by the Navy to establish background levels for metals in soils at the OFFTA site, surface and subsurface soil samples were collected from areas at the south end of Coasters Harbor Island determined to be unaffected by the site or by other non-uniformly distributed anthropogenic sources. The areas selected for background sampling all had the same USDA soil classification as those at the OFFTA site (Udorthents-Urban Land Complex). Data analysis and statistical testing were then performed on validated data to determine appropriate background metals values for the site.

In general, the Navy's background study showed that background metals concentrations are higher in the subsurface soils than in the surface soils. The calculated background values for two metals in surface soil (arsenic and beryllium) and three metals in subsurface soil (arsenic, beryllium, and manganese) exceed the RIDEM Direct Exposure Criteria. The calculated arsenic background [upper tolerance limit (UTL)] value for subsurface soil (42.8 mg/kg) is considerably higher than both the calculated surface soil background value (5.55 mg/kg) and the RIDEM soil criteria for arsenic (1.7 mg/kg). The elevated metals concentrations in the Coasters Harbor Island soils are believed to be attributable to the composition of

the local and regional bedrock formations and the shallow depth of bedrock and glacial till in the area (TtNUS, 2000).

RIDEM performed a separate statistical evaluation of the background data and developed a combined surface and subsurface arsenic level of 6.2 mg/kg (Kulpa, 2000; Kulpa, 2001). Although RIDEM provided a discussion of their statistical approach which included combining the surface and subsurface soil data sets and in deleting higher values from the background data set, RIDEM did not provide supporting calculations.

The Navy did not agree with RIDEM's approach. As discussed above, the Navy's evaluation shows that there is a significant difference between the surface and subsurface metal data sets, and a higher background value for arsenic in subsurface soils is supported by the analysis. Despite these objections, to maintain progress in the OFFTA site remediation the Navy accepted RIDEM's arsenic soil background level of 6.2 mg/kg as a proposed PRG for OFFTA surface and subsurface soils (Shafer, 2001).

Detection Limits: The analytical detection limits for the organic and inorganic chemicals were also considered in developing the PRGs. Because the PRGs have to be detectable by current analytical means to ascertain attainment of these levels, analytical detection limits were designated as the lowest achievable PRGs. Two chemicals, benzo(a)pyrene and dibenz(a,h)anthracene, are controlled by quantitation limits, as footnoted in the RIDEM Method 1 Direct Exposure tables.

After consideration of the above criteria, Table 2-9 presents the proposed soil PRGs and the basis for their selection. The proposed PRGs are the chemical concentrations that would provide the highest level of protection of human health given the nature of the site, the availability of a regulatory standard, and is reasonably achievable by current remediation techniques. The PRG values in Table 2-9 indicate that RIDEM remediation standards are, in general, more conservative than the risk-based standards.

One additional criterion of the RIDEM Remediation Regulations must be checked to ensure that the selected PRGs are protective of human health. As part of the RIDEM remedial objectives, the cumulative excess lifetime cancer risk posed by the contaminated site must not exceed 1×10^{-5}, and the cumulative HI posed by the site must not exceed 1 for any target organ. This check will be performed after the COCs are selected.

2.2.2.3 Identification of Chemicals of Concern in Soil

COCs serve to focus the RAOs to those contaminants that pose a potential threat to human health or the environment. For each soil COPC retained for further consideration, the maximum detected

concentration is compared with its PRG. Any chemical with an exceedance is retained as a COC. Table 2-10 presents such a comparison and lists the chemicals retained as COCs. For each COC, all detected concentrations are compared with the corresponding PRG to delineate the extent of contamination requiring remediation. Tables 2-11 and 2-12 present the list of COCs and PRG exceedances for surface soil and subsurface soil, respectively.

Because the PRGs for carcinogens were developed using a risk of 1×10^{-6} for each individual chemical, the risk due to COCs at the site will be beneath the 1×10^{-5} level as long as there are less than 10 chemicals contributing that level of risk at a given location. By reviewing Tables 2-11 and 2-12 which list the PRG exceedances, only two samples have more than 10 COCs. However, these samples, MW102 and TP3, do not contain more than 10 *carcinogenic* COCs. Therefore, the selected PRGs are consistent with the site's meeting the 1×10^{-5} risk level. The HHRA presented in the RI was used to check the requirement that the cumulative HI not exceed 1 for any target organ. The risk assessment identifies no exposure scenario in which the HI exceeds 1, indicating compliance even if no remediation takes place at the site. Therefore, no adjustments are required for the soil PRGs.

2.2.2.4 Remedial Action Objectives for Soil

RAOs consist of medium-specific or operable unit-specific goals for protecting human health and the environment. The objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited.

The findings of the RI and HHRA and the RIDEM Remediation Regulations were used in developing the RAOs for contaminated soil. As presented in the RI, the estimated risks associated with ingestion of and dermal contact with site soil by future adult and child residents exceed RIDEM’s target incremental lifetime cancer risk (ILCR) of 1×10^{-5}. Contaminants in the soil also exceed RIDEM's direct exposure criteria and GB leachability criteria (leachability for TPH only in seven samples). The soil contamination also exceeds EPA guidelines for lead. Therefore, long-term soil response actions are necessary to protect human health and groundwater quality.

Future use of the site can also be considered in the formulation of RAOs. The Navy has indicated that the OFFTA site should be available for unrestricted, residential use after the remedial action has taken place. Further, the Navy wishes the time duration of remediation to be as short as possible, to allow redevelopment of the site in a timely manner.

The soil RAOs for protection of human health are:

- Prevent the ingestion of and direct contact with vadose zone soil containing contaminants that exceed PRGs developed for the OFFTA site.

- Allow reuse of the site as an unrestricted, residential area as soon as reasonably practicable. Part of the unrestricted use includes no controls on the vadose zone soil.

To achieve the unrestricted use of the property, any soils below the vadose zone that are found to be contaminated during remedial actions will be addressed with the vadose zone soils.

The soil RAO for the protection of the environment is:

- Prevent, to the extent practicable, any transfer of contaminants from soils to groundwater or sediment.

Because petroleum is excluded from CERCLA based actions, TPH and free product are not identified in this FS report as COCs, and cleanup criteria are not established for those contaminants. However, it is anticipated that because of the goal to have unrestricted use of the property, soils with these contaminants will be addressed during the remedial action to meet that goal.

2.2.3 Medium of Concern: Groundwater

The following subsections present the identification of the COPCs, development of PRGs, identification of COCs, and formulation of RAOs for groundwater.

2.2.3.1 Identification of Chemicals of Potential Concern in Groundwater

COPCs for groundwater are identified in the Groundwater Risk Evaluation (TtNUS, 2002a) (see Appendix B). These COPCs were selected primarily based on the maximum concentration exceeding the associated RBC based on a target cancer risk of 1×10^{-6} or a non-cancer HQ of 0.1. The groundwater RBCs used for comparison were obtained from the latest EPA Region 9 listing for residential groundwater us (with RBCs based on non-cancer effects adjusted from an HQ of 1.0 to an HQ of 0.1 to protect against the possibility of additive toxic effects from multiple chemicals).

Essential nutrients were not considered as COPCs, including calcium, chloride, magnesium, potassium, and sodium. In addition, several other metals (aluminum, cobalt, copper, and iron) have only provisional toxicity criteria, based on risk assessment guidance from EPA Region I (EPA, 1999). For groundwater,

this latter group of metals was retained as COPCs for illustration to document cases in which a current lack of knowledge regarding toxicity adds uncertainty to the risk evaluation.

2.2.3.2 Development of Preliminary Remediation Goals for Groundwater

PRGs are developed to determine the degree of remediation necessary to protect human health and the environment. PRGs can be developed based on chemical-specific ARARs, when available, or risk-based factors.

The selected groundwater COPCs were carried forward into the PRG development process. For any COPC with an available Federal MCL or RIDEM Groundwater Objective, the lower of those two criteria was used as the PRG. Although the groundwater at OFFTA is classified as GB, the RIDEM Method 1 GA Groundwater Objectives were used for the comparison, because there are GB objectives for volatiles only. For chemicals without available MCLs or state criteria, a risk-based PRG was used if available. All of the chemicals without MCLs or state criteria but with risk information were non-carcinogens, and the PRGs are based on an HQ of 1.0 for a child resident. Three chemicals (aluminum, cobalt, and iron) remain with no data, and therefore no PRGs are developed for them. All were carried forward as COPCs for the purpose of the risk assessment to document its uncertainty.

Table 2-13 presents the proposed groundwater PRGs and the basis for their selection.

2.2.3.3 Identification of Chemicals of Concern in Groundwater

For each COPC, the maximum detected concentration is compared with its PRG. The data set used for comparison is the same as used in the Groundwater Risk Evaluation, which consists of the 1997 low-flow sampling data. Any chemical with an exeedence of a PRG is retained as a COC. Table 2-14 presents the comparison and lists the chemicals retained as COCs. For each COC, all detected concentrations are compared with the corresponding PRG to delineate the extent of contamination requiring remediation. Table 2-15 presents the COCs and PRG exceedences for groundwater.

COCs include several fuel related organic compounds and two metals, lead and manganese. Manganese exceeds the risk based criteria of 291 in several of the on site wells, although the source of this metal is unknown. Lead can be a product of painted structures that were present and have been reduced to rubble and covered at the site, or partly a product of gasoline used at the site in the past. The other organic compounds identified as COCs are likely related to fuels present, or as a product of combustion. Distribution of COCs exceeding the PRGs is presented on Figure 2-4. As shown on this

figure, many of the wells only show an exceedance for manganese. Only two wells show an exceedance for the fuel related organic compounds.

2.2.3.4 Remedial Action Objectives for Groundwater

The findings of the RI and the Groundwater Risk Evaluation were used to develop the RAOs for contaminated groundwater. As presented previously, the estimated risks associated with residential use of site groundwater by future adult and child receptors exceed the EPA's acceptable risk range. The groundwater concentrations also exceed some federal MCLs, though they do not apply to the site. While a remedial action to address the soil at the site may remove the source of the contamination, residuals will remain in the aquifer and will continue to degrade groundwater in the long term. Therefore, long-term groundwater response actions are necessary to protect human health and protect groundwater quality.

The groundwater RAOs for protection of human health are:

- Prevent the ingestion of and direct contact with groundwater containing contaminants that exceed federal MCLs, or in their absence, state criteria or an excess cancer level of 1×10^{-6} or an HQ of 1.0.

- Allow reuse of the site as an unrestricted, residential area as soon as reasonably practicable.

The groundwater RAOs for protection of the environment are:

- Assure groundwater quality is not further degraded.

- Assure off-site migration of groundwater does not impact remediated soil or sediment.

2.2.4 <u>Medium of Concern: Sediment</u>

The following subsections present the identification of the COPCs, development of PRGs, identification of COCs, and formulation of RAOs for sediment. For the purposes of this report, sediments are defined as any unconsolidated materials north, west, or east of the high tide line at the OFFTA site.

2.2.4.1 Identification of Chemicals of Potential Concern in Sediment

The sediment COPCs are those chemicals that were found to present increased incremental human health or ecological risks. A summary of the risk assessment results is presented in Section 1.0. Sediment contaminants that pose excess human carcinogenic risk greater than 1×10^{-6} or have chemical-specific hazard quotients greater than 1.0 for human non-cancer risk are selected as COPCs for sediment. Sediment was found to pose cancer risks through direct contact to human recreational receptors above the target level. The chemicals exceeding are arsenic, benzo(a)pyrene, benzo(a)anthracene, benzo(k)fluoranthene, and dibenz(a,h)anthracene. Increased risk was also noted via human ingestion of shellfish. Those contaminants that posed excess risk for shellfish ingestion were dominated by arsenic, but included the same chemicals as for direct exposure, as well as indeno(1,2,3-cd)pyrene, PCBs, cadmium, chromium, and mercury. All of these chemicals are selected as COPCs for shellfish ingestion.

Note that the risk described in Section 1.0 reflects risk calculated for shellfish ingestion based on the inorganic form of arsenic. This is an overly conservative assumption, considering that it has been documented that arsenic in shellfish is 80 to 90 percent organic, which is not toxic (FDA, 1993). Therefore, while arsenic contributes to elevated risk, risk managers should consider arsenic as only a secondary contributor in this scenario. .

Sediment COPCs were also selected based on the ERA (SAIC, 2000). The COPCs identified as posing potential increased risk for ecological receptors as well as those selected based on human health risk are presented in Table 2-16.

2.2.4.2 Development of Preliminary Remediation Goals for Sediment

The objective of the PRG development process is to select contaminants of concern (COCs) from the contaminants of potential concern (COPCs) and to calculate corresponding actionable contaminant concentrations that, when implemented as cleanup criteria, will address the areas of unacceptable human health and/or ecological risk. The PRGs must be protective of each of the principal receptors identified at the site (humans and aquatic organisms) and should be reasonable and practical to implement. The complete sediment PRG development process for this site is presented in Appendix D. This section presents a summary of that process and the recommended PRGs.

At the OFFTA site, actionable risk was estimated and calculated in the RI Report and supporting documents for sediment under the following receptor scenarios:

- Human lifetime resident exposure to beach sediment (also referred to as shoreline sediment or inter-tidal sediment)
- Subsistence and lifetime shellfish ingestion
- Ecological risk associated with contaminants in the intertidal, nearshore, and offshore marine sediment

To establish cleanup goals for these three receptor scenarios, PRGs have been developed for each scenario separately and applied to the exposure areas described below. Where PRGs overlap, the more conservative will apply. For the purposes of this PRG approach and for the FS, the following clarifications are made:

Beach Sediment – Intertidal or shoreline area between mean high tide and mean low tide, partially represented by sampling stations SSD-333 through SSD-337.. Samples were collected and used for human health risk (shoreline visitor scenario) only. Shellfish selected for testing were not present in this area, although some oysters were present in the intertidal area. Data available include bulk chemistry.

Nearshore Marine Sediment – Area along the low-tide line (represented by sampling stations OFF-1 through OFF-7). Data available include bulk sediment chemistry, some shellfish, and porewater. Samples were collected for ecological risk, but shellfish data were also used for human health risk evaluation under shellfish ingestion scenarios.

Offshore Marine Sediment – Area further beyond the low-tide line than the nearshore area (partially represented by sampling stations OFF-8 through OFF-21). Data available include bulk sediment chemistry, fish, shellfish, benthic diversity, elutriate, toxicity, and porewater. Samples were collected for ecological risk, but shellfish data were also used for human health risk evaluation under shellfish ingestion scenarios.

PRGs have been developed for the three exposure pathways for sediment contaminant transfer: human lifetime recreational exposure to beach sediment, shellfish consumption, and ecological risk. The methodology for each of these is summarized below. Appendix D of this report provides detail for development and selection of PRGs. Calculated PRG values are presented in Table 2-17.

Sediment PRGs Based on Human Lifetime Resident Exposure to Beach Sediment

Evaluation of risks presented in the OFFTA RI for beach sediment indicates that cancer risks exceeded the state guideline of 1×10^{-5} although cancer and non cancer risks did not exceed the EPA target risk range of cancer exceeding 1×10^{-4} and a noncancer HI of 1.0 for a target organ.

PRGs are back-calculated from the target risk for the lifetime resident exposure to sediment for contaminants that exceed a contaminant specific risk of 1×10^{-6} in the RI Report. These contaminants include arsenic, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. PRGs are developed for site-specific contaminants targeted to the 1×10^{-6} risk level to ensure total cancer risks are less than the RIDEM criteria of 1×10^{-5}. The risk-based PRG for arsenic is compared to the background arsenic level (6.2 mg/kg) to assure that the final PRG is not below background. Calculated PRGs for this scenario are presented on Table 2-17.

Note that RIDEM direct exposure criteria for soils do not apply to sediments, as these materials are under water for approximately 12 hours per 24 hour day. The presence of water reduces the potential for exposure which presumably, were used to determine the direct exposure criteria.

Sediment PRGs Based on Shellfish Consumption

Evaluation of risks presented in the OFFTA RI for shellfish ingestion indicates that cancer risks to recreational fishermen exceeded 1×10^{-5} for arsenic and to subsistence fishermen for arsenic, PCBs, benzo(a)pyrene, and benzo(b)fluoranthene.

Subsistence fishing is typically evaluated as a matter of course in the HHRA process. However, the risk assessment uncertainties explain that the subsistence fisherman scenario does not exist at the site and is unlikely in the foreseeable future. Although the study area is within an area closed to shellfishing, EPA reports that some amount of lobster or crab collection may occur in Coasters Harbor which validates the recreational fishing scenario and indicates a need to address this risk endpoint.

In order to address the risk associated with shellfish collections from this area, PRGs are developed for shellfish ingestion. Contaminants that were predicted in the RI Report to provide a cancer risk of 1×10^{-6} and/or an HQ of 1.0 under the subsistence fishing/ingestion of lobster and shellfish scenario are selected as COPCs. This scenario/endpoint was particularly selected because it provided the highest risk and the largest list of COPCs.

The risk assessment notes that arsenic dominates the risk under the shellfish ingestion scenarios. This is likely because arsenic risks from shellfish are based on EPA's slope factor, accepted for inorganic forms of arsenic in the environment. However, arsenic in seafood actually exists in an organic state known as arsenobetaine. Approximately 80 to 90 percent of the arsenic in seafood is not toxic (FDA, 1993). To adjust for this overestimate provided in the risk assessment, the equation for target arsenic concentrations in the shellfish tissue includes a 10 percent adjustment factor before sediment PRG calculation.

The target tissue concentrations for shellfish are back-calculated using the equations and ingestion rates for recreational exposure to tissue concentrations presented in the RI Report. These tissue concentrations are then converted to sediment concentrations using average Bioaccumulation Factors (BAFs) and Biota-Sediment Accumulation Factors (BSAFs) from co-located shellfish/sediment sampling stations to yield an estimate of the total organic carbon (TOC)-normalized sediment COPC concentration. BAFs are coefficients used to predict metals accumulation in animal tissues from each station. BSAFs are the coefficients used to predict accumulation of organic chemicals in tissues. For this site, both types of coefficients were calculated in the ERA using station-specific data normalized for TOC and lipid content as appropriate.

The shellfish tissue COPC concentration corresponding to a target cancer risk of 1×10^{-6} and/or HQ of 1.0 for the lifetime recreational fishing scenario is divided by the average BSAF, and the resulting values are adopted as the human-health based PRG for offshore sediment. Since there are only ten COPCs for shellfish ingestion, this approach ensures that the aggregate cancer risk from all COCs combined will not exceed 1×10^{-5}.

Conversion of tissue PRGs to sediment PRGs is performed using BAF (metals) and BSAF (organics). Calculations for sediment/ tissue PRG conversions are described below:

For metals, the BAF = median across all sampling locations of the ratio:

- (Tissue Conc. at location / Sediment Conc. at location)

For organics, the BSAF = median across all sampling locations of the ratio:

- (Tissue Conc. (dry wt.) at location / Lipid Conc. at location) / (Sediment Conc. at location / TOC Conc. at location)

Note that sediment data are in dry weight units and tissue data are in dry weight units for the BSAF and BAF values to be meaningful. This requires that the tissue toxicity effects value (TEV) be converted to a dry weight value as follows:

- tissue TEV (dry wt.) = tissue TEV (wet wt.) * 100 / (average % moisture of tissue samples)

The human health sediment PRG is then calculated as follows:

- human health sediment PRG for metals = tissue TEV (dry wt.) / BAF

- human health sediment PRG for organics = [average TOC conc * tissue TEV (dry wt.) / average tissue lipid conc.] / [BSAF]

Appendix D provides complete descriptions of the input and resulting values as well as the calculations described above. Calculated PRGs were evaluated through a risk management effort, as summarized below.

Nearshore and offshore sediment PRGs based on lifetime recreational ingestion of shellfish were calculated for arsenic, cadmium, chromium, mercury, PCBs, and five PAH compounds. PRGs for PCBs were not exceeded at the site. Only one calculated shellfish PRG for a PAH was exceeded at one offshore station, Benzo(a) pyrene (PRG of 9360 ug/kg) exceeded at SD-410 (9500 ug/kg detected). This location is within the eelgrass bed and appears to be a local hot spot that may be more associated with a nearby outfall than with the site. Also, the concentration detected is so close to the calculated PRG value, the concentrations at and near this station should be verified through additional sampling during future PDI efforts before being considered implementable.

Calculated shellfish PRGs for metals were not exceeded at the site with the exception of arsenic. The PRG for arsenic correlating to a cancer risk of 1E-6 was calculated to be 5.48 mg/kg. This value was exceeded at several offshore sample stations, and two nearshore sample stations. The locations where arsenic was exceeded did not match those where PAHs were exceeded, and did not seem to have any spatial pattern at all (Figure 4-1, Appendix D).

Data review indicates that arsenic levels exceed the 5.48 mg/kg value at OFF-1 (6.3 mg/kg), OFF-2 (8.0 mg/kg), OFF-7 (6.8 mg/kg), OFF-13 (6.0 mg/kg), OFF-14 (8.5 mg/kg), and 0FF-19 (5.8 mg/kg), as well as several offshore predesign stations. Arsenic concentrations range from 3.6 mg/kg to 4.3 mg/kg at stations where other PAH PRGs are exceeded, confirming no co-location.

The value of 5.48 mg/kg calculated for arsenic exposure through lobster ingestion is below the value established to account for what appears to be anthropogenic occurrence of arsenic in soils. The arsenic concentrations in surface sediment sampled at the site (those sediments to which lobsters could be exposed) range from 2.7 mg/kg to 8.5 mg/kg with an average concentration of 4.97 mg/kg.

Uncertainties in the model predicting contaminant loading to the receptor also need to be considered. In addition to predicting the uptake of contaminants by persons ingesting the lobster, the shellfish PRGs are also based on predicting the uptake of the contaminants by the lobsters collected and providing those contaminants in a toxic and bioavailable form to the persons ingesting them.

Therefore the arsenic PRG calculated for the ingestion of shellfish is not recommended for implementation. The data distribution does not support the conceptual site model, does not match site related contaminant distribution, and there is too much uncertainty in the models predicting the ability of arsenic to transfer from the sediment to the shellfish and then from the shellfish to the human receptor in its toxic form.

Table 2-17 presents the recommended PRG values for the shellfish ingestion scenario.

Sediment PRGs Based on Ecological Risk

Evaluation of the risks presented in the ERA for the OFFTA site indicate that high potential for risk to ecological receptors is present at one nearshore sediment station (correlated exposure and effects relationships identified) and that an intermediate potential for risk to ecological receptors is present at eight other stations (exposure and/or effects measured). These risks are likely present due primarily to PAHs and, to a lesser degree, metals in sediment. However, the metals in the sediment are unlikely to be toxic, based on the simultaneous extracted metal and acid volatile sulfides (SEM-AVS) data.

EPA has developed Draft Sediment Guidelines for six metals (cadmium, copper, lead, nickel, silver, and zinc) (EPA, 2001). Appendix D of this report details how these guidelines are applied to the site sediment data. The basic premise of the SEM-AVS guideline is that if there is more AVS than SEM (on a molar basis) in a sample, than the AVS will bind the six metals and they will not be toxic (EPA, 2000). The following equation is used to represent this process:

$$\sum \text{SEM} - \text{AVS} \leq 1.0 = \text{non-toxic sediment from the SEM metals}$$

Appendix D summarizes the SEM-AVS results for each station and the sediment concentrations for the metals that are included in the SEM analysis. These results indicate high AVS in sediment at the site, indicating no toxic effects from the metals present. Note that although silver was not included in the SEM analysis, when AVS is present, any silver in the sediment is not of toxicological concern, and none should occur in the interstitial water (EPA, 2000). For the OFFTA site, PRGs are not calculated for the six SEM metals (cadmium, copper, lead, nickel, silver, and zinc) because none of these metals is expected to cause toxicity.

The following steps are used in the PRG process to calculate the Ecological Risk-Based PRGs:

Step 1: Identify the water quality screening value (WQSV) that will be used for comparison to the porewater concentrations.

Step 2: Determine the porewater concentrations for the sediment samples.

Step 3: Classify the toxicity test samples at each station as toxic or non-toxic.

Step 4: Group the samples as toxic or non-toxic for each receptor. Do not include the reference stations in these groupings.

Step 5: Summarize the results of the toxic and non-toxic samples using site-specific toxicity data to determine a No Observed Effects Concentration (NOEC).

Step 6: Compare the NOEC (in Step 5) to the Reference Station porewater concentration (RSV) to ensure that the PRGs will not be below the reference concentrations.

Step 7: Divide the porewater concentrations by the TEVs at each station (except the reference stations) to get the TEV-Hazard Quotient (TEV-HQ) to limit the number of chemicals for which PRGs are developed to the chemicals that are causing the highest risk at each station.

Step 8: Calculate and develop the sediment baseline PRG:

$$PRG = Cs * (TEV) / (PW)$$

Where:

TEV	=	Toxicity Effects Value (µg/L)
Cs	=	Chemical concentration in the sediment (µg/kg)
PW	=	Porewater concentration for the chemical (µg/L)

The final step of the PRG development process for sediment is to define recommended PRG values from the baseline PRGs calculated. This is typically done to rectify the resulting action areas to the areas of the site where elevated potential for risk was determined in the ERA. At this site, contaminant concentrations exceeding the calculated PRGs are limited to the nearshore area and center on station OFF-5. OFF-5 is the only station where high probability for ecological risk was identified in the risk

assessment report (SAIC, 2000). Therefore, this step does not appear necessary, and the calculated baseline PRGs are recommended for implementation.

A summary of the sediment PRGs is provided in Table 2-17.

2.2.4.3 Identification of Chemicals of Concern in Sediment

For each sediment COPC retained for further consideration, the maximum detected concentration is compared with its PRG. Any chemical with an exceedance is retained as a COC. Table 2-18 presents such a comparison and lists the chemicals retained as COCs. For each COC, all detected concentrations are compared with the corresponding PRG to delineate the extent of contamination requiring remediation. Table 2-19 presents the list of COCs and PRG exceedances for sediment.

Two PRG exceedances for PAH compounds was noted for the offshore sediment. 2-methylnaphthalene was detected at 210 µg/kg in deep sediment (1.6-1.8 feet below surface) at station OFF-18, located at the former area of a boathouse and bridge noted in Figures 1-5 and 1-6. Surface sediment at this location (0-0.5 feet) is below PRG concentrations, and deeper sediment (3.5-3.6 feet) is also below PRG concentrations. These data indicate the presence of a small pocket of slightly elevated PAHs, with only one exceedance of an OFFTA PRG. Because this small area does not impact surface sediment where bioturbation is expected to occur, and because the location indicates another possible source long since removed, it is not recommended that this area be considered a remedial action area for OFFTA.

A single PRG exceedance for benzo(a)pyrene was noted based on shellfish ingestion at station SD-410. Because this location is in a sensitive habitat, and because the concentrations of PAHs were abnormally high, there was speculation from the sampling team that these contaminants may be a result of storm water outfalls at this location. Therefore, this exceedance requires confirmation during phase 2 predesign investigations. Regardless, this and exceedance of an ecological PRG for a different PAH compound was also present at this station, which indicates the station be considered for remedial action.

2.2.4.4 Remedial Action Objectives for Sediment

RAOs for site sediment were formulated based on the site-specific risk assessments, the RI marine investigations, COC identification, and PRG development presented in the preceding sections. RAOs were identified for different marine portions of the site pertinent to the actionable PRG exceedances.

The RAOs for the sediment address the COC-related risks identified in the HHRA and the marine ERA. In accordance with CERCLA, the RAOs developed for these areas address unacceptable risks to

humans identified in the HHRA and potential risks to aquatic organisms identified in the marine ERA. The RAOs identified for the Coasters Harbor marine sediment are presented below.
The RAOs for the protection of human health are:

- Reduce exposure of contaminants in beach sediment exceeding the selected PRGs to a recreational user.

- Prevent human ingestion of shellfish that are impacted by sediment with actionable COC concentrations exceeding the selected PRGs.

Although PRGs were initially calculated for shellfish ingestion, only two were exceeded by the site conditions. The PRG for arsenic is discounted and considered not actionable because arsenic distribution does not appear to match that of the site model, and because of the uncertainties in the contaminant uptake model. The PRG for Benzo(a)pyrene is barely exceeded at station 410, located within the eelgrass beds on the west of the site. Because this detection is so close to the PRG, and due to the presence of the sensitive habitat present, confirmation testing is required prior to considering this an actionable exceedance.

The RAO for the protection of the ecological receptors and the environment is:

- Provide a remedy that will reduce exposure of aquatic organisms to sediment with COC concentrations exceeding the recommended PRGs.

Locations where sediment PRGs are exceeded for COCs are presented on Figure 2-4.

2.3 ESTIMATION OF AREAS AND VOLUMES

The areas and volumes of soil and sediment to be considered for remediation were estimated based on current data and the PRGs identified in Sections 2.2.2, 2.2.3, and 2.2.4.

2.3.1 Soil

The samples exceeding soil PRGs have been identified on Figure 2-1 along with their corresponding concentrations. Separate indications are made for the surface and subsurface samples that exceed PRGs. Figure 2-2 shows the former location of the OFFTA facility overlaid on samples exceeding PRGs. This indicates the correlation between the old facility and the location of contaminated soil.

Areas and volume estimates for the soil were calculated based on the samples exceeding PRGs listed in the exceedance table. The basis for these volume estimates is presented in Appendix E. The estimation of volume for the soil alternatives was accomplished in two parts: the mounds at the site and the remaining soil below grade. To estimate the volume of the mounds, a contour map was used, and the area between each successive concentric contour line was measured. A base elevation for the surrounding terrain was chosen for each mound, and the volume within each contour was calculated based on its height above the base elevation.

The second volume estimate was performed for the remaining soil below grade, assuming that the mounds were removed to the elevation of the surrounding terrain. The depths of contamination were estimated for different blocks of the site as shown on Figure 2-3. For example, the depth of contamination for a large portion of the western end of the site is estimated at 2 feet, indicated by blue on Figure 2-3. The assigned depth of each block was then multiplied by its area to estimate the volume of each block. The volumes of all blocks were then summed. The areas are presented on the color-coded map in Figure 2-3.

After the volumes were determined, an estimate of the percentages of soil and debris were made. For the mounds, 50 percent of the volume is assumed to be debris. For the remaining parts of the site, 20 percent of the volume was estimated to be debris.

The areas and volumes to be addressed in the FS are as follows:

- The total volume of the mounds is 10,900 cubic yards (cy). The subtotals for each mound are 6,900 cy for the central mound, 3,400 cy for the western mound, and 600 cy for the small, far-western mound.

- The areal extent of contaminated soil is approximately 229,000 square feet (5.3 acres).

- The volume of debris and contaminated soil in the vadose zone (excluding the mounds) is approximately 37,600 cy.

A summary of the volumes is as follows:

Cubic Yards of:	Mounds	Remaining Areas	TOTAL
Debris	5,450	7,520	12,970
Soil	5,450	30,080	35,530
TOTAL	10,900	37,600	48,500

2.3.2 Groundwater

The samples exceeding groundwater PRGs have been identified on Figure 2-4 along with their corresponding concentrations. Figure 2-5 shows the groundwater contours from the 1997 sampling round, which is the most current available.

Because all the wells on the OFFTA site have PRG exceedences, it is assumed that the areal extent of the contamination is the same as the areal extent of soil contamination (229,000 square feet). The volume of groundwater exceeding PRGs is estimated by multiplying the areal extent by the average saturated thickness of 15 feet and multiplying by the estimated porosity of 0.25.

The areas and volumes to be addressed in the FS are as follows:

- The total pore volume of contaminated groundwater is 859,000 cubic feet, or 6.4 million gallons.
- The areal extent of contaminated groundwater is approximately 229,000 square feet (5.3 acres).

2.3.3 Sediment

The areas of concern and the receptors for each area of sediment are presented on Figure 2-4. Areas and volume estimates for these areas are presented below. The basis for these volume estimates is presented in Appendix E.

Sediment samples were collected in three different areas along the shore. Samples SSD-333 through SSD-337 and 411, 412, 413, 432, 414, 417, 442, 445, 439, 424, and 425 were collected along the shoreline in the intertidal area. Samples OFF-1 through OFF-7 as well as numerous 400 series samples were collected from the nearshore marine sediment at and immediately below the low-tide line. The remaining samples, OFF-8 through OFF-23, were collected from offshore marine sediment seaward of the low-tide line.

The areas along the beach (samples SSD-333 through SSD-337 and 411, 412, 413, 432, 414, 417, 442, 445, 439, 424, and 425) are considered areas of concern because those samples exceed human health PRGs. The areas surrounding samples 410, OFF-3, OFF-5, and OFF-6 are also areas of concern based on those samples exceeding ecological PRGs. Sample OFF-18 exceeded PRGs based on ecological risk; however, it is not included as an area of concern because of its isolated location near a former boathouse in Coasters Harbor.

Samples at all stations included a depth interval of 0-0.5 feet. At three locations, 5, 5E and 6, sediment samples were collected to a maximum depth of approximately 3.5 feet. These samples revealed concentrations of COCs above PRGs only within the upper intervals (maximum depth of less than one foot). Therefore a depth of 1 foot has been selected as a conservative target interval for determination of sediment volume for the areas below the low tide line. The depth of the contaminated sediment at the beach area is assumed to be 2 feet and is based on the maximum depth of observed contamination in the beach samples.

Based on currently available data, the areas and volumes to be addressed in the FS are as follows:

- The areas exceeding recreational PRGs were estimated by using phase 1 predesign data that shows all intertidal sediments sampled exceeds these PRGs. The area exceeding the human recreational PRGs is limited to intertidal sediment and is estimated to be approximately 77,171 square feet. The volume is approximately 5,716 cy.

- The areas exceeding ecological PRGs is 17,638 square feet. Of this amount, approximately 7,824 square feet is the area below the low tide line. The volume of sediment below the low tide line is approximately 290 cy, based on a one foot depth interval.

- Areas of eelgrass are present beyond the low-tide line and intersect a small area of the contaminated nearshore sediment. The area of eelgrass in this contaminated zone is approximately 2,039 square feet. The associated volume of the contaminated sediment in the eelgrass beds using a 1-foot depth is 76 cy, based on currently available data. Additional data will be developed to better define this area.

A summary of the areas and volumes is as follows:

Medium	Area (sq. ft)	Volume (cy)
Intertidal (beach) Sediment (between high and low tide)	77,171	5,716
Subtidal Sediment (below low tide), includes eelgrass	7,842	290
Eelgrass only	2,039	76

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Technology identification and screening are important preliminary steps in developing remedial alternatives. In this phase of the FS, potentially applicable technology types and process options are identified. The technologies and process options are then screened by evaluating each with respect to technical implementability, thereby reducing the number considered further. The technologies and process options considered to be implementable are then evaluated in greater detail, and representative options are selected for subsequent development and evaluation of remedial alternatives.

The identification, screening, and evaluation of technology types and process options are summarized below by completing the following steps:

- Developing GRAs for each medium of concern that will satisfy the RAOs.
- Identifying and screening remedial technologies applicable to each general response action.
- Evaluating and selecting representative technology types and process options.

Section 3.1 identifies the GRAs that may be implemented at the site. Section 3.2 discusses the technologies to be considered and provides a preliminary screening to focus the technology types deemed applicable. Section 3.3 presents a discussion of the final evaluation and selection of representative technologies. A summary of the technologies retained for further consideration in site-specific remedial alternatives is provided in Section 3.4.

3.1 GENERAL RESPONSE ACTIONS

General response actions describe categories of actions that could be implemented to satisfy the RAOs for each medium of concern at a site. GRAs may include treatment, containment, excavation, extraction, disposal, institutional controls, or a combination. Typically, in developing remedial alternatives, combinations of GRAs may be identified to fully address all the RAOs.

GRAs identified as applicable for remediating soil, groundwater, and marine sediment at the site include the following:

- No Action
- Limited Action
- Containment

- Removal
- Disposal
- Treatment

These GRAs are summarized below.

3.1.1 No Action

Under the no action option, the site is left ″as is,″ without implementing institutional controls, containment, removal, or treatment. This option, furthermore, does not provide for monitoring or placing access restrictions on contaminated media at the site. However, examination of this option is retained throughout the FS process, as required by the NCP. Although this option requires no remedial action, it provides a baseline against which other GRAs can be evaluated.

3.1.2 Limited Action

The limited action option is comprised primarily of institutional controls and access restrictions that may limit use or access to the site to reduce or eliminate risks of exposure to hazardous materials. Limited actions also include implementing a long-term monitoring program to assess changes in environmental conditions existing at the site. While institutional controls and access restrictions alone do not reduce the toxicity, mobility, or volume of contaminated media through direct means, naturally occurring attenuation processes may reduce contaminant concentrations over an extended period of time. Data generated from long-term monitoring activities would provide information to assist in determining the rate of natural attenuation, as well as the potential migration of COCs from the soil and marine sediment. Monitoring would also provide information on which to base a decision regarding the need to implement additional remedial actions should migration be observed.

3.1.3 Containment

Containment options reduce potential exposure risks through the application of physical means. Physical barriers prevent direct contact with contaminated media as well as managing potential erosion or migration. Barriers may consist of permeable or impermeable caps and may be comprised of natural and/or synthetic materials. Containment may also reduce the mobility of the contaminated media but does not affect toxicity or volume.

Containment of sediment in an underwater, marine environment also involves issues related to settling of the capping material during placement, and both permeability and transmissivity of the cap once in place. The cap must also be designed to withstand erosion forces of tides, waves, and localized currents.

3.1.4 Removal

Removal technologies are used to collect contaminated media from their present locations and move them for subsequent disposal. For soil, removal is typically performed by excavation equipment, such as trackhoes, backhoes, and pan scrapers. For groundwater, removal is typically accomplished by pumping the water to the surface using recovery wells or dewatering trenches. For marine sediment, removal is typically performed by the use of excavation and/or dredging equipment. Removal reduces the volume of contaminated media remaining on site and allows site conditions to attenuate more rapidly than they would under natural conditions.

Removal of marine sediment also involves materials-handling issues related to sediment suspension, sediment dewatering, and residual water treatment/disposal. Sediment dewatering is necessary as a processing step to render the removed material suitable for disposal as a consolidated solid. Residual water generated from dewatering the sediment removed from the marine environment may require treatment prior to direct discharge into Narragansett Bay or disposal at a local publicly owned treatment work (POTW).

3.1.5 Disposal

Disposal technologies are combined with removal and/or treatment technologies to develop alternatives to clean up contaminated media at the site. Depending on the nature of the contaminated media, disposal may include the following options: disposal at an off-base Resource Conservation and Recovery Act (RCRA) Subtitle C/RCRA Subtitle D landfill or treatment, storage, and disposal facility (TSDF); disposal on land at a designated on-site/on-base location; or, for marine sediment, contained aquatic disposal (CAD). Disposal in a properly secured and maintained manner reduces the mobility of the contaminated media.

3.1.6 Treatment

Treatment technologies can be implemented in situ or combined with removal and disposal options. Following removal, contaminated sediment may require treatment to reduce their volume, mobility, and/or toxicity prior to disposal. Treatment options include technology types and process options using thermal,

physical, chemical, and/or biological means. Treatment options include in situ and ex situ processes. Ex situ processes may further include both on-site/on-base and off-base options.

For sediment, in situ treatment options may not be viable, primarily due to the location of the remedial areas within the marine environment. The nature of the contaminants, their relatively low concentrations, and the extremely low PRGs set for the coastal area may further deem in situ options ineffective and inefficient in achieving the RAOs. However, options are identified and evaluated for applicability in Section 3.2.

Ex situ treatment options are included for consideration in combination with off-base disposal options. Based on existing analytical data, marine sediment removed from the site is expected to be of acceptable quality for direct disposal in a RCRA Subtitle D landfill without pretreatment. However, because the available data regarding contaminant concentrations at depth is limited, and sediment has not been sampled for all disposal parameters, contingency has been included for treating a fraction of the materials removed. This contingency includes treating approximately 20 percent of the material from the site area because of elevated concentrations of metals and PAHs. In addition, use of a bulking agent may be necessary for all materials dredged due to the free liquids that may be present.

3.2 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

3.2.1 Preliminary Screening

A variety of technologies and process options exist for each GRA described in Section 3.1. A range of these technology types and process options was identified and screened to focus on relevant technologies and process options. Summaries of the identification and preliminary screening of technologies and process options appropriate for soil are provided in Table 3-1. Many options are eliminated based on technology screening. All options not eliminated due to overall applicability concerns (technical implementability) are retained for a more detailed evaluation in Section 3.2.2.

3.2.2 Evaluation of Technologies and Process Options

In this step, process options considered implementable following preliminary screening are evaluated in greater detail prior to selecting representative process options to use in developing remedial alternatives. One representative process option is selected, if possible, from each technology category to simplify subsequent development and evaluation of alternatives without limiting flexibility during remedy selection or remedial design. The evaluation criteria include effectiveness, implementability, and cost, with a focus on effectiveness. Brief descriptions of the criteria are as follows:

- Effectiveness focuses on the potential ability of a process option to handle the estimated areas or volumes of media, and to meet the remediation goals identified in the RAOs, the potential impacts to human health and the environment during construction and implementation, and the technical reliability (effectiveness of innovative versus well-proven technologies) with respect to the contaminants and conditions at a site.

- Implementability encompasses both the technical and institutional feasibility of implementing a process. The preliminary screening of technology types and process options was based on an evaluation of technical implementability issues in order to eliminate options that were clearly ineffective or unworkable at a site. The subsequent, more detailed, evaluation places greater emphasis on the institutional aspects of implementability [coordination with various regulatory agencies and contractors; the availability of treatment, storage, and disposal services; and the availability of necessary equipment and skilled workers to provide long-term operation and maintenance (O&M) services, etc.].

- Cost plays a limited role in the screening of process options. Options are evaluated based on relative capital and O&M costs (whether the costs are high, medium, or low relative to the other options in the same technology type). At this point in the evaluation, the cost analysis is based on engineering judgment and not on detailed estimates.

A discussion of the screening and detailed evaluation of technology types and process options using these criteria is provided in the following sections.

3.2.2.1 No Action

The no action scenario is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no removal or treatment of the contaminated soil would occur.

Assessment of this option is as follows:

- Effectiveness: The no action option would not achieve any of the remedial objectives. Human health risks associated with exposure to carcinogenic and non-carcinogenic contaminants in the soil could become greater over time as a result of erosion; long-term protection of groundwater would not be provided since the contaminants in the soil would potentially continue to migrate into the groundwater; and re-use of the property would be impeded. Because contaminated soil

would remain on site, 5-year site reviews would be conducted to evaluate the contamination status of the area. Other effectiveness criteria are not applicable for the no action scenario.

- Implementability: No implementability considerations are associated with the no action scenario.

- Cost: Because no actions would be taken other than 5-year reviews of site status, capital and O&M costs would be negligible.

The no action scenario is retained as a baseline, as required by the NCP.

3.2.2.2 Limited Action

The components of limited action that are evaluated in this screening are deed restrictions, fencing, posting of signs, and monitoring.

Deed Restrictions/ Land Use Restrictions

Deed restrictions are institutional controls that are typically placed on property deeds. These restrictions are used to limit future activities or uses of a site to prevent human contact with contaminated soil or groundwater. Deed restrictions commonly used to reduce exposure to contaminated media include prohibitions on installing water supply wells, restrictions on types of development allowed (e.g., no residential use), and limitations on certain types of construction (e.g., excavation, buildings with basements).

The State of Rhode Island requires Environmental Land Usage Restrictions (ELURs) in most cases where contaminants are left in place at concentrations greater than those protective against direct exposure associated with residential land usage. The decision document describes the types of pollutants, location of pollutants, and what activities and uses are prohibited. Any land use controls would be implemented in accordance with the *Department of Defense Guidance on Land Use Controls Associated with Environmental Restoration Activities for Active Installations*, dated January 17, 2001.

When the Navy excesses property through lease or sale, they will do an Environmental Baseline Survey to identify possible hazards associated with that property. Any restriction based on the contaminants present will be identified in the baseline survey for the next occupant. If the land is to be leased, the use restrictions identified in the baseline survey are written into the lease. If the land is sold and released from Navy jurisdiction, the ELUR is written into the new property title and deed.

Any time that the Navy retains the property, the "activity" (in this case Naval Station Newport Public Works Dept.) enforces any land use control necessary, an ELUR is not required, and the RIDEM has no jurisdiction.

If an ELUR is developed, a legal description of the Land Use Controls and a class 1 survey prepared by a surveyor licensed in Rhode Island will be prepared as required by RIDEM Remediation Regulations cited above. The Navy would then request the General Services Administration include a covenant prohibiting residential use of the property should it be transferred outside the federal government so long as the residential standards in soils are exceeded.

In cases where Deed Restrictions or ELURs are placed to address contamination at a site, the responsible party must submit an annual report to the DEM documenting that all of the restrictions are being met. This report must be submitted every year as long as the restrictions remain on the property. The Office of Waste Management will periodically inspect the site to ensure that the provisions of the deed restrictions are being met (RIDEM 4/02).

Assessment of this option is as follows:

- Effectiveness: Deed restrictions could be applied to limit construction activities and future residential or commercial/industrial land use of the area. However, these restrictions do not address the contaminant migration component of the remedial objectives. They are also not effective for ecological receptors. Deed restrictions, by themselves, are not effective in the long term to reduce risk and, therefore, would not achieve the RAOs. No additional risks to human health and the environment would directly result from the imposition of deed restrictions.

- Implementability: Deed restrictions may be implemented by the property owners or by state and local authorities. If property owners are not willing to place the desired restrictions on the property deeds, legal action by state or local authorities would be necessary to implement the deed restrictions. In Rhode Island, deed restrictions are voluntarily placed on the property by the owner.

- Cost: Because only administrative actions would be taken, capital costs would be very low and no O&M costs would be incurred.

Deed restrictions are not effective as a stand-alone action, although they can be used in conjunction with other technologies to restrict future exposure to surface or subsurface contaminants. However, they do

not meet the RAO to allow unrestricted residential use of the site. Therefore, deed restrictions are eliminated from further consideration.

Fencing

Fencing may be used as a barrier to restrict access to areas where contaminants are present at or near the surface, thereby limiting direct contact exposure. Access to the OFFTA, where contaminated soil is present, is currently restricted by fencing.

Assessment of this option is as follows:

- Effectiveness: Fencing would not meet RAOs because it does not reliably prevent access to contaminated soil and would not reduce leaching of contamination to groundwater and surface water. Fencing provides limited protection of human health by discouraging trespasser access to areas where subsurface contamination is present. The effectiveness of fencing in reducing access and thereby reducing exposure to contaminants is highly dependent on fence maintenance and on the determination of the would-be trespasser. Even well-maintained fencing is not likely to be completely effective in restricting access, particularly by a determined trespasser. Fencing would not be effective in the long term to eliminate risk. Fencing would not protect ecological receptors or groundwater nor limit the migration of contaminants from source areas and may impede re-use of the property. No additional risks to human health and the environment would result from the installation of fencing.

- Implementability: Installation of new fencing is readily implementable. Contractors and equipment are readily available for fence installation and maintenance.

- Cost: The capital and O&M costs for fencing would be low.

Fencing is not effective for achieving RAOs because it does not allow unrestricted residential reuse of the site. Fence installation is eliminated from further consideration.

Post Signs

The posting of signs may be used as a means of indicating areas where contaminants are present at or near the surface, thereby preventing direct contact exposure. The OFFTA, where contaminated soil is present beneath the surface, is currently posted with warning signs.

Assessment of this option is as follows:

- Effectiveness: Sign posting would not meet RAOs because it does not reliably prevent access to contaminated soil and would not reduce leaching of contamination to groundwater and surface water. Signs provide only limited protection of human health by discouraging trespasser access to areas where subsurface contamination is present. Signs would not be effective in the long term to eliminate risk, nor would they protect ecological receptors or groundwater nor limit the migration of contaminants from source areas. No additional risks to human health and the environment would result from the installation of signs.

- Implementability: Installation of new signs is readily implementable. Contractors and equipment are readily available for sign installation and maintenance.

- Cost: The capital and O&M costs for posting signs would be low.

Signs are not effective for achieving RAOs because they do not allow unrestricted residential reuse of the site. Sign installation is eliminated from further consideration.

Monitoring

Sampling and analysis of groundwater and soil at the OFFTA could be used to evaluate potential leaching and migration of contaminants from contaminant source areas. Monitoring will be required for any technologies and process options where contaminated soil remains in place.

Assessment of this option is as follows:

- Effectiveness: Monitoring would not reduce the toxicity, mobility, or volume of contaminants in the soil or groundwater. Monitoring would not provide any additional protection to the environment since contaminants could spread into uncontaminated or less contaminated areas. However, by serving as a warning mechanism, periodic monitoring would allow the responsible agency to gauge contaminant migration and determine whether future actions are necessary to mitigate risk. Monitoring will facilitate evaluating the effectiveness of source control measures in preventing contaminant leaching.

- Implementability: A monitoring program could be readily implemented at the OFFTA, using existing monitoring wells. For soil samples, additional borings or hand augers would be necessary.

- Cost: The capital and O&M costs for periodic monitoring would be moderate.

Monitoring would be an effective and easily implementable method of observing contaminant migration and the progress of remediation. Alone, it would provide no additional protection of human health or the environment. Monitoring will be required for any technologies and process options where contaminated soil remains in place. As a result, monitoring will be retained for consideration only in combination with other process options.

3.2.2.3 Containment

The following containment technologies and process options for contaminated soil are evaluated in this section.

- Impermeable Cap
- Permeable Cover

Impermeable Cap

Capping involves installing an impermeable barrier over the contaminated soil to restrict access and reduce infiltration of precipitation into the subsurface. Impermeable and low-permeability barriers are appropriate where soil contamination threatens groundwater or surface water. Regrading of soil prior to capping may be required. Cap materials can either be natural or synthetic. Frequently used materials include low-permeability clays such as bentonite and synthetic membranes such as high-density polyethylene, polyvinyl chloride, and Hypalon. These materials are typically covered with a clean fill and vegetation (grass) or asphalt to protect them against damage caused by puncturing and weathering. Capping will involve regrading to provide for erosion and drainage control.

Assessment of this option is as follows:

- Effectiveness: Capping can achieve RAOs associated with preventing exposure to contaminated soil and minimizing the migration of contaminants from the site, although it would not meet the RAO of allowing unrestricted residential reuse of the site. Capping is a reliable technology that would reduce risk to human health by providing a barrier between contaminated soil and potential receptors, thus significantly limiting fugitive dust emissions and direct contact with contaminated soil. Capping would be effective in limiting the infiltration of precipitation and consequently the potential leaching of contaminants from unsaturated soil to groundwater. Capping alone would

not prevent potential contaminant leaching to groundwater from saturated soil. Because capping does not eliminate the natural flow of groundwater through the subsurface, any contaminated saturated zone soil would remain a continuing source of contamination to groundwater. Capping only isolates existing contamination, offering no decrease in contaminant levels. Since contaminants remain in place, the long-term effectiveness of capping depends on adequate long-term cap maintenance. During remedial activities, fugitive dust emissions would have to be controlled to minimize effects on human health and the environment. Emissions can be safely and adequately controlled using standard engineering controls such as dust suppressants and enclosures.

- Implementability: The construction of an impermeable cap is readily implementable at the OFFTA. A variety of proven capping materials can be used, including soil, clay soil, geosynthetic membranes, and combinations of these materials. Due to the mounds and grade differential across the OFFTA, significant earthwork may be required to achieve proper slopes for cap stability and surface water runoff control. Remedial activities involving capping are relatively common and can be conducted by many contractors. No permits or other administrative requirements would be necessary for on-site activities. Because the contaminated soil would remain in place, the need for TSDFs is not a concern. However, deed restrictions and ELURs would be required in conjunction with capping to limit the future use of the capped areas or actions that may damage the cap. Long-term groundwater monitoring would also be implemented.

- Cost: The capital costs for conventional cap construction are expected to be moderate. O&M costs are low for an impermeable cap.

Capping with an impermeable barrier would prevent exposure to contaminated soil and minimize migration of source contaminants, but it would also prevent unrestricted residential reuse. It will be eliminated from further consideration because it does not meet the RAO of allowing unrestricted use.

Permeable Cover

Permeable covers and soil caps are lower cost alternatives to conventional caps. Permeable covers and soil caps are placed over contaminated soil to prevent access to surficial and near-surface contaminants. Because they provide little or no reduction in infiltration, they are appropriate for use where direct exposure to contaminated material is to be prevented and contaminant leaching to groundwater is not a concern.

Assessment of this option is as follows:

- Effectiveness: Installation of a permeable cover or soil cap would achieve the RAO for preventing direct exposure to contaminated soil but would not achieve the RAO for protection of the environment, which is to minimize leaching of contaminants to groundwater or the RAO that the site be available for unrestricted residential reuse. A permeable cover or soil cap would not be effective in preventing infiltration or potential leaching of soil to groundwater. Because contaminated soil remains in place, the effectiveness of a permeable cover or soil cap in preventing direct exposure to contaminants depends on adequate cover maintenance.

- Implementability: Construction of a permeable cover or soil cap is readily implementable at the OFFTA. Specialized construction techniques are not required, and qualified contractors and necessary cover materials are readily available. Earthwork requirements would be similar to those described for an impermeable cap. No permits or other administrative requirements would be necessary. Because no off-site activities would be occurring, the need for TSDFs is not a concern. Deed restrictions and ELURs would be required in conjunction with the cover to limit the future use of or intrusion into the covered areas.

- Cost: The capital and O&M costs for a permeable cover are low.

Because a permeable cover or soil cap would not achieve all RAOs, use of a permeable cover or soil cap will be eliminated from further consideration.

3.2.2.4 Removal

The only component of removal that is evaluated in this screening is bulk excavation.

Bulk Excavation

Bulk excavation involves the large-scale removal of soil and debris. Traditional excavation equipment such as hydraulic excavators, scrapers, bulldozers, wheel loaders, and off-road dump trucks are typically used. The excavated material could be loaded onto trucks and hauled to an approved treatment or disposal facility, or could be treated and/or relocated at the site or another location on base. Backfilling open excavations would require the use of clean fill or decontaminated, solidified/stabilized soil.

Assessment of this option is as follows:

- Effectiveness: Bulk excavation would be effective for handling the volume of contaminated soil and noncontaminated debris at the OFFTA. Control of fugitive dust would be required during excavation to protect on-site workers and the surrounding community. Standard engineering controls such as dust suppressants would adequately and safely control airborne contaminants. This technology, combined with subsequent treatment and/or disposal, would be a permanent solution and attain the goals outlined in the RAOs. The quantities of material involved and the types of soil at the study area can be excavated.

- Implementability: Excavation is readily implementable for shallow, easily accessible soil. Deeper soil and saturated soil at or near the water table are somewhat more difficult to excavate. Excavation would most likely be accomplished in a staged approach to minimize adverse conditions. Contractors for this type of excavation are readily available in this area. If excavated materials are disposed of off base, transportation and TSDF requirements must be met.

- Cost: The costs range from moderate for shallow soil to high for deeper, saturated soil.

Removal of contaminated soil by bulk excavation is retained for further evaluation in conjunction with other process options.

3.2.2.5 Disposal

Landfills

Contaminated soil and debris may ultimately be disposed of at a regulated landfill. Depending on the contaminants and their concentrations, the material may or may not require treatment prior to landfilling. The treatment, if necessary, can be part of a process option chosen in the selected remedy or can be provided by the operator of the landfill as part of the disposal service.

The types of landfills considered are hazardous waste landfills and non-hazardous waste landfills. The principal differences between these landfills are the administrative requirements and the design of the cap and base to prevent infiltration and leaching. These two types of landfills are described as follows:

- **Hazardous Waste Landfill**

Hazardous waste landfills are regulated by the landfill and post-closure requirements of RCRA (40 CFR 264 and 265, Subparts G and N), the Toxic Substances Control Act (TSCA) for PCBs, and state and local laws. Among the requirements are foundations, double liner systems, leak detection systems, leachate

collection and treatment systems, capping, post-closure inspections and maintenance of the landfill (30-year period), and post-closure groundwater monitoring (30-year period).

- **Non-hazardous Landfill**

Non-hazardous landfills include municipal waste landfills and construction/demolition waste landfills. Design and operating practices are somewhat similar to hazardous waste landfills; however, the permitting requirements are not as stringent. These landfills may be used for wastes that are not classified as hazardous but may still significantly contaminate groundwater. Among the design and operating requirements are foundations, liner systems, leak detection systems, leachate collection and treatment systems, capping, post-closure inspection and maintenance of the landfill, and post-closure groundwater monitoring.

Hazardous and non-hazardous landfills are currently available off base to accept wastes.

Assessment of this option is as follows:

- Effectiveness: Disposal of soil and debris at a landfill would achieve the RAOs by preventing direct exposure to and the leaching of contaminated soil. Since a significant portion of the soil is contaminated with metals, which are not easily treated, a landfill may be required for ultimate disposal. The options available include a secure hazardous waste landfill and a non-hazardous landfill. The selection of one landfill over another depends on the relative toxicity of the soil and debris, the risks associated with their disposal, and the regulatory requirements. The contaminated soil contains elevated levels of metals and organics.

  Soil containing contaminants restricted under RCRA land disposal restriction (LDR) regulations would have to be treated to acceptable levels prior to landfilling. In addition to these RCRA-mandated LDRs, pre-treatment requirements are typically established by individual landfill operators to comply with their respective permit conditions. The treatment can usually be provided by the operator of the landfill as part of a turnkey package of the disposal service.

  Disposal of hazardous substances would have to comply with the CERCLA Off-site Rule 40 CFR 300.440), which establishes criteria for selecting an appropriate TSDF and prohibits the use of a RCRA facility for off-site management of Superfund hazardous substances if the facility has significant RCRA violations.

A hazardous waste landfill is appropriate for disposal of most contaminated soil, and a non-hazardous landfill may be appropriate for slightly contaminated soil or those that have been treated by a process option.

Landfills should be capable of handling the volumes of contaminated soil and debris from the OFFTA. Landfilling alone would achieve some of the remediation objectives. Because concentrations of leachable metals are present in the site soil, some treatment (either as part of the selected remedy or by the landfill operator) would likely be required prior to landfilling the contaminated soil. Risks to human health and the environment associated with implementing landfilling are considered minor.

- Implementability: Landfill disposal is implementable, although availability of off-base landfill capacity may be limited. For off-base landfill disposal, transportation requirements must be met to transport the various types of wastes from the base. Treatment of the wastes in compliance with RCRA LDRs prior to landfilling may be required for some of the soil. Off-base TSDFs are available to receive this waste, although the high volume of soil and debris from the OFFTA may limit the number of facilities willing to accept the material. Also, no hazardous waste landfills are located in Rhode Island (the closest is Model City, New York). Equipment and resources needed to transport the soil are readily available.

- Cost: For disposal in off-base landfills, the relative capital costs are moderate to high (depending on the distance of transportation of wastes). Disposal in hazardous waste landfills is the most expensive of the landfill options, while disposal in a non-hazardous landfill is less expensive.

Landfilling is an effective containment option for the contaminated soil and is implementable when using existing off-base facilities. As a result, off-base landfill disposal is retained for further consideration.

On-Site Backfill

Treated or clean soil would be used to backfill any excavated areas at the site. If an on-site treatment process is also used in conjunction with excavation, backfilling is accomplished using the treated soil. After the contaminated soil has been treated and certified as being "clean," it is placed back in the excavated areas from which it was removed. If no treatment process is included with the excavation, clean soil would be brought in from off site to use for backfill.

Assessment of this option is as follows:

- Effectiveness: Backfilling is an effective method for disposing of treated soil. Clean, off-site soil could also be effectively used as backfill if no treatment process is used at the site.

- Implementability: Backfilling with treated soil is implementable when used in conjunction with a treatment process. No treatment is necessary if clean backfill is brought in from an off-site location.

- Cost: Backfilling costs are considered to be minimal.

Backfilling with either treated soil or clean, off-site soil is retained for further consideration.

Treatment, Storage, or Disposal Facility

A TSDF is a facility that accepts contaminated material for disposal and provides treatment prior to landfilling, if necessary. A TSDF is similar to a landfill facility other than the treatment aspect; in fact, many landfill operators also operate TSDFs. TSDFs are controlled by regulations contained in 40 CFR Parts 264 and 265. The TSDF and the transporter would be selected during the remedial design phase of the remediation program from an approved list generated by RIDEM.

Several factors should be considered when selecting a TSDF for treatment of hazardous wastes. RCRA permits are likely to be required. Other federal and state hazardous waste permits as well as air quality permits might also be required.

The generator must be careful when choosing a TSDF because some may still be under interim status, which could cause a liability problem. Usually, a facility can accept several types of waste but offers only one waste management technology, such as a secure landfill, solvent extraction, or incineration. References should be checked and validated before choosing a TSDF. Also, a reliable hazardous waste transporter should be chosen.

Assessment of this option is as follows:

- Effectiveness: TSDFs, if operated properly, are effective in treating, storing, and disposing of hazardous wastes.

- Implementability: The TSDF option is implementable. Facilities are available to accept the types and volumes of waste from the OFFTA, although an out-of-state facility would likely be required.

- Cost: Costs for TSDFs are high.

The use of TSDFs is retained for further consideration.

3.2.2.6 Treatment

The following treatment technologies and process options for contaminated soil are evaluated in this section.

- Immobilization
  - Solidification/Stabilization
- Thermal Treatment
  - Incineration
  - Low-Temperature Thermal Stripping
  - Vitrification
- Physical Treatment
  - Soil Flushing
  - Soil Washing
- Chemical Treatment
  - Solvent Extraction
- Biological Treatment
  - Aerobic Biodegradation

Discussion of in situ treatment indicates that treatment takes place in the ground without excavation. Ex situ treatment implies the removal of waste from the ground and transport to a treatment unit either on the site or off base.

Solidification/Stabilization

Solidification/stabilization processes involve mixing excavated contaminated materials with proportional amounts of treatment reagents to physically or chemically decrease the mobility of contaminants in the waste and convert the contaminants to a less soluble, less mobile, or less toxic form. The end product may be a standing monolithic solid or may have a crumbly, soil-like consistency, depending on the amount and type of reagent added. A typical ex situ treatment system consists of a materials feed system, a reaction tank equipped with mixing equipment, and an area for curing. For in situ treatment, the treatment reagent is mixed into the soil using large augers or tilling equipment. The effectiveness of the immobilization process is evaluated by running leaching tests such as the Toxicity Characteristic

Leaching Procedure (TCLP) or the Synthetic Precipitation Leaching Procedure (SPLP) on the treated materials.

Portland cement and pozzolanic (silica-bearing substances) materials such as fly ash are widely used as immobilization reagents because of their ready availability and effectiveness in binding contaminants to minimize leaching. A number of additives have been developed for use with cement and pozzolanic materials to improve the physical characteristics and decrease the leaching losses from the resulting solidified material. In addition to cement and pozzolanic materials, other reagents such as organic polymers, thermoplastic materials, and sorbents are also utilized; however, these materials are less effective in binding the contaminants, and the resultant products are more susceptible to degradation and leaching than materials stabilized with cement or pozzolanic materials.

Solidification/stabilization has reportedly been capable of immobilizing up to 99 percent of inorganic contaminants at some sites, but was not successful at significantly immobilizing organic contaminants (EPA, 1989a). One study indicated that VOCs did not leach from the solidified matrix; however, the study attributed the removal of VOCs in part to volatilization during extraction and mixing (Longest, 1989). Another study found that PCBs were 100 percent immobilized, but also suggested that TCLP results from samples of the soil before treatment indicated no PCB leaching (EPA, 1989b).

Assessment of this option is as follows:

- Effectiveness: Solidification/stabilization processes have been widely demonstrated in full-scale remediation projects to immobilize metals in soil. Cement- and pozzolan-based methods have been effective for immobilizing heavy metals including lead. Additionally, the cured mix can be solidified as a soil-like product that could be more easily placed as fill.

  Immobilizing of organic compounds may be effective in some cases. Data from several bench-scale studies indicate that immobilization of SVOCs, particularly PAHs, is possible. PCB immobilization may be effective, particularly where initial concentrations are low. However, limited test data are available to support this conclusion (EPA, 1990). Solidification/stabilization would likely be effective in immobilizing lead and other metals, even at high concentrations, to prevent their leaching into the groundwater; however, immobilization of all organic contaminants is unlikely, although some reduction in leachability for select organics may occur.

  Solidification should be capable of handling the volume of contaminated soil at the site. The process should be effective in significantly reducing the mobility of the COC metals present in the soil. The treated residual must be tested prior to disposal to ensure that disposal requirements

are met. Implementation should not cause any adverse effects on human health and the environment.

Solidification/stabilization can be performed either ex situ or in situ. However, the ex situ process is more easily controlled and is therefore easier to ensure effective treatment. In situ treatment may prove more difficult to ensure complete mixing of treatment reagents, especially at depth.

- Implementability: Solidification/stabilization is an implementable technology for soil at the site but would require significant staging. The equipment and resources necessary to treat the soil are available, with several vendors capable of performing this work. If treatment is conducted on site, either in situ or ex situ, space is necessary to build or stage treatment equipment; constraints such as meeting TSDF requirements and facility monitoring are also concerns. If the treatment is conducted off base, some facilities are available that would be able to treat this waste. Transportation and TSDF requirements must be met for off-base treatment. If solidification is chosen as a treatment option, it would probably be better implemented in situ at the site due to the large extent of contaminated soil. Also, less effort would be required to stage equipment for in situ treatment than for ex situ treatment.

- Cost: The relative capital and O&M costs are moderate for cement-based solidification/ stabilization methods.

In situ solidification/stabilization is an effective and implementable technology for immobilizing metals in contaminated soil and can provide stabilization for some organics. Ex situ cement-based solidification of the contaminated soil should be effective to immobilize COC metals in the soil but may be difficult to implement; in situ solidification may be more easily implemented but may be less effective. Both in situ and ex situ cement-based solidification are retained for further consideration.

Incineration

Incineration is a thermal oxidation process that uses high-temperature, controlled flame combustion in an enclosed reactor to decompose organics in solids, liquids, and gases. Carbon and hydrogen waste components are converted to carbon dioxide and water, respectively. Chlorine, if present, is mostly converted to hydrochloric acid. Other combustion products are also formed in smaller quantities and may include carbon monoxide, nitrogen oxides, and free chlorine and fluorine. Inorganics are not treated in incineration and, in some situations, the end product may become more toxic due to a concentration effect. Incineration produces a solid stream from the incombustible portion of the original material, which is removed as bottom and fly ash, detoxified soil, and possibly other solid treatment residuals. If a wet

scrubber air pollution control system is used, a liquid waste stream could also be generated. Depending on the original waste stream, process residuals may require further treatment and/or disposal (for example, residuals may need treatment to remove or immobilize metals). The rotary kiln incinerator, which is capable of burning a broad range of hazardous solids, slurries, liquids, and gases, is the most common and versatile type of incinerator. Other types of incinerators capable of treating contaminated soil include the circulating bed, multiple hearth, and infrared incinerators.

Assessment of this option is as follows:

- Effectiveness: Incineration is a highly proven technology to treat wastes containing high concentrations of organics. Incinerators have successfully been demonstrated to destroy refractory compounds such as PCBs as well as other organic contaminants at efficiencies in excess of 99.99 percent. Incineration should be capable of achieving the remediation goals for organics. Incineration does not destroy metals or other inorganics. Metals in the waste matrix will form metal oxides that enter the gas stream or will be concentrated in the treated soil. Treated soil may require additional treatment to remove or immobilize metals prior to disposal. Conventional air pollution control equipment such as scrubbers and baghouse dust filters would be required to remove acid gas and particulates. Air emissions from the incinerator would be monitored closely to ensure that human health and the environment are not adversely affected.

- Implementability: Incineration, whether conducted on or off base, is implementable. The equipment and resources necessary to incinerate soil are available, and several vendors are capable of performing this work. The large volume of contaminated soil at the site may pose logistical problems for incineration; several facilities would likely be needed to treat the large volume. Off-base TSDFs are available that could treat the OFFTA soil. If incineration is conducted off base, transportation requirements would be applicable and the off-base facility would have to meet RCRA permit requirements.
- Cost: The relative capital and O&M costs are high for incineration.

Incineration is an effective option for destroying the organics present in the contaminated soil; however, inorganics would be left untreated. Incineration would require substantial logistics and restrictions due to the large volumes to be treated. Due to the lack of treatment of inorganic contaminants and its high cost, incineration is eliminated from further consideration.

Low-Temperature Thermal Stripping (LTTS)

LTTS is a treatment process that uses heat and physical agitation to volatilize organic contaminants from soil; the resulting vapor stream is subsequently treated to collect or destroy the contaminants. A typical LTTS system consists of a rotary drum thermal processor equipped with heat transfer surfaces, and a vapor treatment system. Direct-fired and indirectly heated systems (generally heated by circulating hot oil) are available. Temperatures used in the thermal processor are contaminant- and matrix-specific, with a range of approximately 150 to 800ºF. Most units incorporate mechanical agitation during treatment to facilitate complete desorption of organics. An induced air flow conveys the volatilized organics through a gas treatment system, such as a carbon adsorption unit, a thermal oxidizer, or a condenser unit. The air stream is then discharged through a stack. LTTS is a well-demonstrated technology for industrial sludge and product drying applications, but its use for remediation of soil is less demonstrated. The process is most effective on VOCs, but units operating at higher temperatures are also capable of treating SVOCs and PCBs.

Assessment of this option is as follows:

- Effectiveness: LTTS should be capable of accommodating the volumes of contaminated soil at the site. LTTS at a relatively high temperature would be expected to achieve the remediation goals for the SVOCs in the soil. Metals would not be addressed by this technology. The effectiveness of LTTS is dependent primarily on the boiling point of the contaminant. For VOCs with relatively low boiling points, nearly complete removal from the soil would be expected at relatively low operating temperatures. Many of the organics present in the contaminated soil, such as PAHs, have much higher boiling points. The upper temperature range for LTTS approaches the lower temperature range for incineration, and some LTTS systems are permitted as incinerators.

- Implementability: LTTS is implementable. The equipment and resources necessary to treat the soil are available, with several vendors capable of performing this work. Rhode Island Air Quality Standards would have to be met. Few, if any, off-base LTTS facilities would be able to accept the soil; therefore, consideration of LTTS is effectively limited to on-site treatment. LTTS, if selected, would likely be included as part of a treatment train of multiple process options due to its ineffectiveness for inorganic contaminants.

- Cost: The relative capital and O&M costs for LTTS are moderate.

LTTS is an effective and implementable technology to remove organics from contaminated soil. LTTS will be retained for further consideration for treating contaminated soil.

Vitrification

Vitrification is a thermal destruction process that immobilizes soil contaminants by converting the contaminated soil to a chemically inert, stable, glass product. In situ vitrification is conducted by applying energy through electrodes inserted around the area to be melted. Wastes are heated to temperatures of 1,350 to 3,000ºF, forming a molten glass and thereby destroying organics and immobilizing metals. Organics in the waste matrix are volatilized, and the resulting gases are oxidized. Metals are retained in the glass which, when cooled, is a stable, non-leachable, vitreous solid. In situ vitrification reduces the volume of the soil column, so clean backfill is placed on top of the solidified mass.

Assessment of this option is as follows:

- Effectiveness: Vitrification is an effective technology to destroy organics and immobilize metals. The vitrification process should be capable of achieving the remediation goals for organics and metals. Using this process, inorganic contaminants would be immobilized while organic contaminants would be destroyed to below clean-up levels. Human health and environmental concerns are similar to those for incineration. Air pollution control equipment would be necessary to remove particulates and acid gases. Vitrification should be reliable with respect to the site contaminants and conditions. Short-term concerns associated with vitrification are the potential risks resulting from volatilization; however, the site soil contains few VOCs.

- Implementability: Vitrification is implementable for site soil, and the equipment and resources necessary to vitrify the soil are commercially available from a few vendors. However, the vitrification process is extremely energy intensive and requires sophisticated machinery and highly trained personnel for operation. Also, it is more difficult to implement and more energy intensive when the water table is high. Application of this technology has been primarily limited to treating radioactive or highly toxic wastes.

- Cost: The relative capital costs are high. Operation costs are also high because of intensive energy usage, although maintenance costs are low.

Vitrification is eliminated from further consideration due to its high costs.

Soil Flushing

Soil flushing is a process that uses a closed loop recirculation system of injection and extraction wells to remove contaminants from the saturated and unsaturated soil. Under soil flushing, water, with or without other additives, is sprayed onto or injected into the soil. Additives are used to increase the mobility of the contaminants. To remove organics, surfactants or alkalis are commonly used. Acids, alkalis, oxidizers, reducing agents, and/or complexing agents are commonly used to remove inorganics. Collection of the flushing agent solvent is an important step. At the collection point, treatment systems such as air stripping or carbon adsorption are then utilized to separate the contaminants from the extracted water. The treated water is recirculated through the system by reinjection into the contaminated soil.

Assessment of this option is as follows:

- Effectiveness: Soil flushing may be effective in treating some of the organic and inorganic contaminants at the site; however, several factors can limit its effectiveness. Of primary concern is the difficulty of treating organics and inorganics simultaneously and the ability to capture mobilized contaminants. Some other effectiveness concerns are the ability to contact all the soil, the ability to separate the contaminants from the flushing agent, and the ability to monitor compliance. The heterogeneity and stratification of the soil make contact with soil and capture of mobilized contaminants uncertain. Additionally, the burdened flushing fluids would likely contain significant concentrations of contaminants in highly mobile forms; a significant threat to human health and the environment might result if the contaminated fluids are not completely captured.

- Implementability: Soil flushing would be difficult to implement at the site. A primary concern is the difficulty of ensuring complete capture of mobilized contaminants and restrictions on underground injection of wastes mandated by state and federal regulations. If treatment of extracted groundwater/flushing fluids is conducted at the site, space is necessary to build or stage treatment equipment. TSDF requirements must be met, and facility monitoring would be required. If soil flushing is chosen, then consideration of capturing the groundwater and recovering the flushed contaminants is critical. Off-base TSDFs may be necessary if residuals such as spent carbon or biomass are generated during treatment of the captured water. The equipment and resources necessary to implement soil flushing are available, and a few vendors are capable of performing this work.

- Cost: The capital and O&M costs of soil flushing are highly dependent on the cost of treating the extracted water. Because of the complex mixture of contaminants in the soil, the cost of implementing soil flushing at the site is likely to be moderate.

Due to several effectiveness and implementability concerns, including a potential risk to human health and the environment, soil flushing will be eliminated from further consideration as a process option.

Soil Washing

Soil washing is an ex situ treatment process that removes contaminants from soil by either dissolving or suspending them in the wash solution (which is later treated by conventional water treatment methods) or by concentrating them into a smaller volume of soil through standard particle size separation techniques. The concept of reducing soil contamination by particle size separation is based on the finding that most organic and inorganic contaminants in soil tend to bind to fine-sized clay and silt particles through surface adsorption. Soil washing relies heavily on this principle of separating highly contaminated fine materials from washed coarse materials to decrease the volume of particles that require treatment.

Soil washing is generally a water-based process; however, chemicals such as surfactants are sometimes added to the wash fluid to enhance removal of specific contaminants. Organic or inorganic compounds can be removed using this process. In the washing process, soil is screened and then scrubbed to break up soil aggregates and liberate fines. The surfaces of the coarse particles are "washed" by abrasive action and by desorption of contaminants upon contact with the washing solution. The contaminated fine particles typically require further treatment. Applicable processes to treat fine particles may include chemical extraction, biodegradation, immobilization, or destruction processes.

Assessment of this option is as follows:

- Effectiveness: Depending on the proportion of coarse and fine materials in the contaminated soil, soil washing can be effective in reducing the volume of material that requires intensive treatment. Soil washing would be effective for removal of both organic and inorganic contaminants from coarse material within the area, minimizing the volume of materials requiring intensive treatment. Contaminants would be concentrated in the relatively smaller fine soil fraction or the wash solution; contaminant extraction from the fine fraction by the soil washing process would likely be incomplete. The fine fraction and wash solution would likely require additional treatment. Effective removal of the contaminants in the site soil may require multiple cycles of treatment.

- Implementability: Soil washing is a proven and reliable technology to remove organic and inorganic contaminants from soil with a relatively small fines fraction. The equipment and resources necessary to treat the soil are available, and several vendors are capable of performing this work. If treatment is conducted at the site, space is necessary to build or stage

treatment equipment; constraints such as meeting TSDF requirements and facility monitoring are also concerns. Few, if any, off-site TSDFs would be able to accept and treat the large volume of contaminated soil from the site. This shortage effectively limits consideration of soil washing technologies to on-base processes.

- Cost: The relative capital and O&M costs are moderate to high.

Soil washing is an effective and implementable technology to remove organics and inorganics from contaminated soil. Soil washing will be retained for further consideration for treating site soil.

Solvent Extraction

Solvent extraction is an ex situ treatment technology that employs a solvent to extract contaminants from soil, sediment, sludge, or wastewater. Extraction of organics is accomplished by various mechanisms including dissolution, formation of an emulsion or soluble chelation product, and chemical reaction. For metal extraction, acidification and chelation are the predominant mechanisms. The selection of the appropriate solvent depends on the chemical and physical properties of the contaminants present. Aqueous solutions including surfactants can be used to enhance removal or emulsification of a wide range of hydrophobic organic compounds. Dilute solutions of acids and bases can remove a wide range of metal ions.

Typical solvent extraction units include countercurrent extraction equipment, a pug mill, or a truck-loaded cement mixer. After contact and mixing, the solvent laden with contaminants is removed from the soil by methods such as centrifugation or filtration. The extraction process results in a cleaned soil and a liquid waste stream that concentrates the extracted contaminants within the recovered solvent.

Contaminants within the waste stream are not destroyed, and the waste stream requires additional treatment or disposal. In many cases, contaminants retained in the solvent can be separated out, and the solvent can be re-used in the extraction process. Depending on the solvents used and the contaminants to be removed, the soil may require supplemental treatment by soil washing or by extraction using additional solvents to target different contaminants.

Assessment of this option is as follows:

- Effectiveness: Solvent extraction is an effective technology to remove a wide range of inorganic and organic contaminants from medium to coarse soil. Commercial processes using secondary and tertiary amines have effectively removed PCBs, VOCs, and SVOCs from contaminated soil.

Acid and alkaline solutions have been used to remove a wide range of metals. The process may have limited effectiveness for the site soil due to the difficulty in formulating a suitable extraction fluid to treat a complex mixture of contaminants. Additionally, the variations in contaminant concentrations and contaminant distribution in the soil may require frequent adjustment or reformulation of the extraction fluid. The removal of metals and organics would likely have to be conducted in stages, using different solvents. A treatability study would likely be required to select the appropriate extraction solutions and determine operating parameters to ascertain whether effective treatment is possible.

- Implementability: Solvent extraction is a widely demonstrated and reliable technology for the treatment of simple waste streams. Several commercial vendors are available that provide solvents to treat a variety of organic and inorganic contaminants. If treatment is conducted on base, space is necessary to build or stage treatment equipment. Few, if any, off-base TSDFs using solvent extraction would be able to accept and treat the large volume of contaminated soil from the site. This shortage effectively limits consideration of extraction technologies to an on-base system.

- Cost: The relative capital and O&M costs of solvent extraction are moderate.

Solvent extraction is an effective and implementable technology to remove organics and inorganics from contaminated soil. Solvent extraction will be retained for further consideration.

Aerobic Biodegradation

Ex situ aerobic biodegradation is a destruction process that uses microorganisms to chemically break down and detoxify organic compounds in the presence of oxygen. The organic compounds are used as energy sources and are metabolized by microorganisms such as bacteria, actinomycetes, and fungi. Biodegradation process residuals are carbon dioxide, water, and biomass. The biomass, which consists mainly of cell protein but also contains partially degraded constituents and intermediate biodegradation products, must be tested and may require additional treatment prior to disposal.

Several types of aerobic biodegradation have been used to treat contaminated soil. The primary ex situ methods are (1) slurrying the waste and treating it in a bioreactor and (2) using standard irrigation and soil mixing techniques to treat the soil directly on land (landfarming) or in an above-ground cell (composting). Landfarming is generally less effective than other ex situ techniques because operating parameters are difficult to control.

Assessment of this option is as follows:

- Effectiveness: The effectiveness of biodegradation is highly dependent on the nature and concentration of the contaminants. In general, aerobic biodegradation of organics is applicable to petroleum hydrocarbons, halogenated and non-halogenated aromatics, phenols, biphenyls, and pesticides (EPA, 1985). It may be less effective for PAHs and residual, weathered petroleum in the site soil. Metals are not destroyed in the process, and high metals concentrations may be toxic to the microorganisms. Aerobic biodegradation may be effective for treating some of the organics in site soil, although it may be difficult to reach PRGs, and the metals present in the soil would not be treated.

- Implementability: The equipment and resources necessary to conduct ex situ biodegradation are readily available, and several vendors are capable of performing this work. Aerobic biodegradation is an implementable technology for the site soil. However, due to the concentrations of difficult-to-degrade contaminants, the throughput capacity of the units is expected to be relatively low for treating the soil. If treatment is conducted on base, space is necessary to build or stage treatment equipment; constraints such as meeting TSDF requirements and facility monitoring are also concerns. If the treatment is conducted off base, few, if any, facilities would be able to treat this waste. Lack of off-base treatment capacity effectively limits consideration of bioremediation to an on-base process.

- Cost: The relative capital and O&M costs are low for in situ and ex situ aerobic biodegradation.

Because of concerns about the effectiveness of this process for site organic contaminants, its inability to treat metals, and the anticipated low throughput capacity for treating the soil, aerobic bioremediation is eliminated from further consideration.

3.2.3 Representative Process Options for Soil

EPA guidance for conducting FSs (EPA, 1988) recommends that one representative process option (RPO) be selected for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. RPOs are selected from the treatment techniques remaining after screening based on effectiveness, implementability, and cost. The RPOs selected provide a basis for developing performance specifications during preliminary design. Although specific process options are selected for alternative development and evaluation, these process options are intended to represent the broader range of process options within a general technology type. The

specific process for implementation of the remedial action may not be selected until the remedial design phase.

Table 3-2 identifies the soil RPO(s) chosen for each technology type. The RAOs specify that the goal of remediation is to restore the site for residential use without any restrictions. In order to meet this requirement, technologies involving containment and/or in situ technologies that require long-term monitoring are not considered, and, therefore, the selected RPOs primarily reflect removal, treatment, and disposal options. No action, low-temperature thermal stripping, soil washing, clean backfilling, and removal to a TSDF have been selected as the RPOs. Excavation is considered as part of the removal and treatment/disposal options.

The no action option consists of undertaking no remedial action at a particular site. Inclusion of the no action alternative is required under CERCLA guidance, and this alternative is used as a baseline consideration in the detailed evaluation or to address sites that do not require any active remediation. No technologies or process options are associated with this RPO.

LTTS was chosen over other treatment processes because of its effectiveness in removing organics at a lower cost. It also has fewer implementation requirements than do the other processes. LTTS uses direct or indirect heating to thermally desorb or volatilize organic contaminants present in soil. LTTS is a proven method that provides immediate results, and the experience resulting from its use at other sites has been positive.

Soil washing was selected as an RPO for ex situ physical/chemical treatment based on its cost effectiveness at removing metals from soil. It also has the ability to treat both organics and inorganics. Solvent extraction is a similar technology, but soil washing is a potentially more versatile technology and is therefore retained as the RPO.

Clean backfilling was chosen as an RPO because it is an effective, low-cost method of disposing of clean, treated soil and the easiest method to fill excavated sites. The source of the backfill material would be treated soil (with chemical concentrations below PRGs) or clean soil from off site. Backfilling would be implemented in conjunction with removal or an ex situ treatment process. If treated soil is used as backfill, verification would be required to confirm that the backfill soil is not contaminated. The backfilled areas would be contoured to the desired grades.

Disposal at a TSDF was also retained as an RPO for the disposal GRA for use either in conjunction with a remediation process that produces residuals that must be disposed of off base or for disposal of

contaminated soil. Use of a TSDF would be a very effective, long-term solution to contaminated soil disposal.

3.3 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

3.3.1 Preliminary Screening

As with the soil technologies, a variety of technologies and process options exist for groundwater for each GRA described in Section 3.1. A range of these technology types and process options was identified and screened to focus on relevant technologies and process options. Summaries of the identification and preliminary screening of technologies and process options appropriate for groundwater are provided in Table 3-3. Many options are eliminated based on technology screening. All options not eliminated due to overall applicability concerns (technical implementability) are retained for a more detailed evaluation in Section 3.3.2.

3.3.2 Evaluation of Technologies and Process Options

In this step, process options considered implementable following preliminary screening are evaluated in greater detail prior to selecting representative process options to use in developing remedial alternatives. One representative process option is selected, if possible, from each technology category to simplify subsequent development and evaluation of alternatives without limiting flexibility during remedy selection or remedial design. The evaluation criteria include effectiveness, implementability, and cost, with a focus on effectiveness. Brief descriptions of the criteria are provided in Section 3.2.2.

A discussion of the screening and detailed evaluation of technology types and process options using these criteria is provided in the following sections.

3.3.2.1 No Action

The no action scenario is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no removal or treatment of the contaminated groundwater would occur.

Assessment of this option is as follows:

- Effectiveness: The option would not be effective in achieving the RAOs for contaminated groundwater. Contaminants would remain and could continue to pose a risk to the environment

and/or human health. Impacted groundwater could migrate off site and discharge into Narragansett Bay.

- Implementability: No implementability considerations are associated with the no action scenario.

- Cost: Because no actions would be taken other than 5-year reviews of site status, capital and O&M costs would be negligible.

The no action scenario is retained as a baseline, as required by the NCP.

3.3.2.2 Limited Action

The components of limited action that are evaluated in this screening are institutional controls and groundwater monitoring.

Institutional Controls

Deed restrictions are institutional controls that restrict future use of land in the event that a property is sold or transferred. These restrictions may limit future activities such as placement of new wells or construction.

Assessment of this option is as follows:

- Effectiveness: Institutional controls could be applied to the OFFTA site to restrict future use of the groundwater beneath the site, thereby reducing the potential risk to human health associated with drinking the contaminated groundwater. Institutional controls would not address the restoration and migration components of the remedial objectives. No additional risks to human health and the environment would directly result from the imposition of institutional controls.

- Implementability: Institutional controls could be implemented by the property owners. If property owners are not willing to place the desired restrictions on the property deeds, legal action by state or local authorities would be necessary to implement the institutional controls.

- Cost: Because only administrative actions would be taken, capital costs would be very low and no O&M costs would be incurred.

Retained for further consideration to ensure restricted exposure to contaminated groundwater during the remediation period.

Groundwater Monitoring

Sampling and analysis of groundwater throughout the area of potential groundwater contamination could be used to evaluate flushing and /or migration of contaminants. Monitoring can also be used to assess the progress of groundwater remediation.

Assessment of this option is as follows:

- Effectiveness: Groundwater monitoring by itself would not reduce the toxicity, mobility, or volume of contaminants in the groundwater. Periodic groundwater monitoring and evaluation of contaminant migration data would allow the responsible agency to anticipate and take action to prevent potential adverse impacts, such as contaminant transport off site. Monitoring would also be helpful in measuring and evaluating the effectiveness of groundwater remediation and source control measures.

- Implementability: A groundwater monitoring program could be readily implemented at the OFFTA site. Access may be required for the installation of new monitoring wells on town, state, or private properties.

- Cost: The capital and O&M costs for periodic groundwater monitoring would be relatively low.

Retained for further consideration. Groundwater monitoring would be an effective and implementable method of observing contaminant migration/flushing and the progress of groundwater remediation.

3.3.2.3 Containment

Hydraulic Containment

The hydraulic containment option would use a pumping well system, composed of a series of wells installed in the overburden and bedrock aquifers, to capture contaminated groundwater for treatment. A hydraulic containment system is identical to an extraction well system; containment and extraction are achieved. The wells used in a groundwater extraction system would be designed and situated to provide optimum efficiency in capturing contaminated groundwater if possible.

Assessment of this option is as follows:

- Effectiveness: The effectiveness of a hydraulic containment system depends largely on the geology and hydrogeology of the aquifers. Aquifer pumping tests would be required for more complete assessment of the local hydrogeology and design of an effective containment system. A properly designed system would effectively control the migration of contaminants in and remove the contaminated groundwater for subsequent treatment and disposal. However, at this site, these wells would be subject to drawing saline water in from the ocean, due to its proximity resulting in more water handling than is practical. Well technology is generally reliable and minimal effects on human health and the environment would be expected during implementation.

- Implementability: Groundwater hydraulic containment using a pumping well system can be readily implemented at the OFFTA site, as has been demonstrated through pumping tests conducted as part of the pre-design effort under the NTCRA. The technology uses readily available equipment and standard techniques and has proven to be effective in similar situations. Implementation of this technology would require long-term operation and maintenance of wells and pumps. Required maintenance may include periodic replacement of mechanical components and well flushing to remove fine-grained material that may clog the wells. Local and/or state permits would be required to install any off-site extraction wells. Access permits and/or property easements may be required to install extraction wells on other private properties.

- Cost: The capital costs for groundwater extraction wells are low. The O&M costs are low to moderate.

A hydraulic containment system should be effective and implementable and is retained for further consideration as a representative method for groundwater containment.

3.3.2.4 Removal

Two collection methods are considered: extraction wells and collection trenches.

Extraction Wells

The extraction well option would use a pumping well system, composed of a series of wells installed in the overburden and bedrock aquifers, to capture contaminated groundwater for treatment. The wells used in a groundwater extraction system would be designed and situated to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater.

Assessment of this option is as follows:

- Effectiveness: The effectiveness of an extraction well system depends largely on the geology and hydrogeology of the aquifers. Pumping tests would be required for more complete assessment of study area hydrogeology and design of an effective extraction system. A properly designed system of extraction wells would effectively remove the contaminated groundwater for subsequent treatment and disposal, although seawater would be drawn in due to the proximity to the ocean. Extraction well technology is reliable and minimal effects on human health and the environment would be expected during implementation.

- Implementability: Groundwater extraction using a pumping well system can be readily implemented at the OFFTA site. The technology uses widely available equipment and standard techniques and has proven to be effective in similar situations. Implementation of this technology would require long-term operation and maintenance of wells and pumps. Required maintenance may include periodic replacement of mechanical components and well flushing to remove fine-grained material that may clog the wells. Local and/or state permits would be required to install any off-site extraction wells.

- Cost: The capital costs for groundwater extraction wells are low. The O&M costs are low to moderate.

An extraction well system should be effective and implementable and is retained for further consideration as a representative method for groundwater extraction.

Collection Trench

A collection trench is a groundwater extraction system that essentially functions like an infinite line of extraction wells. A typical system consists of an excavated trench filled with coarse material such as gravel, with a perforated drain pipe placed in the bottom. The highly permeable trench acts as a preferential pathway for groundwater, creating a continuous cone of depression or zone of influence in which groundwater flows toward the drain. Water in the drain is conveyed to a collection sump or storage tank by gravity flow or pumping. In strata with low or variable hydraulic conductivity, conditions that complicate the design and operation of an effective extraction well system, collection trenches can be a more cost-effective method of ensuring complete containment.

Assessment of this option is as follows:

- Effectiveness: Collection trenches are an effective means of creating a continuous hydraulic boundary and collecting groundwater for subsequent treatment. Gravity flow trenches are capable of passively intercepting a contaminant plume as it migrates downgradient from its source. Because they have little cross-gradient or downgradient influence, proper placement of gravity trenches is critical to ensure complete capture and containment of the plume. Pump-operated collection trenches are capable of both intercepting and actively collecting contaminants from a larger zone of influence (upgradient and downgradient). Collection trench technology is reliable and minimal effects on human health and the environment would be expected during implementation.

- Implementability: Collection trenches are implementable in the shallow overburden, but would be more difficult to implement in deep overburden. Collection trenches are constructed using standard excavation methods; necessary equipment and resources are readily available. Trench excavation is possible to almost any depth, in most subsurface conditions.

- Cost: The capital cost of a collection trench in the shallow overburden would be moderate. O&M costs would be low for gravity trenches and low to moderate for pump-operated trenches.

Under most hydraulic conditions, collection trenches and extraction wells are similarly effective, however, collection trenches are more difficult to implement and more costly to construct. Installation of a trench in bedrock will be difficult. This option is eliminated because of higher costs and would be more difficult to implement than the extraction wells.

3.3.2.5 Treatment

Physical Treatment

This section presents the evaluation of treatment technologies that remove the contaminants from groundwater and technologies that may be required for water conditioning before or after primary treatment. The following technologies and process options are evaluated:

- Equalization
- Dewatering
- Sedimentation
- Filtration

- Air Stripping
- Carbon Adsorption

Equalization

Equalization, in the form of a holding tank at the treatment plant inlet, allows for dampening of flow fluctuations and reduction of variations in chemical composition of the influent. This process option promotes a constant discharge rate and minimizes fluctuations in water quality to prevent flow surges or upset conditions that could affect downstream processes. It does not directly remediate contaminants.

Assessment of this option is as follows:

- Effectiveness: Although equalization does not directly remediate contaminants, it is a necessary part of any treatment scheme at the site. Because the groundwater extraction system will consist of numerous wells, each extracting water of a different chemical composition, flow and chemical equalization will be required for proper operation of downstream equipment. Equalization will be able to dampen flow and contaminant surges. Equalization would not be necessary if treatment was conducted at only one point source location, for example, an individual treatment system at a potable well.

- Implementability: Equalization is readily implementable. The equipment necessary is standard to many water treatment systems and is available from several vendors.

- Cost: Equalization capital costs and O&M costs are low.

Equalization is effective and implementable and will be retained for use in each treatment alternative.

Dewatering

Dewatering is the mechanical removal of free water from wastes and can be used to treat residues generated by various groundwater treatment technologies. Dewatering produces a relatively dry, concentrated sludge cake. Typical equipment includes a belt filter press, plate and frame press, and vacuum filter.

Assessment of this option is as follows:

- Effectiveness: Dewatering of groundwater treatment residuals (sludge) will likely be required to improve sludge handling characteristics and lower disposal costs. Of the available options (plate and frame filter press, belt filter press, and vacuum filter), the plate and frame filter press produces the driest sludge cake. This may be the most advantageous option to minimize sludge volumes.

- Implementability: Dewatering is readily implementable. Equipment and resources are readily available.

- Cost: Capital and O&M costs for dewatering are moderate.

Dewatering is an effective and implementable technology for processing treatment residuals and will be retained. The plate and frame filter press will be used as the representative option.

Sedimentation

Sedimentation is a process that removes suspended solids from a liquid by producing quiescent hydraulic conditions. This allows the forces of gravity to settle out large, unstable solids from suspension. This technology may be used in conjunction with precipitation and flocculation processes to remove metals from the groundwater. Two slightly different sedimentation processes are generally used in series: clarification (to produce a 2 to 8 percent solids sludge) and thickening (to further concentrate clarification sludges to 8 to 15 percent solids).

Assessment of this option is as follows:

- Effectiveness: Sedimentation is an effective process for removing settleable solids such as those formed by precipitation and flocculation processes. Because dissolved and unsettleable solids would not be removed by sedimentation, by itself it will not reduce metals concentrations to the required action levels. However, if a precipitation/flocculation process is used to remove metals from solution, sedimentation can be used to enhance removal of the precipitated/flocculated solids.

- Implementability: Sedimentation is readily implementable as part of a treatment scheme. The equipment and resources are readily available from several vendors.

- Cost: Capital and O&M costs for sedimentation are low.

Sedimentation is an effective and implementable process for removal of settleable solids from aqueous waste streams. Sedimentation is retained for use in conjunction with precipitation/flocculation.

Filtration

Filtration is a process that uses a porous medium to remove suspended solids from a liquid. It is valuable in wastewater treatment to remove suspended solids prior to primary treatment processes or for the final cleaning or polishing of treated effluent. It is effective in removing organic and inorganic contaminants (particularly metals) that are bound to suspended solids in groundwater, often reducing the need for further treatment of these contaminants.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), or beds of granular material. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Assessment of this option is as follows:

- Effectiveness: This technology is widely used to remove particulate metals and organic compounds that are bound to suspended solids from aqueous waste streams. Filtering systems can be staged to progressively remove smaller materials; many system variations have been designed to reduce clogging and provide easy maintenance. Conventional filtration is not effective in removing dissolved contaminants.

- Implementability: Filtration is a readily implementable technology. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. Filter media will occasionally have to be replaced or regenerated, potentially resulting in the generation of sludges requiring specialized disposal because of contaminant content.

- Cost: Capital costs for filtration are low, as are O&M costs. O&M costs may elevate slightly if high turbidity in the pumped groundwater requires additional filter maintenance.

Filtration is an effective and implementable technology to remove suspended solids from an aqueous waste stream. Filtration will be retained as a process option for particulate metals removal, if deemed necessary.

Air Stripping

Air stripping is a phase separation process that utilizes countercurrent air flow to encourage the transfer of VOCs from the aqueous phase to the vapor phase. The countercurrent packed tower is the most commonly used air stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. Loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. Another increasingly common configuration is the low profile air stripper, which consists of one or a series of aeration trays in place of a tower. The contaminated water is sprayed into the inlet chamber and flows along the baffled aeration tray. Air is blown up through hundreds of small holes in the tray, forming a froth of bubbles that provides a large mass transfer surface area where volatilization occurs. Key factors that influence air stripping process performance include air to water ratio, type of packing material or tray configuration, operating temperature, surface hydraulic loading, and contact time. In general, air stripping is effective for VOCs with a Henry's Law constant greater than or equal to 3.0 atm-L/mole.

Assessment of this option is as follows:

- Effectiveness: Air stripping is a well-proven and reliable technology that would be effective for removing the VOCs from groundwater. Since the stripping process removes the contaminants from the water and concentrates them in the off-gas, the off-gas would have to be treated by other means such as granular activated carbon adsorption, condensation, catalytic oxidation, or thermal destruction. The type of off-gas treatment depends on the specific contaminants and their concentrations.

- Implementability: Air stripping would be readily implementable at the site. The equipment and resources necessary to implement air stripping are readily available from commercial vendors. A maintenance problem associated with air stripping towers is the channeling of flow resulting from clogging in the packing material. Common causes of clogging include high oils, suspended solids, and iron concentrations, and slightly soluble salts such as calcium carbonate. These problems can be mitigated with effective pre-treatment of the influent. The site's remote location may render this process option difficult to maintain. Specialized personnel, equipment, and supplies may be required to keep this system operating effectively.

- Cost: The capital costs of air stripping are low and O&M costs range from low to moderate depending on influent contaminant concentrations, the degree of removal required, and the type of off-gas treatment required.

While air stripping is an effective and reliable technology for VOC removal from groundwater it is not retained for further consideration because high maintenance requirements may render this option difficult to implement.

Carbon Adsorption

Activated carbon adsorption is a frequently applied technology to remove organic compounds from contaminated water. Activated carbon will adsorb most organic compounds to some extent but is most effective for less polar, less water soluble compounds. Removal efficiency exceeding 99 percent is possible depending on the type of organic contaminants present and system operating parameters such as retention time and carbon replacement frequency. The fundamental principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As water is filtered through the adsorbent, the organic molecules eventually occupy all of the surface sites on the carbon grains. The exhausted carbon must then be either regenerated or disposed of according to federal (RCRA) or state regulations.

Typical activated carbon adsorption treatment systems include gravity flow or pressure flow columns in series configuration with backwashing capability. Granular activated carbon (GAC) is generally used in these systems. Common flow rates range from 0.5 to 5.0 gpm/ft2. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), and sorptive characteristics of the organic compound will affect the carbon adsorption process.

Assessment of this option is as follows:

- Effectiveness: Carbon adsorption is a well-proven, reliable technology to remove organics from aqueous waste streams. With adequate contact time, carbon adsorption should be effective for removal of the organic compounds present in OFFTA groundwater.

- Implementability: Carbon adsorption would be readily implementable at the OFFTA site. A sufficient number of vendors provide carbon adsorption units. Implementation factors also include planning for regeneration or disposal of the spent carbon. Thermal, steam, and solvent treatments are the most common types of regeneration technologies. Regeneration services, which are typically conducted off site, are generally provided by the carbon suppliers. If regeneration is conducted on site, special handling and disposal of the backwash liquids must also be taken into account. Spent carbon would likely require disposal in a RCRA hazardous waste facility. Such facilities are available.

- Cost: Capital costs of carbon adsorption are low. O&M costs range from low to high, depending on the carbon usage rate, which is a function of influent constituents and concentration.

Based on its effectiveness in treating organics and the anticipation of a relatively moderate carbon usage rate, implementation of an activated carbon treatment system would be both technically and economically feasible. This technology will be retained for further consideration as a primary treatment option.

Chemical Treatment

This section presents the evaluation of chemical treatment options that remove the contaminants from groundwater and processes that may be required for water conditioning before or after primary treatment. The following technologies and process options are evaluated:

- Ion Exchange
- Chemical Oxidation
- UV Oxidation
- Neutralization
- Precipitation/Flocculation
- Zero-Valent Iron
- Fenton's Reagent

Ion Exchange

Ion exchange is a process in which toxic ions are removed from the aqueous phase through exchange with relatively harmless ions held by the ion exchange material. Ion exchange resins are insoluble solids containing fixed cations or anions capable of reversible exchange with mobile ions of the same charge in solutions with which they are brought into contact. The ion exchange resins will eventually be exhausted and must be regenerated. The regeneration waste contains a high concentration of contaminants and must be further treated and/or disposed.

Assessment of this option is as follows:

- Effectiveness: Ion exchange is effective for removing soluble metals and anions such as halides, sulfates, and nitrates. Because of resin capacity and regeneration restrictions, ion exchange is most applicable for treating dilute waste streams. Influent suspended solids must be very low to minimize fouling or plugging of the resin bed. Some organics, especially aromatics, can be irreversibly adsorbed by the resin, resulting in decreased capacity. Ion exchange should

effectively remove dissolved metals (manganese, iron, etc.) from the groundwater. However, suspended solids and organics present in the groundwater may cause fouling of the ion exchange resins, decreasing its ion exchange capacity. Sophisticated controls are required to detect breakthrough of contaminants when the capacity of the resin is close to being exceeded. The regenerant stream produced would require additional treatment prior to disposal.

- Implementability: Ion exchange would be implementable. Many vendors provide ion exchange units.

- Cost: Capital costs are moderate and O&M costs range from moderate to high, depending on the frequency of regeneration required, which is a function of influent contaminant concentrations.

Ion exchange will be retained as a treatment process to remove dissolved metals from groundwater.

Chemical Oxidation

Chemical oxidation is a process by which the oxidation state of a compound is raised in order to change the chemical form of the compound to render it less toxic or change its solubility or stability. The process is commonly used in water and wastewater treatment to destroy organic compounds, to remove reduced, soluble forms of iron and manganese from aqueous solutions, or to control odors. Oxygen, hydrogen peroxide, chlorine, and potassium permanganate are the most commonly used oxidizing agents.

Assessment of this option is as follows:

- Effectiveness: Either chlorine, peroxide, or potassium permanganate can chemically oxidize organic compounds. The compounds are also used to oxidize soluble iron and manganese. The main advantage of permanganate is its high rate of reaction, which is many times faster than chlorine. Also, the permanganate process is less sensitive to changes in pH than the chlorine process. Potassium permanganate is a solid that can be more easily handled and stored than chlorine gas, hydrogen peroxide or oxygen. Oxidation using only oxygen (aeration) is effective in removing iron, but is generally not effective for removing manganese.

- Implementability: Chemical oxidation is a readily implementable, conventional water treatment process. It is widely used and commercially available.

- Cost: The capital and O&M costs for chemical oxidation are expected to be low.

Chemical oxidation is an effective and implementable treatment process to destroy organics and to remove iron and manganese from extracted groundwater. It is retained for further consideration.

Ultraviolet Oxidation

Ultraviolet (UV) oxidation processes use a controlled combination of ozone and/or hydrogen peroxide and UV light to induce photochemical oxidation of organic compounds. Hydrogen peroxide, ozone, and UV radiation have been used separately to disinfect sanitary wastewater. The combination of UV radiation with ozone or hydrogen peroxide results in the formation of hydroxyl radicals, which are more powerful and less selective oxidants than ozone, hydrogen peroxide, or UV radiation alone.

A typical continuous-flow ozone/hydrogen peroxide/UV system consists of an ozone generator and/or hydrogen peroxide feed system and a UV/oxidation reactor. Flow patterns and reactor configurations are designed to maximize exposure of the wastewater to the UV radiation, which is supplied by an arrangement of UV lamps. If ozone is utilized, reactor gases are passed through a catalytic ozone decomposer, which converts remaining ozone to oxygen and destroys any volatiles prior to release. With UV/hydrogen peroxide systems, no toxic off-gases are produced.

Assessment of this option is as follows:

- Effectiveness: Enhanced oxidation technology has been demonstrated to effectively oxidize a wide variety of organic compounds. The ease of treatment varies greatly depending on the particular contaminants. Effective destruction of some compounds requires much longer retention time in the reactor than is required for oxidation of most other organic compounds.

- Implementability: Enhanced oxidation technology should be implementable. Currently, only a few vendors offer this technology. Most of the commercially available systems utilize hydrogen peroxide with UV; few ozone systems are currently available. This system would require storage and handling of hydrogen peroxide. Most UV/oxidation systems require high maintenance because of manganese of iron fouling of the UV lamps. This option may not be easily implementable because of the site's remote location, difficulty in assuring availability of hydrogen peroxide, and potentially high maintenance requirements.

- Cost: Capital and O&M costs are moderate to high. Operating costs vary significantly depending on flow rate, and contaminant types and concentrations. Enhanced oxidation requires high energy usage, which can result in prohibitive costs, particularly if contaminants are difficult to destroy.

The effectiveness of enhanced oxidation may be similar to that of activated carbon. However, because it would be considerably more expensive than treatment by activated carbon and because of implementability issues (remoteness of site, high maintenance), enhanced oxidation is eliminated from further consideration.

Neutralization

Neutralization is a treatment process for altering the pH or acidity/alkalinity of a solution. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa. The technology is particularly useful as a pretreatment step for pH adjustment before other treatment processes that require specific pH levels for optimum efficiency. Neutralization is also frequently used as a finishing step prior to discharge to meet specified water quality criteria.

Assessment of this option is as follows:

- Effectiveness: Neutralization is an easily accomplished means of balancing or changing the pH of a solution. The process is best performed in a well-mixed system. A thorough analysis of the wastewater to be treated is advisable to avoid the creation of compounds more toxic than the original compounds and to ensure that incompatible compounds are not introduced into the system.

- Implementability: Neutralization technology is easily implemented; it is widely used and commercially available.

- Cost: The capital and O&M costs for neutralization are expected to be low.

Neutralization will be retained as a process option for groundwater treatment where required by a given technology.

Precipitation/Flocculation

Precipitation and flocculation are closely related treatment processes that facilitate the removal of dissolved or particulate metals from aqueous waste streams. Precipitation is a physicochemical process by which dissolved metals are transformed to insoluble salts through the addition of chemical reagents. Flocculation is a process in which chemical reagents, which act to neutralize surface charges on suspended solids, are added to the waste stream to promote the agglomeration of small, unsettleable,

suspended particles into larger, more settleable particles. The processes are often used in combination to facilitate complete removal of dissolved and suspended metals from aqueous waste streams. In a typical treatment system, precipitants and flocculants are added to the waste stream in a rapid mixing tank. The water then flows to a flocculation chamber where mixing at lower velocities, for longer periods, facilitates the formation of large, readily settleable flocs.

Common precipitation methods involve removing dissolved metals through formation of hydroxides by lime or caustic soda addition; formation of sulfides by sodium hydrosulfide, ferrous sulfide, or hydrogen sulfide addition; or formation of metal-iron compounds by adding ferric chloride or ferric sulfate. Metal hydroxides have a tendency to redissolve outside an optimum pH range; however, they are much easier to handle, safer, and less expensive to generate than sulfides. Sulfide precipitation; however, generally allows for significantly lower treated effluent concentrations. Co-precipitation techniques are also capable of attaining low effluent concentrations. Proprietary processes, such as SulfexR and UnipureR employ ferrous iron compounds that can simultaneously result in reduction and precipitation of the metals at neutral pH conditions.

Many precipitants such as lime and alum act dually as flocculants, facilitating the precipitation of dissolved metals and the agglomeration of the suspended precipitates into large, settleable particles. However, other precipitants such as sulfide ions form very fine, relatively stable colloidal particles, which require the addition of flocculating agents to facilitate settling. Commonly used flocculants include alum, lime, various iron salts, and organic polymers.

Assessment of this option is as follows:

- Effectiveness: Precipitation/flocculation is useful for removing dissolved metals from groundwater. The dual process is effective for removing most metals. Precipitation units are capable of handling the projected influent flow rates. Sludge produced may require further treatment prior to disposal, based on results of waste characterization testing to determine whether the material is considered hazardous.

- Implementability: This technology is widely used in groundwater treatment and is readily available commercially, although proprietary processes are only available through a few vendors. Key process parameters include reagent dosages, pH adjustment requirements, and sludge handling capabilities. Precipitation/flocculation is a non-destructive treatment process that generates a sludge that requires special handling. The sludge produced by this process must be properly disposed in a permitted facility. As with filtration, excessive suspended solids in the raw water will increase the volume of sludge generated and may necessitate added maintenance.

- Cost: The capital costs are expected to be moderate, as are O&M costs due to chemical addition and sludge handling/disposal requirements.

Precipitation/flocculation will be retained as a process option for removal of dissolved metals from site groundwater.

Zero-Valent Iron

Zero-valent iron (ZVI) has been found to be an effective reducing agent capable of degrading chlorinated solvents. It is increasingly being used as a chemical enhancer for the purpose of destroying VOC in-situ, and has been considered for ex-situ use.

Assessment of this option is as follows:

- Effectiveness: Under ideal circumstances, the VOCs at the site would be completely degraded by ZVI, resulting in the formation of ethene and dissolved iron. However, research has shown that incomplete degradation does occur, leaving behind daughter products that are as equally harmful as the parent compounds. Furthermore, most of the research performed on ZVI has been based on its performance as part of a permeable reactive wall. Use of ZVI in ex-situ treatment applications is possible and is gradually being offered by vendors. Under ideal conditions, there would be few treatment residuals to dispose of. Additional information and possibly a treatability study may be desirable to assess the potential effectiveness of this process for the site.

- Implementability: Zero-valent iron technology should be implementable. Currently, only a few vendors offer this technology. Most ZVI applications involve treatment by a permeable reactive barrier. Ex-situ ZVI treatment units are less common.

- Cost: Capital costs of a ZVI treatment unit would be low. O&M costs would be low to moderate, depending on the usage rate of the iron material.

Zero-valent iron will be retained as a potential option for addressing VOCs.

Fenton's Reagent

Fenton's reagent (iron-catalyzed hydrogen peroxide) can be used in the chemical oxidation process as an alternative to ultraviolet radiation. The cost of using UV light energy to create the hydroxyl radicals necessary for effective oxidation can be substantial. Using Fenton's reagent to produce favorable oxidation conditions is less costly and may be nearly as effective.

Similar to the UV oxidation process, Fenton's reagent (Fe^{2+} or Fe^{3+}) is applied along with hydrogen peroxide to form a hydroxyl radical, which is a non-selective, highly reactive oxidant. Under ideal conditions, complete destruction of organic contaminants will occur.

Assessment of this option is as follows:

- Effectiveness: While the long-term effectiveness of Fenton's reagent in an enhanced oxidation system is largely unknown, studies have been performed that have revealed some of the strengths and limitations of iron-catalyzed hydrogen peroxide. The ideal conditions for the generation of hydroxyl radicals using Fenton's reagent are at pH 3, although effective radical production may occur between pH values ranging from 3 to 5. This could be a concern for the groundwater conditions at the site, since under higher pH conditions iron will decompose the hydrogen peroxide to oxygen and water, dramatically reducing the effectiveness of treatment. Frequent monitoring would be required to insure that oxidation conditions within the treatment unit remained favorable. Another drawback of this process is the presumed temperature dependence of the rate of reaction with Fenton's reagent. Reaction rates increase with increasing temperature, but the effects are more pronounced at temperatures above 20 degrees centigrade.

- Implementability: A treatment system using Fenton's reagent for enhanced oxidation is implementable, but regular monitoring would be required to maintain favorable reaction conditions.

- Cost: Capital costs for such a system would be low. O&M costs would be moderate due to monitoring and maintenance needs.

Due to the extensive monitoring necessary to maintain treatment effectiveness, Fenton's reagent will be eliminated from consideration as a remediation option.

In-situ Treatment

This section presents the evaluation of chemical treatment options that remove the contaminants from groundwater and processes that may be required for water conditioning before or after primary treatment. The following technologies and process options are evaluated:

- Oxygen Release Compound
- Hydrogen Release Compound

Oxygen Release Compound (ORC)

This method involves the injection of a chemical compound (i.e., magnesium peroxide) into the subsurface that, when hydrated, forms magnesium hydroxide and molecular oxygen. This release of oxygen will subsequently enhance the natural biodegradation of organic contaminants.

Assessment of this option is as follows:

- Effectiveness: The long-term effectiveness of this method is largely unknown. The ORC is believed to last approximately 6 months in field applications before it must be replenished, and past applications of this technology have used it to enhance bioremediation. This process may potentially be viable for site groundwater contaminated by VOCs. However, there is insufficient information to fully evaluate its effectiveness under site specific-conditions and bench-scale or pilot-scale treatability studies may be required to develop the necessary data to evaluate treatment effectiveness.

- Implementability: Many oxygen-releasing compounds are commercially available and are used, and could be acquired for the groundwater remediation at the OFFTA site. ORCs may be applied as an injectable slurry (through boreholes) or through groundwater wells. Both methods can be implemented at this site. More information regarding the site hydrogeology for the southern VOCs plume will be required to assess whether ORCs can be introduced into the overburden and bedrock aquifers.

- Cost: Capital costs for an ORC system would be low to moderate, depending upon the associated technology. O&M costs would be low to moderate depending on the frequency of ORC replacement.

The oxygen release compound is a potentially viable in-situ treatment process that could be effective to enhance the natural biodegradation of the chlorinated compounds in groundwater. However, there is insufficient information at this time to fully determine its effectiveness under site-specific conditions. This process option will be tentatively retained for future consideration.

Hydrogen Release Compound (HRC)

The hydrogen release compound is a specially formulated chemical that is injected into the subsurface, and is designed to release lactic acid when hydrated. Indigenous anaerobic microbes metabolize the lactic acid to produce hydrogen, which can be used by various reductive dehalogenators to dechlorinate chlorinated aliphatic hydrocarbons such as PCE and TCE. Essentially, the HRC facilitates in situ anaerobic degradation of organic contaminants.

Assessment of this option is as follows:

- Effectiveness: Studies have shown that anaerobic conditions favor PCE and TCE degradation over other chlorinated hydrocarbons. As a result, the use of HRC has been successful in degrading PCE and TCE, but less effective in treating the degradation products 1,2-DCE and vinyl chloride. Consequently, HRC is most effectively implemented in conjunction with an oxygen release compound to create aerobic conditions under which DCE and vinyl chloride are more effectively degraded.

  An HRC/ORC dual phase treatment system could be implemented in two ways: simultaneously or sequentially. In the first option, HRC would be applied to the higher order chlorinated aliphatic hydrocarbon at the source while ORC is concurrently applied in a downgradient zone to treat the resulting daughter products. In the sequential strategy, HRC is applied for an appropriate amount of time to the DCE/TCE contamination. As vinyl chloride accumulates, the use of HRC is terminated and ORC is applied to treat the remaining chlorinated compounds. However, there is insufficient information at this time to fully evaluate HRC's effectiveness under site-specific conditions. Bench-scale or field pilot-scale studies may be required to develop more useful data.

- Implementability: Hydrogen release compounds and technical consultation are available from a vendor and could be readily acquired for use at the site. HRCs may be implemented as an injectable slurry or through groundwater wells. Both methods are readily implementable at the site. Additional hydrogeologic information for the southern VOCs plume area will be needed to

determine whether the HRC can be applied into the overburden and bedrock aquifers underlying the site.

- Cost: Capital costs for the use of HRC would be low. O&M costs would be low to moderate depending on the frequency of HRC replacement. Additional hydrogeologic information for the southern VOCs plume area will be needed to determine whether the HRC can be applied into the overburden and bedrock aquifers underlying the site.

This process option will be tentatively retained for future consideration because of potential advantages of accelerating the degradation of chlorinated compounds in groundwater. However, additional site-specific treatment and hydrogeologic data will be required to better assess effectiveness and implementability.

3.3.2.6 Disposal

This section presents the evaluation of various options for discharge of extracted groundwater. The discharge options evaluated include on-site reuse, direct discharge to surface water, discharge to a local publicly owned treatment works (POTW), reinjection to the aquifer, and redistribution via an infiltration gallery.

On-site Beneficial Reuse

Treated water would be used to water vegetation and shrubbery that is present at the OFFTA site.

Assessment of this option is as follows:

- Effectiveness: This method for discharging water treated to meet PRGs is viable for beneficial reuse on site.

- Implementability: On-site reuse of treated water at the OFFTA site would be easily implementable.

- Cost: The capital and O&M costs for direct on-site discharge are low.

On-site reuse is an effective, readily implementable, low-cost method of discharging treated water at the OFFTA site. It will be retained for further consideration.

Direct Discharge to Surface Water

This discharge option considers direct discharge of treated water to Narragansett Bay.

Assessment of this option is as follows:

- Effectiveness: Direct discharge to Narragansett Bay is an effective means of disposing of the volume of water that would be generated by the groundwater extraction/treatment system.

- Implementability: Direct discharge to the Narragansett Bay is implementable. The discharge of treated groundwater would have to meet appropriate discharge limitations to protect the bay's water quality.

- Cost: The capital and O&M costs for direct discharge to Narragansett Bay are low.

Direct discharge to the Narragansett Bay is an effective, implementable, and low cost option for discharging treated groundwater. It will be retained for further consideration.

Infiltration Gallery

This option would consist of the pumping of treated groundwater from the treatment system to a designated on-site discharge area through an underground pipe. Treated water would then be reintroduced to the aquifer through an infiltration gallery. The infiltration gallery would be made up of a perforated PVC discharge pipe placed within a 2-foot layer of crushed stone bedding material. The crushed stone would be overlain with a geotextile filter fabric and backfilled excavated materials.

Assessment of this option is as follows:

- Effectiveness: The infiltration gallery is a widely used and effective method of reintroducing treated water to the aquifer, providing that the overburden materials have adequate permeability to accept the required discharge rate. The soils at the site are expected to have adequate permeability to handle the anticipated flow rates.

- Implementability; The infiltration gallery is a widely utilized method for the on-site redistribution of treated water and is readily implementable at OFFTA.

- Cost: Since construction of an infiltration gallery involved excavation and installation of a network of pipes, capital costs are moderate to high compared with other discharge methods. O&M costs are expected to be low.

An infiltration gallery would be an effective means of reintroducing treated water to the subsurface at the site and will be retained for further consideration.

3.3.3 Representative Process Options for Groundwater

EPA guidance for conducting FSs (EPA, 1988) recommends that one RPO be selected for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. RPOs are selected from the treatment techniques remaining after screening based on effectiveness, implementability, and cost. The RPOs selected provide a basis for developing performance specifications during preliminary design. Although specific process options are selected for alternative development and evaluation, these process options are intended to represent the broader range of process options within a general technology type. The specific process for implementation of the remedial action may not be selected until the remedial design phase.

Table 3-4 identifies the groundwater RPO(s) chosen for each technology type.

3.4 PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT

3.4.1 Preliminary Screening

As with the soil technologies, a variety of technologies and process options exist for sediment for each GRA described in Section 3.1. A range of these technology types and process options was identified and screened to focus on relevant technologies and process options. Summaries of the identification and preliminary screening of technologies and process options appropriate for sediment are provided in Table 3-5. Many options are eliminated based on technology screening. All options not eliminated due to overall applicability concerns (technical implementability) are retained for a more detailed evaluation in Section 3.4.2.

3.4.2 Evaluation of Technologies and Process Options

In this step, process options considered implementable following preliminary screening are evaluated in greater detail prior to selecting representative process options to use in developing remedial alternatives. One representative process option is selected, if possible, from each technology category to simplify

subsequent development and evaluation of alternatives without limiting flexibility during remedy selection or remedial design. The evaluation criteria include effectiveness, implementability, and cost, with a focus on effectiveness. Brief descriptions of the criteria are provided in Section 3.2.2.

A discussion of the screening and detailed evaluation of technology types and process options using these criteria is provided in the following sections.

3.4.2.1 No Action

The no action scenario is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no removal or treatment of the contaminated sediment would occur.

Assessment of this option is as follows:

- Effectiveness: The option would not be effective in achieving the RAOs for contaminated marine sediment. Contaminants would remain and could continue to pose a risk to the marine environment and/or human health. Impacted sediment could migrate to other areas within Narragansett Bay and connected waterways.

- Implementability: No implementability considerations are associated with the no action scenario.

- Cost: Because no actions would be taken other than 5-year reviews of site status, capital and O&M costs would be negligible.

The no action scenario is retained as a baseline, as required by the NCP.

3.4.2.2 Limited Action

The limited action GRA consists of activities designed to minimize potential risks to human health and the environment primarily by prohibiting or controlling access to impacted areas. The technology types/process options include institutional controls, access restrictions, and long-term monitoring. These options may be conducted independently or in conjunction with other process options to protect human health and the environment.

Institutional Controls

Institutional controls include administrative actions to restrict future use of the site that may result in exposure risks. The intertidal and subtidal areas are property of the State of Rhode Island, so any efforts to restrict access or activities must be coordinated with the state. Use restrictions could prohibit recreational use of the site.

Assessment of this option is as follows:

- Effectiveness: Since the option would offer no containment or removal of contaminated marine sediment, it would not be effective in achieving all the RAOs. Institutional controls would not prevent contaminant migration, reduce toxicity, or reduce contaminated sediment volume, and they would not protect marine biota. New use restrictions, such as bans on swimming and diving in the area, could be placed to provide additional protection. However, additional restrictions may not provide substantially more protection, and the effectiveness of such restrictions would also depend on adequate enforcement by the landowner of the shoreline. No additional risks to human health and the environment would result from implementation of use restrictions.

- Implementability: The Navy currently has a no swimming rule for the NAVSTA Newport shoreline. Additional use restrictions could be implemented by the State of Rhode Island to prohibit general recreational use (diving/bathing) of contaminated areas if the property is excessed. However, adopting the new controls may be difficult and take considerable time. RIDEM enforcement of the bans would be necessary since the restrictions would be placed on state-owned or privately held land. Navy assistance and coordination with Rhode Island authorities would likely be necessary to enhance enforcement of the restrictions.

- Cost: The capital and O&M costs for administrative actions and 5-year reviews would be relatively low.

New institutional controls are eliminated from further consideration for the shoreline and nearshore area because restrictions on recreational use would be difficult to implement and would likely provide no additional reduction in risk.

Access Restrictions

Access restrictions include placing physical barriers or markings to limit site use. Placement of fencing, signs, and buoys would demarcate the impacted area and identify the use restrictions and associated risks. These actions would deter access to the site and the impacted sediment.

Assessment of this option is as follows:

- Effectiveness: Since access restrictions would offer no containment or removal of contaminated marine sediment, they would not be effective in achieving all the RAOs. Access restrictions would not prevent contaminant migration, reduce toxicity, or reduce contaminated sediment volume. They would provide no protection of ecological receptors or the environment. However, access restrictions would reduce use of the intertidal area from a recreational use to a trespasser use. Such reduction would correlate to a risk within acceptable range.

  Access restrictions such as signs on fencing and buoys would notify people of the existing state shellfishing ban and warn people of the hazards present. These restrictions should deter fishermen and recreational users from walking/wading along the shoreline, shellfishing, or diving in the area. Since the access restrictions would be used to reinforce the existing use restrictions on state-owned land, RIDEM enforcement may be necessary. Navy assistance and coordination with Rhode Island authorities would likely be necessary to enhance enforcement of the restrictions; currently, the Navy patrols the shoreline, however, if property is excessed, RIDEM would ultimately be responsible for enforcement. Adequate enforcement would be difficult to ensure, particularly in the long term.

- Implementability: The NAVSTA Newport may be able to limit shellfishing and access to contaminated sediment in the state-owned nearshore area by placing fencing, buoys, and signs in the intertidal zone warning people of the existing shellfishing ban and the hazards in the area. Fencing would be placed perpendicular to the shoreline, from the top of the slope to below the mean low water line at the eastern and western ends of the OFFTA area, and the buoys would be placed along the perimeter of the impacted area, seaward of the mean low water line.

  Installing and maintaining fencing and signs on Navy-owned land above the high-tide line would be readily implemented. Coordination with the state would be required to install and maintain fencing and buoys on state-owned land below the high tide line. However, because the access restrictions would be used to reinforce existing, state-imposed use restrictions, coordination with

the state is not expected to be an impediment to placement. Buoy and fence placement would be conducted in accordance with all applicable state and federal regulations.

The fence and buoy system would require at least yearly maintenance to remain effective. Routine maintenance of the access restrictions by the Navy would be readily implementable.

- Cost: The capital and O&M costs for placement of fencing, buoys, and signs would be relatively low.

Access restrictions are retained for further consideration for the shoreline and nearshore area. Signs and buoys would be placed to identify and demarcate areas of risk in order to deter human access and use of the area for shellfishing. Fencing would be installed in the intertidal zone to deter site access from both the eastern and western directions along the shoreline. Buoys would deter access to the site by water. No protection would be provided to marine biota.

Long-Term Monitoring

Long-term monitoring includes collecting sediment samples from selected locations to assess the migration of contaminants within the contaminated media (sediment) and to adjacent media (porewater, and subsequently into Narragansett Bay). Monitoring would also provide a means of measuring any natural attenuation processes (intrinsic abiotic and biotic degradation) occurring within the contaminated marine sediment or determining if any of the contaminants present have been diluted or covered by sedimentation processes. It would also provide information to assess potential needs for future remedial action.

Assessment of this option is as follows:

- Effectiveness: Monitoring would not be effective in preventing contaminant migration or reducing toxicity, mobility, or volume of contaminated sediment. However, data collected from monitoring activities would help to identify trends in contaminant concentrations associated with natural attenuation and potential migration off site. Monitoring could also provide information to assess the need for future remedial action, as well as to monitor the effectiveness of any remedial action being conducted. Short-term risks to human health during monitoring activities would be minimized by the use of personal protective equipment (PPE).

- Implementability: A long-term monitoring plan would be readily implementable, since trained personnel are available for sample collection and analysis.

- Cost: The capital and O&M costs for a periodic sediment monitoring program would be relatively low for the nearshore area and low to moderate for the offshore area.

The long-term monitoring option is retained for further consideration. While providing no direct protection of human health and the environment, monitoring would provide a means of assessing exposure risks and potential for contaminant migration existing at the site at any point in time. Combined with other process options, monitoring would further provide a means of determining the effectiveness of remedial action activities.

3.4.2.3 Containment

The containment GRA involves using engineering controls to limit potential risks to human health and the environment. It consists of installing and maintaining physical barriers to isolate and contain the contaminated marine sediment. Containment was eliminated from further consideration during preliminary screening (see Table 3-5). Permeable caps were eliminated because of the concern that they would not properly contain the contaminants present in the sediment, and impermeable caps were eliminated because any water movement or gas formation under the cap could become trapped and stress the integrity of the cap.

3.4.2.4 Removal

Removal technologies are included as key components of both the removal/disposal and the removal/treatment/disposal GRAs. Removal activities involve excavating and/or dredging contaminated sediment to reduce or eliminate on-site toxicity, mobility, and volume. These operations require instituting sediment resuspension/turbidity control measures, transporting removed materials, dewatering sediment, treating water generated during dewatering activities, and restoring altered intertidal and subtidal habitats. Sediment consolidated from dewatering activities would also require disposal or treatment. Removal of sediment results in the complete destruction of natural habitats present in the area affected.

In general, selection of the most efficient and cost-effective excavation and/or dredging techniques depends on sediment removal rates which, in turn, depend on the following factors:

- Equipment (type and size)
- Volume and depth of contaminated material
- Sediment characteristics (amount of debris, sediment grain size, and water content)
- Location/navigational constraints (bridges, water depth, currents, etc.)
- Weather conditions

- Pretreatment requirements (dewatering, water treatment and disposal, etc.)
- Marine ecological concerns related to resuspension of contaminated sediment during removal and associated turbidity control (silt curtains, booms, etc.)
- Health and safety issues related to handling contaminated sediment
- Transport
- Method of disposal or treatment

Removal of sediment from the shoreline and nearshore area would be conducted from the shoreline in areas where access is possible and there is adequate shallow area in which to work. Land-based removal would be conducted with the assistance of a temporary cofferdam system and continuous dewatering to keep the area relatively dry. Use of a cofferdam system would allow greater access to deeper sediment, possibly extending beyond the intertidal zone. Contaminated sediment that cannot be reached from the shoreline would be reached by building a bay haul road out into the water and using land-based excavation or dredging equipment or would be removed using barge-mounted dredging equipment. A preliminary design investigation (PDI) would further evaluate the feasibility of removing sediment, either using land-based or barge-mounted equipment.

The sediment removal options may include the following excavation and dredging technology types.

Mechanical Dredging and Excavation

Mechanical dredging and excavation may be conducted using a number of techniques including clamshells, dippers, bucket ladders, draglines, and conventional earth-moving equipment. This equipment operates by the direct application of mechanical force to dislodge materials to be removed.

Clamshells: The most commonly used mechanical dredge for removing contaminated soil and sediment is the clamshell dredge. Clamshells can recover all types of material and debris, except highly consolidated sediment. This type of dredge is generally equipped with an open, hinged bucket with a capacity of 1 to 12 cy. The bucket is attached by a cable to a land-based crane or flat-bottomed barge. The clamshell dredge can excavate to practically any depth, restricted only by the crane lifting capacity.

The clamshell dredge is operated by opening the jaws of the bucket, lowering the bucket into the material to be removed, closing the jaws, and hoisting the bucket by means of the crane cable. The dredge removes a heaped bucket of material, part of which is excavated by drag forces during hoisting. If properly operated, conventional clamshell dredges can operate with limited loss of sediment and can efficiently remove a large volume of material. For marine dredging applications, a modified, watertight bucket is sometimes used to minimize the resuspension of solids into the water column. However, the

large rocks and debris within the sediment to be dredged would frequently prevent the bucket from closing, thereby reducing the effectiveness of the watertight bucket.

Dippers: The dipper is a powered 8 to 12 cy shovel designed for digging out rock and very hard, compacted material. Its use is suited for excavation of soft rock and highly consolidated sediment within a working depth of 50 feet. Since this technique operates with a violent digging action and tends to drop small particles, its application for marine dredging is often limited. However, it may be well suited for removing debris and large rocks. It could be operated from the shoreline or a barge to remove contaminated sediment.

Bucket Ladders: A bucket ladder dredge is comprised of a submersible ladder that supports a continuous chain of buckets that rotate around two pivots. When the buckets rotate around the underside of the ladder, they scoop up material and transport it up the ladder for discharge into a storage bin. These dredges are most commonly used in mining operations abroad, such as sand and gravel production. The bucket ladder dredge generates considerable turbidity because of the mechanical agitation of sediment and leakage from the bucket. Therefore, its use is limited to removal of contaminated sediment exposed during low tide.

Draglines: Draglines use the same basic equipment as the clamshell dredge. However, the dragline operates by the use of a drag cable to pull the bucket through the material being excavated toward the crane. Dragline dredges typically provide for a longer reach than clamshell dredges operated by the same crane. Since draglines cause a great deal of mechanical agitation of the material being removed and because the buckets are generally open, their use generally results in excessive sediment resuspension. However, use of dragline dredges may be required to remove materials in hard-to-reach areas. If possible, their use should be limited to removing contaminated sediment exposed during low tide.

Conventional Earth-Moving Equipment: Conventional, track-mounted, earth-moving equipment (excavators, front-end loaders, backhoes, and bulldozers) have limited application in removing contaminated sediment from underwater locations; however, they may be well suited to removing consolidated sediment and debris from the shoreline and shallow nearshore area. Front-end loaders and bulldozers are generally used to remove loose or soft materials from a few feet above to a few feet below grade. Since they must be in close proximity (both horizontally and vertically) to the material being removed, shore-based or barge-mounted operations are not practical; however, bulldozers and front-end loaders could be employed to excavate materials behind a cofferdam. Excavators and trackhoes, typically used for trenching and other subsurface excavations, consist of a bucket on a fixed arm and have reaches of up to 100 feet. They can be operated from the shoreline or mounted on a barge.

A brief summary of the advantages and disadvantages of mechanical dredging is as follows:

Advantages of mechanical dredging include the fact that excavation can be conducted to maximize the solids content and, thereby, minimize the scale of the dewatering and handling activities. Mechanical dredges are highly maneuverable, can remove many types of debris, and provide dredging accuracy. Clamshell dredges and excavators are further capable of efficiently removing materials with depth. Many techniques are available for shoreline use, while fewer options are suited for barge-mounted operation.

Disadvantages of mechanical dredging include the potential to resuspend large amounts of sediment, as well as offering a lower production capacity and typically higher costs than other dredging techniques. Mechanical dredging operations also require significant rehandling of materials.

Assessment of this option is as follows:

- Effectiveness: Mechanical dredging would be effective in removing contaminated sediment from the marine environment. Removal would minimize future exposure risks to human health and the marine environment while preventing contaminant migration within Narragansett Bay. The effectiveness of mechanical dredging is limited by difficulty of achieving complete removal in an underwater environment. Multiple passes over the contaminated area may be required to remove all contaminated materials. The effectiveness can be improved, but not to 100 percent, by state-of-the-art positioning equipment. The use of appropriate turbidity control measures during marine sediment dredging would minimize contaminant migration during implementation. Any aquatic habitats that are altered by the remedy would require mitigation measures to offset the aquatic habitat loss. Restoration of the habitat would be accomplished by refilling the excavated area to the existing grade using materials similar to the existing substrate. Additionally, if necessary, active restoration of any impacted eelgrass beds could be attempted. However, successful restoration of eelgrass beds has not been widely demonstrated.

- Implementability: Mechanical dredging is readily implementable by companies with trained personnel qualified to handle contaminated sediment dredging operations. Fewer companies are available with direct experience in associated contaminated sediment dewatering and treatment techniques; however, qualified companies are assumed to be available within the Rhode Island coastal business community. All on-site personnel must be trained in hazardous waste site operations due to the nature of the sediment to be removed.

Mechanical dredging is implementable by both shoreline and barge-mounted operations. However, technical issues related to implementation are challenging for both types of operations. Removal using conventional earth-moving equipment would be possible from the shoreline or a haul road constructed into the water. Barge-mounted operations are limited by the draft requirements of the vessel and the reach of the mechanical dredge (up to 100 feet). Because of the weight and size of the equipment required for dredging and processing the sediment on the barge, the barge is expected to require 6 to 10 feet of water for operation. Because the water in the nearshore area is relatively shallow, some locations may be difficult to access by barge. It may be difficult to replace the aquatic communities destroyed by the dredging activities, although the backfill material would provide habitat structure suitable for regrowth of these aquatic communities.

- Cost: The capital costs are moderate to high for dredging of contaminated materials. No O&M costs are associated with dredging, but some O&M would be required in the first few years following dredging to monitor the aquatic habitat restoration. Overall O&M costs would be low.

Mechanical dredging is a viable removal option for nearshore areas and has therefore been retained for further consideration. Contaminated sediment removal activities may include both conventional earth-moving excavation techniques from the shoreline or a haul road constructed in the water and mechanical dredging using barge-mounted equipment for sediment inaccessible from the land.

Hydraulic Dredging

Hydraulic dredges use centrifugal pumps to remove sediment in a liquid slurry form and transport the slurry by suction to a designated location on a barge or along the shoreline. Slurries of 10 to 20 percent solids by weight are typically achieved. A cutterhead, or similar device, is often fitted at the suction end of the dredge to assist in dislodging bottom materials and allowing for transport to the suction pipe. The cutterhead is probably the most efficient and versatile type of hydraulic dredge available. However, new hydraulic dredge designs are available that attempt to increase the solids content of the pumped slurry while minimizing the sediment resuspension caused by the dredging activity.

Both cutterhead and plain suction hydraulic dredges can efficiently remove large volumes of relatively small materials. Typical hydraulic dredges cannot remove stones or debris larger than approximately 4 to 6 inches in diameter because they are limited by the size of the suction head and slurry pipeline. The plain suction dredges are capable of removing relatively free-flowing sediment (sand, gravel, and unconsolidated material), while cutterhead dredges are capable of removing free-flowing as well as very hard and cohesive sediment. Portable dredges (with or without a cutterhead) can be used to remove

moderate volumes of materials that are more surficial in nature (depths of up to approximately 18 inches). The cutterhead, plain suction, and portable dredges can all be operated from the shoreline or from barge-mounted equipment.

A brief summary of the advantages and disadvantages of hydraulic dredging is as follows:

> Advantages of hydraulic dredging include limiting the resuspension of sediment and minimizing the handling of dredged material by transporting the dredged slurries by suction through pipelines. The cutterhead can efficiently dredge and pump all types of alluvial materials or compacted deposits, such as clay or hardpan. The cutterhead is also capable of grading and finishing slopes efficiently.
>
> Disadvantages of hydraulic dredging include the fact that large volumes of water, which may require treatment prior to disposal or release, are typically removed along with the sediment (80 to 90 percent water by weight). The slurry pipelines used to transport dredged material may temporarily obstruct navigational traffic. Nonhopper dredges cannot be operated in rough water, and hopper dredges may require drafts of over 10 feet. The presence of large stones and concrete may limit the effectiveness and suitability of hydraulic dredging in some areas, particularly the nearshore areas. Hydraulic dredges cannot remove material with diameters greater than the diameter of the suction head or slurry pipeline.

Assessment of this option is as follows:

- Effectiveness: Hydraulic dredging would be effective in removing contaminated marine sediment. However, in areas where the marine environment contains rocks or debris greater than the diameter of the dredge, mechanical excavation and dredging techniques may be required to prepare the area prior to hydraulic dredging. The effectiveness of hydraulic dredging is limited by difficulty of achieving complete removal in an underwater environment. Multiple passes over the contaminated area may be required to remove all contaminated materials. The effectiveness can be improved, but not to 100 percent, by state-of-the-art positioning equipment. Removal of impacted sediment would minimize future exposure risks to human health and the marine environment, and prevent contaminant migration within Narragansett Bay. The use of appropriate turbidity control measures during dredging activities would minimize contaminant migration during implementation. Any aquatic habitats that are altered by the remedy would require mitigation measures to offset the aquatic habitat loss. Restoration of the habitat would be accomplished by refilling the excavated area to the existing grade using materials similar to the existing substrate. Additionally, if necessary, active restoration of any impacted eelgrass beds

could be attempted. However, successful restoration of eelgrass beds has not been widely demonstrated.

- Implementability: Hydraulic dredging is readily implementable by companies with trained personnel qualified to handle contaminated sediment dredging operations. All on-site personnel must be trained in hazardous waste site operations. Fewer companies are available with direct experience in associated contaminated sediment dewatering and treatment techniques; however, qualified companies are assumed to be available within the Rhode Island coastal business community.

  Hydraulic dredging is implementable by both shoreline and barge-mounted operations. Barge-mounted operations are limited by the draft requirements of the vessel (6 to 10 feet) and the reach of the hydraulic dredge. Because the water in the nearshore area is relatively shallow, some locations may be difficult to access by barge. It may be difficult to replace the aquatic communities destroyed by the dredging activities, although the backfill material would provide habitat structure suitable for regrowth of these aquatic communities.

- Cost: The capital costs are moderate for hydraulic dredging of contaminated materials. No O&M costs are associated with dredging, but some O&M would be required in the first few years following dredging to monitor the aquatic habitat restoration. Overall O&M costs would be low.

Hydraulic dredging in the nearshore area has been eliminated from further consideration due to the nature of the substrate. There is a large amount of cobbles and stones greater than 6 inches in diameter in all areas, and this size material cannot be effectively removed with hydraulic dredging as discussed in this section. Mechanical equipment is necessary to remove subsurface debris prior to sediment removal activities, and mechanical excavation/dredging would be more efficient for removing the contaminated sediment present.

Materials Handling and Disposal

Disposal technologies are included as key components of the removal GRAs. Disposal media include any debris and sediment excavated and/or dredged from the marine environment. Disposal options may include both on-base and off-base locations.

Additional activities associated with excavation/dredging operations are related to materials handling. These activities include transporting dredged materials for processing, screening, and dewatering sediment, and treating/disposing of both the residual water and the dewatered sediment.

Transportation of Excavated/Dredged Materials

Marine sediment removed from the impacted areas would be transported for processing (removal of debris, dewatering, etc.) prior to disposal. The type of transport depends on the method of excavation/dredging (mechanical transport for mechanical removal activities and hydraulic transport through suction pipelines for hydraulic dredging). Final transportation methods would be selected after the dredging method is selected.

Initial Processing

Processing would take place either at a designated shoreline location or on a barge/scow located near the removal location. All excavated/dredged materials are expected to be placed directly on a barge or scow for processing or on a staging area at the OFFTA site.

Dewatering Activities: Dewatering is the first step of processing dredged materials. This is generally required to reduce the moisture content of the sediment, enhance the handling characteristics, and prepare the sediment for further treatment and disposal. Typically, dredged material is screened to remove large objects and debris that may plug or foul the dewatering equipment.

Dewatering technologies appropriate for marine sediment include centrifuging, filtration, and gravity thickening. The effectiveness of these technologies can be influenced by the content of clay, silt, and organic matter in the sediment.

Centrifuging techniques use the force developed by the fast rotation of a cylindrical drum or bowl to separate solids and liquids due to differences in densities. They can generally achieve a product composed of 10 to 35 percent solids. The effectiveness of using centrifuges is limited by sediment containing tars, small particle sizes, low density particles, large objects, or fibrous materials. Centrifuges are generally compact and are, therefore, well-suited for use in areas with space limitations.

Filtration is a physical process whereby liquid is forced through a permeable medium and dewatered solids are retained. Filtration techniques are able to dewater fine-grained sediment over a wide range of solids concentrations. The effectiveness depends on the type of filter, the particle size, and the water content of the sediment. Three commonly used filtration systems include belt press filtration, vacuum filtration, and pressure filtration. The achievable solids content of dewatered sediment is expected to be in the range of 10 to 50 percent.

Gravity thickeners concentrate solids in a tank, similar to a conventional sedimentation tank or clarifier. They can concentrate dredged sediment slurries of nearly any grain size to at least 2 to 15 percent solids. Heavier material will dewater quickly and more efficiently than fine-grained material. Thickened material is typically further dewatered by other methods. The use of gravity thickening techniques for dewatering marine sediment has limited applicability. However, it may be used as a preliminary dewatering technique in cases when the solids content is very low, as in the case of slurries generated from hydraulic dredging operations.

The selection of a dewatering process or combination of processes depends on the sediment volume and solids content (a function of the dredging technique), available land space, and degree of dewatering required. The system may be operated on the barge/scow or at the onshore portions of the site in the vicinity of the removal activities.

Treatment/Disposal of Residual Water: The water generated from sediment dewatering processes may require treatment to remove dissolved and colloidal contaminants prior to disposal.

Treatment can take place on the dredging platform or at a NAVSTA Newport-owned shoreline property, through a skid-mounted clarifier and membrane filter prior to discharge into Narragansett Bay. The clarifier would remove inorganic constituents by metals precipitation. Unsettled metals precipitant and other suspended particles would be removed by sedimentation and/or filtration. Organic constituents (PAHs) are expected to be adsorbed onto the surface of the suspended particles, and thereby removed along with these particles. However, should a need arise to further reduce the concentrations of these organic constituents, additional process units may be added to the skid-mounted treatment train. These may include dissolved air flotation and/or granulated activated carbon process units. The treated effluent would be required to meet specific contaminant concentration limits prior to discharge into the bay.

Actual materials that would be used for precipitation (alum, etc.) and the volumes required would be determined upon performance of a pilot scale test. This is appropriate for design of any treatment plant. The volume of water to be treated will be determined based on the dredging equipment to be used and the recovery rate of dredged sediment. The water treatment plant would be designed to keep pace with the dredging schedule, once it is determined. Current estimates indicate that under optimal conditions, dredging could progress at a rate of 435 cubic yards per day. If one assumes dredge spoils are 80 percent water, the plant would have to treat and discharge up to 75,000 gallons per day. Backup storage would have to be available to withhold as much pretreatment water that could be produced during a full day of dredging at optimal rate. This safeguard will assure that the treatment plant is not over-taxed at any time, and that dredging can be delayed if there is a delay in treatment production.

3.4.2.5 Disposal

All sediment will be tested for hazardous characteristics after dredging. Once the marine sediment has been tested for hazardous characteristics, approximately 80 percent is expected to be acceptable for disposal at a RCRA Subtitle D landfill following dewatering. It is assumed that the remainder of the material (estimated to be 20 percent) would require treatment and/or disposal at a RCRA Subtitle C TSDF or landfill.

Assessment of this option follows:

- Effectiveness: Off-base disposal offers a full range of disposal and treatment/disposal options depending on the contaminant type and concentration. Disposal at a licensed RCRA Subtitle D/RCRA Subtitle C landfill or TSDF is an effective means of off-base disposal. Furthermore, these facilities may be capable of providing treatment of selected materials if required prior to disposal.

- Implementability: This disposal option is implementable, and RCRA Subtitle D landfills are available locally. RCRA Subtitle C TSDFs are available for disposing and/or treating removed sediment but may require shipping out of state. Proper handling and transport of contaminated materials, complete with bill of lading, would be required. Some stabilization of the materials may be required prior to transport to minimize the presence of free liquids.

- Cost: The capital costs are expected to be relatively high. No O&M costs are associated with this option.

Off-base disposal is retained for further consideration for dredged materials.

3.4.2.6 Treatment

Treatment is included as a potentially required component of the removal/treatment/disposal GRA. Contaminated marine sediment removed by dredging techniques may require treatment, following dewatering and prior to disposal. Treatment would ensure that all contaminated solids are of acceptable quality for disposal at the off-base facilities. Treatment may include stabilization or solidification to immobilize contaminants within the material, or use of bulking agents to remove excess water for transportation.

Appropriate off-base treatment options would be determined by the disposal facility accepting the material.

It is anticipated that once the marine sediment has been tested for hazardous characteristics, most of the dredged material may be disposed of in a RCRA subtitle D facility following dewatering.

On-Base Treatment

On-base treatment may be required for sediment contaminated with elevated concentrations of metals. Potential on-base treatment technologies include chemical/physical (stabilization/ solidification) options. Additional thermal, physical, chemical, and biological options were eliminated during preliminary screening.

Chemical/Physical Treatment (Solidification/Stabilization): Solidification/stabilization is a technique that mixes reactive materials with contaminated solids, semisolids, and sludge to immobilize the contaminants by forming a chemically stable matrix of limited permeability. Volume increases exceeding 20 percent can result. Solidification/stabilization agents may include cement, siliceous materials, lime, or proprietary agents. Selection of the most appropriate agent, the waste-to-additive ratio, mixing variables, and curing conditions all depend on the chemical and physical characteristics of the waste. Solidification/stabilization techniques are most successful in treating wastes containing inorganics; however, some success has been experienced with oily sludge and solvents.

Assessment of this option follows:

- Effectiveness: Solidification/stabilization is a well-accepted technique to treat inorganic contaminants. Success in forming a chemically stable matrix depends on the selection of the stabilizing agents, the mix ratios of waste to agent, and proper mixing and curing. Its effectiveness in treating organics is inconclusive. Treatability studies would be required to confirm the effectiveness in treating organics, as well as in determining the optimum processing steps to reduce leaching of inorganic constituents from the solidified/stabilized medium. Addition of stabilizing agents is also used effectively to reduce the amount of free liquid present in sediment that may otherwise be of acceptable quality for disposal without additional treatment.

- Implementability: The implementation of the solidification/stabilization process may prove difficult for sediment or sediment slurries with high water content. Initial dewatering of these materials would be necessary to minimize the amount of stabilizing agent required. This preparatory step would, in turn, reduce the time required to stabilize the contaminants and minimize volume

increases associated with bulking of the contaminated material. Treatability studies would be required to determine appropriate treatment processes.

- Cost: The capital costs are expected to be relatively low. Dredged and dewatered sediment requiring solidification/stabilization are expected to be treatable on-site for a minimal cost per cubic yard. No O&M costs are associated with this option.

Solidification/stabilization is a viable treatment option for inorganic contaminants and has been retained for further consideration.

Off-Base Treatment

Off-base treatment has been evaluated as a contingency in case onshore portions of the site are not available for treatment. The appropriate off-base treatment technologies will be determined by the disposal facility accepting the material.

Assessment of this option follows:

- Effectiveness: Treatment at a licensed RCRA Subtitle C/RCRA Subtitle D landfill or TSDF are effective means of rendering the contaminated material acceptable for off-base disposal. Treatment would reduce the toxicity and mobility of the contaminated media. The volume of the media would be increased (typically by up to 20 percent) by solidification/stabilization processes.

- Implementability: This option is implementable at a licensed off-base facility. Many facilities offer stabilization/solidification. Fewer facilities are available for treatment of organics. Proper handling and transport of contaminated materials, complete with bill of lading, would be required. Some stabilization of the materials may be required prior to transport to minimize the presence of free liquids.

- Cost: The capital costs are expected to be relatively low. Materials requiring solidification/ stabilization are expected to be treatable off-site for a minimal cost per cubic yard. No O&M costs are associated with this option.

Off-base treatment is retained for further consideration for the site area.

3.4.2.7 Aquatic Habitat Restoration

Aquatic habitat restoration is a required component of any remedial alternative that significantly damages or destroys the existing aquatic habitat. Dredging/excavation is expected to cause significant impacts to the aquatic habitat by destroying the existing aquatic habitat in the remediation area. Additionally, the aquatic habitat outside the remediation area may be damaged by construction activities associated with dredging.

This section evaluates aquatic restoration options for the ecological community at risk of damage from remedial alternatives: the eelgrass community in a portion of the subtidal area of the site. Restoration of damaged portions of these communities may be required following remedial action; however, all possible efforts will be made to avoid damage to the aquatic communities during remediation.

Eelgrass Communities

This section describes the eelgrass habitat and evaluates the measures that can be taken to restore damaged habitat.

Characteristics of the Habitat: Eelgrass (*Zostera marina L*) is one of approximately 50 species of marine vascular plants capable of vegetative and reproductive growth. It is found in coastal and estuarine waters in large meadows or small disjunct beds ranging in size from 1 yard across to acres in area. This species is a true flowering plant, with roots and rhizomes that inhabit sediments ranging from soft mud to coarse sand. The thin, green strap-like leaves range from 6 inches to over a yard long. It grows in water ranging from 1 to 8 meters deep and has been found to exist in a wide salinity range. Eelgrass is a sensitive species that grows where several physical, chemical, and biological parameters are in balance with the needs of the plant.

The availability of light controls the depth of eelgrass and is considered the most critical factor in maintaining healthy eelgrass beds (Kenworthy and Haunert, 1991). In Narragansett Bay, the most important factor contributing to the continuing decline of seagrass has most likely been light reduction caused by turbidity created by algal blooms and periodic disturbances such as dredging (TtNUS, 1999). The algal blooms are the result of increasing amounts of anthropogenic nitrogen since the 1870s (Nixon, 1993; Nixon, Granger, and Nowicki, 1995; Nixon, 1997). Natural factors such as wave and tidal action and shifting sediment have also contributed significantly to eelgrass bed instability.

Eelgrass is present in large healthy stands in the sub-tidal area near the OFFTA site, as documented in an underwater survey conducted in July 2001 (Pare Engineering, 2001). The healthy condition of these

stands indicate that physical conditions (light, substrate, etc.) are appropriate for growth, so these stands should be somewhat resilient to moderate impacts such as limited short-term disturbance.

Natural Restoration of the Eelgrass Habitat: Natural restoration is an option that could be considered to mitigate minor damage to eelgrass beds resulting from turbidity-related impacts such as decreased light availability or increased siltation. Natural restoration would be limited to the use of sediment resuspension/turbidity controls such as installing floating silt curtains during dredging or capping, implementing a turbidity monitoring program to ensure the effectiveness of the turbidity controls, and monitoring the restoration of the habitat following completion of the remedial action.

An assessment of the natural restoration of slightly damaged eelgrass communities follows:

- Effectiveness: The natural recovery potential for eelgrass indirectly affected (not excavated) by a remedial action in the nearshore area is favorable if the physical conditions of the area already provide healthy stands. Light availability is not expected to be a significant factor in the long-term (i.e., the period following implementation of the sediment remediation alternative); however, uncontrolled sediment suspension caused by dredging during the remediation may decrease the available light for a short period. Effective dredging/excavation management and use of sediment resuspension/turbidity controls should minimize this problem. Under all circumstances, the sediment removal area would be enclosed by floating silt curtains to limit the dispersion of resuspended particulates. A turbidity monitoring program would be implemented to ensure the effectiveness of sediment containment procedures.

  Similarly, wave and current action in the area are not likely to be significantly altered by the sediment remedial action. Any minor changes in wave and current action are not expected to interfere with natural restoration of damaged eelgrass beds. Because the present stability of the eelgrass bed is unknown, it will be difficult to discern natural from anthropogenic stresses that might result from the remedial action. To address this concern, eelgrass bed monitoring would be conducted during remediation in conjunction with turbidity monitoring to provide some insight into whether operation-induced siltation is occurring.

- Implementability: Natural restoration of slightly impacted eelgrass beds is easily implemented. It would principally involve proper use of operational and sediment resuspension/turbidity controls during active remediation of the nearshore areas to limit damage and allow the area to quickly return to its original condition.

- Cost: The capital and O&M costs for natural restoration of slightly impacted eelgrass beds would be low. The costs for minimizing damage to the area would be included as part of the normal dredging costs. Additional costs would include turbidity monitoring and any monitoring associated with the restoration of the habitat.

Natural restoration is a viable option to address eelgrass beds slightly impacted by remedial actions in the nearshore area. It is retained for further consideration for alternatives that could result in slight damage to eelgrass beds.

Assisted Restoration of the Eelgrass Habitat: Assisted restoration is an option that could be considered to mitigate destruction of the eelgrass community caused by dredging within the limits of the eelgrass beds. Assisted restoration of eelgrass beds consists of providing the optimum habitat structure and transplanting eelgrass into the sediment structure. Seagrass transplanting methods can be grouped into three broad categories: (1) shoots with sediment intact, (2) seeds, and (3) shoots with bare roots. After initial transplanting, the success of the restoration would have to be monitored and additional transplanting would likely be necessary to replace grasses that did not survive.

An assessment of assisted restoration of severely damaged eelgrass communities follows:

- Effectiveness: The potential for accelerating the recovery of eelgrass impacted by a remedial action is evaluated below in light of the success of recent eelgrass restoration projects in Narragansett Bay.

  In 1995, the National Marine Fisheries Service (NMFS) conducted eelgrass restoration projects at 10 sites (Bristol Ferry North, Bristol Ferry South, Sakonnet River (2), Dutch Harbor, Dyer Island, Hog Island, Northern Jamestown, T-Dock, and West Prudence) chosen for their high clarity of water, sandy sediment, and protection from heavy wave action and strong tidal currents. By 1997, only three sites were found to still be supporting any plants (T-Dock, Prudence Island, and Dutch Harbor). The loss of sites has been attributed to strong winds that accompanied the passage of a hurricane in 1996, crab bioturbation, and excessive reduction in light transmission due to macroalgae; one site was probably set too shallow and one too deep.

  Further restoration efforts conducted by the University of Rhode Island (URI) in 1995 involved two separate eelgrass restoration projects: one involving eelgrass shoots with bare roots as the transplant media, and another using only eelgrass seeds. For each proposed transplant area, a careful evaluation of environmental variables was conducted, including collecting information on bathymetric data coupled with light extinction data, wave energy, sediment type (i.e., sandy

bottom, presence/absence of existing eelgrass, and current human use). In addition, preference was given to areas known to have historically contained eelgrass beds vs. those areas that did not.

Out of six sites selected for eelgrass shoot/root transplant by URI in 1995, only one site (Hope Island) has persisted to this date. Similarly, of the four sites where eelgrass seeding was conducted, only one site (Dutch Harbor) was successful. Limited success for both projects is most likely a result of early planting (for seeding the project) and strong wave action. Both URI and NMFS found the higher density plots are more likely to succeed than are those with a lesser density.

In summary, eelgrass restoration projects underway in Narragansett Bay have targeted the most promising locations with respect to environmental conditions believed to favor growth. Despite extensive experimentation in transplantation methods, densities, and locations, very few sites have persisted more than a few years. Hence, it would appear that the potential for a successful assisted eelgrass restoration in the OFFTA area is low to negligible for eelgrass beds that might be destroyed by remedial activities.

- Implementability: Assisted restoration of eelgrass beds significantly damaged by remedial activities could be attempted by transplanting eelgrass shoot or seeds and optimizing the habitat structure to encourage eelgrass survival. However, successful restoration may not be possible. As described above, assisted restoration of eelgrass beds has not been widely successful, even under ideal conditions. It is unlikely the assisted restoration would be successful in the OFFTA area, which has less than ideal conditions.

- Cost: The costs of assisted restoration at this site or elsewhere would likely be high due to the need for multiple plantings and extensive monitoring. As noted, little success with assisted restoration of eelgrass in Narragansett Bay has been achieved to date.

Assisted restoration does not appear to be a viable option to enhance restoration of damaged eelgrass beds in the OFFTA area. However, if planned remedial actions would severely damage eelgrass beds and some form of mitigation is required, assisted mitigation could be reconsidered to restore the damaged bed or to restore a damaged eelgrass bed in another part of Narragansett Bay.

Surveys performed during July 2001 indicate that eelgrass beds offshore of OFFTA are viable with respect to cover, bed size, and shoot density, to the extent that these features characterize self-sustaining beds. Since the eelgrass beds are characterized as viable and self-sustaining, and since

actions are likely to impact only a portion of these beds, attempts should only be made to restore these beds in place after sediment removal. Should this action be necessary, further restoration options would be evaluated employing habitat modifications that would structurally enhance eelgrass restoration, e.g., sand bottom and flatness. This effort would rely on the experience gained in other restoration projects noted above for optimal location and restoration procedures.

3.4.3 Representative Process Options for Sediment

EPA guidance for conducting FSs (EPA, 1988) recommends that one RPO be selected for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. RPOs are selected from the treatment techniques remaining after screening based on effectiveness, implementability, and cost. The RPOs selected provide a basis for developing performance specifications during preliminary design. Although specific process options are selected for alternative development and evaluation, these process options are intended to represent the broader range of process options within a general technology type. The specific process for implementation of the remedial action may not be selected until the remedial design phase.

Table 3-6 identifies the sediment RPO(s) chosen for each technology type. The RAOs specify that the goal of remediation is to restore the site for residential use without any restrictions. In order to meet this requirement, technologies involving containment and/or in situ technologies that require long-term monitoring are not considered, and, therefore, the selected RPOs primarily reflect removal, treatment, and disposal options. No action, dredging/excavation, disposal at an off-site landfill or TSDF, and solidification/stabilization have been selected as the RPOs.

The no action option consists of undertaking no remedial action at a particular site. Inclusion of the no action alternative is required under CERCLA guidance, and this alternative is used as a baseline consideration in the detailed evaluation or to address sites that do not require any active remediation. No technologies or process options are associated with this RPO.

Mechanical dredging is a viable removal option for nearshore areas and has therefore been retained for assembly into alternatives. Contaminated sediment removal activities may include both conventional earth-moving excavation techniques (behind a temporary cofferdam) and mechanical dredging using barge-mounted equipment for sediment inaccessible from the shoreline or haul road constructed into the water. This process option has been selected to represent the excavation/dredging technology for the removal/disposal and removal/treatment/disposal GRAs for the shoreline and nearshore areas.

Off-site disposal at a landfill or a TSDF was retained as an RPO for use either in conjunction with a remediation process that produces residuals that must be disposed of off base or for disposal of contaminated sediment. Use of a TSDF will be a very effective, long-term solution to contaminated soil disposal.

Solidification/stabilization is retained as the treatment RPO. If treatment is required, this RPO will effectively immobilize contaminants within the sediment.

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES FOR SOIL

The purpose of this section is to develop and screen alternatives and to assemble an appropriate range of remedial options to achieve the site RAOs. Remedial technology process options retained for further consideration in Section 3.0 are combined to form remedial alternatives. Detailed evaluation of these alternatives is performed subsequently.

4.1 RATIONALE FOR DEVELOPMENT OF ALTERNATIVES

The alternatives are developed to comply with regulatory criteria applicable to the site conditions and the media of concern, as directed by the following regulations and guidance:

- *Navy/Marine Corps Installation Restoration Manual* (2000), which dictates that remedial alternatives be consistent with the procedures outlined in the NCP (40 CFR 300.430).

- National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300), which establishes the criteria for development and evaluation of remedial alternatives and further suggests consideration of applicable EPA directives and guidance.

- *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988).

These documents require that a range of alternatives be developed that eliminate, reduce, or control human and ecological risks. The goal is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste. According to Section 121 of CERCLA, as amended by SARA, the statutory preference is for remedies that will result in a permanent and significant decrease in toxicity, mobility, or volume of contaminants and provide long-term protection. In addition, the NCP requires that certain expectations be considered in developing and screening remedial alternatives. These expectations are as follows:

- Treatment will address the principal threats posed by the site, wherever practical. Principal threats are considered to be liquids, areas contaminated with high concentrations of toxic compounds, and highly mobile materials.

- Engineering controls, such as containment, will be used for waste that poses a relatively low, long-term threat and for which treatment is impractical.

- A combination of methods will be used, as appropriate, to achieve protection of the environment. In appropriate site situations, treatment of principal threats will be combined with engineering and institutional controls for dealing with residuals and relatively low, long-term threats.

- Institutional controls, such as deed restrictions, will supplement engineering controls for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants.

- The use of innovative technologies will be considered when such use offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts, or lower costs for similar levels of performance than previously demonstrated technologies.

Environmental media will be returned to their beneficial uses, when practical, within a reasonable time frame. When restoration of a medium is not practical, actions are expected to prevent further migration and exposure to contaminated media and to evaluate further risk reduction measures.

From the technologies that passed the screening, RPOs were selected to represent a typical remedial action in Section 3.0. Alternatives are developed by assembling RPOs. The *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988) identifies six steps for developing alternatives. The six steps as specified by EPA are described below.

1. Develop RAOs specifying the chemicals and media of interest, exposure pathways, and PRGs that permit a range of treatment and containment alternatives to be developed. The PRGs are developed on the basis of chemical-specific ARARs and, when available, other available information (e.g., reference doses [RfDs]) and site-specific risk-related factors.

2. Develop general response actions for each medium of interest defining containment, treatment, excavation, or other actions, singly or in combination, that may be taken to satisfy the RAOs for the site.

3. Identify volumes or areas of media to which GRAs might be applied, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the site.

4. Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented at the site. Further define the GRAs to specify remedial

technology types (e.g., the GRA of treatment can be further defined to include chemical or biological technology types).

5. Identify and evaluate technological process options to select an RPO for each technology type to be retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

6. Assemble the selected RPOs into alternatives representing a range of treatment and containment combinations, as appropriate.

The purpose of providing a range of alternatives is to ensure all reasonable GRAs are represented and evaluated.

Table 3-2 listed the soil RPOs and the corresponding technology types. The soil remedial alternatives in this FS report are formulated from these RPOs and are presented in Table 4-1.

Based on current data, the remedial action for soil at OFFTA is to address approximately 48,500 cy of impacted surface and subsurface soil. Several PAHs, arsenic, beryllium, lead, and manganese exceeded RIDEM standards for surface soil. Subsurface soil contaminants exceeding RIDEM standards include several PAHs, antimony, arsenic, beryllium, lead, manganese, and petroleum hydrocarbons. The areal extent and depth of contamination are depicted on Figure 2-3. In order to address RIDEM requirements and be able to achieve residential cleanup standards with no land use restrictions, three alternatives were developed to address soil contamination at OFFTA. The alternatives are as follows:

Soil Alternative 1: No Action
Soil Alternative 2: Removal, Ex situ Treatment, and Backfill
Soil Alternative 3: Removal and Disposal

No alternatives using the Limited Action and Containment GRAs were assembled because they would not meet the RAO of allowing unrestricted residential use of the site.

4.2 DESCRIPTION OF ALTERNATIVES

The alternatives were developed to address soil and debris in the areas identified as posing potential risks to human health. As discussed previously, the volume requiring remediation consists of about 48,500 cy. The depth of contamination varies across the site.

Sections 4.2.1 through 4.2.3 describe the alternatives developed to address the site soil. Table 4-1 identifies the components of each alternative.

4.2.1 Soil Alternative 1: No Action

The no action alternative, as required under the NCP, would involve no remedial response activities and would provide no additional protection of human health or the environment. However, it would provide a baseline for comparison to other alternatives. Since contamination would remain and unrestricted future use of the area would be allowed, 5-year reviews of the no action decision would be required.

Under this alternative no remedial actions would be performed, no measures would be implemented to restrict access to the OFFTA site, and no actions would be taken to warn people of the hazards. Existing measures that provide some protectiveness include fencing and signs around the OFFTA that limit access to the site.

4.2.2 Soil Alternative 2: Removal, Ex situ Treatment, and Backfill

Alternative 2 would eliminate long-term management by addressing contaminated soil through excavation and treatment. This alternative would offer aggressive remediation through excavation and on-site treatment by LTTS and soil washing to reduce the contaminant concentrations to levels below PRGs. Elements of Alternative 2 would include:

- Pre-design investigation to determine the extent of excavation and types of disposal required
- Pilot test for LTTS and soil wash
- Excavation of the mounds and segregation of soil and debris
- Excavation of site to remove debris and contaminated soil
- Segregation and testing of debris and contaminated soil
- Removal and replacement of the on-site storm drains as needed
- Removal of inactive storm drains, sanitary piping, or other unused utilities
- Confirmation sampling of excavated areas to ensure complete removal of contaminated soil
- Temporary storage of contaminated and contaminant-free materials
- On-site treatment of contaminated soil with LTTS to remove organics
- On-site treatment of contaminated soil with soil washing to remove inorganics
- Confirmation sampling of treated soil
- Backfill with treated soil supplemented with clean fill material
- Disposal of debris and treatment residues
- Construction of a new revetment along the shoreline

- Post-remediation groundwater monitoring (Section 5 of this report)
- Institutional controls limiting the use of groundwater
- Five-year review

LTTS uses direct or indirect heating to thermally desorb or volatilize organic contaminants present in soil. LTTS has been used extensively at various CERCLA sites, and the experience resulting from its use has been positive. Soil washing involves treating soil with wash liquids that would separate the contaminants from the soil media; it would be used to remove metals from the soil. The combination of LTTS and soil washing would address all site contaminants, both organic and inorganic. Removal would involve the removal of surface and subsurface soil (up to 10 feet) using trackhoes. An estimated 48,500 cy of soil and debris would be excavated, with approximately 35,530 cy of that being soil to be treated. As part of pre-construction, the existing mounds at the OFFTA (10,900 cy) would be excavated and the debris disposed of in order to allow access to any contaminated soil beneath the mounds. It is assumed for the FS that the debris within the mounds and surrounding areas is suitable for disposal as solid waste; however, the materials would be tested prior to disposal to verify this. Excavation and backfilling with treated soil would be performed in conjunction with each other, with work progressing in stages across the site. Sampling of the excavated areas and analysis with field test kits and quick-turnaround lab analyses would be used to ensure complete removal of the contaminated soil before backfilling.

4.2.3 Soil Alternative 3: Removal and Disposal

Alternative 3 would eliminate long-term management by addressing contaminated soil through excavation and disposal. This alternative would offer aggressive remediation through excavation and transportation of contaminated soil to a TSDF or landfill. Elements of Alternative 3 would include:

- Pre-design investigation to determine the extent of excavation and types of disposal required
- Excavation of the mounds and segregation of soil and debris
- Excavation of site to remove debris and contaminated soil
- Segregation and testing of debris and contaminated soil
- Removal and replacement of the on-site storm drains as needed
- Removal of inactive storm drains, sanitary piping, or other unused utilities
- Confirmation sampling of excavated areas to ensure complete removal of contaminated soil
- Temporary storage of contaminated and contaminant-free materials
- Disposal of debris and non-hazardous soil at a municipal landfill as appropriate for the constituents present
- Disposal of hazardous soil at a TSDF
- Backfill with clean fill material

- Construction of a new revetment along the shoreline
- Post-remediation groundwater monitoring (in accordance with section 5)
- Institutional controls limiting the use of groundwater
- Five-year review

An estimated 48,500 cy of soil and debris would be excavated for disposal. It is assumed that as part of pre-construction, the existing mounds at the OFFTA (10,900 cy) would be excavated and the debris disposed of as solid waste in order to allow access to any contaminated soil beneath the mounds. The material in the mounds would be tested prior to disposal to determine the appropriate disposal facility.

Removal would involve the removal of surface and subsurface soil (up to 10 feet) using trackhoes. Excavated material would be loaded onto trucks and hauled off site to an approved disposal facility. The effectiveness of the technique has been demonstrated in many full-scale operations. Excavation and backfilling with clean fill would be performed in conjunction with each other, with work progressing in stages across the site. Sampling of the excavated areas and analysis with field test kits and quick-turnaround lab analyses would be used to ensure complete removal of the contaminated soil before backfilling.

TSDFs are controlled by regulations contained in, but not limited to, 40 CFR 264 and 265. It is not practical to select a specified TSDF or transporter at this time; however, potential TSDFs are available in neighboring states. The TSDFs and transporters would be from an approved list of EPA- and/or state-registered vendors.

4.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The remedial alternatives developed in Section 4.2 are described and analyzed in detail in this section. The detailed analysis of the alternatives provides information to facilitate selection of a specific remedy or combination of remedies. The detailed analysis of alternatives was developed in accordance with the NCP [40 CFR 200.430(e)] and the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988).

In conformance with the NCP, seven of the following nine criteria were used to evaluate each of the retained alternatives during the detailed analysis. The last two criteria, state and community acceptance, will be addressed following the receipt of state and public comments on the proposed plan.

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost
- State Acceptance
- Community Acceptance

Under the NCP, the selection of the remedy is based on the nine evaluation criteria, which are categorized into three groups:

- Threshold Criteria - Overall protection of human health and the environment and compliance with ARARs are threshold criteria that each alternative must meet in order to be eligible for selection.

- Primary Balancing Criteria - The five primary balancing criteria are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost.

- Modifying Criteria - State and community acceptance are modifying criteria that will be considered in remedy selection.

Brief, general discussions of these evaluation criteria are presented in the following text. Detailed analyses of the alternatives using the evaluation criteria are presented in Section 4.4. A comparative analysis of the alternatives is presented in Section 4.5.

Overall Protection of Human Health and the Environment

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria including long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The evaluation focuses on whether a specific alternative achieves adequate protection and how risks are eliminated, reduced, or controlled.

Compliance with ARARs

ARARs are considered during the detailed evaluation of alternatives. Alternatives are assessed on whether they attain ARARs. When an ARAR cannot be met, the basis for justification of a waiver under CERCLA, or within the specific requirement, is presented.

Potential ARARs are determined by the Navy in consultation with EPA and RIDEM. ARAR identification is an iterative process, and potential ARARs must be reexamined throughout the RI/FS process until a ROD is issued.

Long-Term Effectiveness and Permanence

Under this criterion, the alternatives are evaluated for long-term effectiveness, permanence, and the degree of risk remaining after the RAOs have been met. The following components are evaluated:

- Magnitude of residual risks - assesses the residual risk remaining from untreated wastes or treatment residuals at the conclusion of remedial actions, the remaining sources of risk, and the need for 5-year reviews.

- Adequacy and reliability of controls - assesses controls that are used to manage treatment residuals or remaining untreated wastes. This assessment includes addressing the likelihood of technologies to meet required efficiencies or specifications, type and degree of long-term management, long-term monitoring requirements, O&M functions to be performed, uncertainties associated with long-term O&M, potential need for replacement of technical components and associated magnitude of risks or threats, degree of confidence in controls to handle potential problems, and uncertainties associated with land disposal of untreated wastes and residuals.

Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element by assessing the relative performance of different treatment technologies for reducing the toxicity, mobility, or volume of the contaminated media. Specifically, the analysis should examine the magnitude, significance, and irreversibility of the estimated reductions.

The degree to which remedial alternatives employ treatment that reduces toxicity, mobility, or volume are assessed by considering the following factors:

- The treatment processes that the remedies employ, the media they would treat, and threats addressed.

- The approximate amount of hazardous materials that would be destroyed or treated.

- The degree of expected reduction in toxicity, mobility, or volume as a result of treatment.

- The degree to which the treatment is irreversible.

- The type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, mobility, and bioaccumulation capacity of the contaminants of concern and impacted media.

- The ability of alternatives to satisfy the statutory preference for treatment as a principal element.

Short-Term Effectiveness

The assessment of short-term effectiveness during construction or implementation until the RAOs are met includes consideration of the following factors:

- Potential short-term impacts to the community during remedial actions and whether risks may be addressed or mitigated.

- Potential impacts to, and protection of, the workers during remedial actions.

- Potential adverse environmental impacts that result from construction and implementation of the alternative, and the reliability of mitigation measures.

- Time until RAOs are achieved.

Implementability

The ease or difficulty of implementing a remedial alternative is assessed by considering the following factors during the detailed analysis:

- Technical Feasibility:

- Degree of difficulty or uncertainties associated with constructing and operating the alternative.

- Technical difficulties associated with the technologies' reliability that could result in schedule delays.

- Likelihood of additional remedial actions and anticipated ease or difficulty in implementation.
- Ability to monitor the effectiveness of the remedy and risks of exposure if monitoring is insufficient to detect remedy failure.

- Administrative Feasibility:

  - The need to coordinate with other offices and agencies and obtain necessary approvals and permits.

- Availability of Services and Materials:

  - Availability of adequate capacity and location of treatment, storage, and disposal services, if required.
  - Availability of necessary equipment and specialists.

  - Availability of treatment technologies comprising the alternative, sufficient demonstration of the technologies, and availability of vendors.

  - Availability of services and materials, and the potential for obtaining competitive bids.

Cost

A detailed cost analysis is performed for each alternative to assess the net present worth cost to implement the remedial actions. The cost analysis consists of the following:

- Estimation of capital (direct and indirect) and annual O&M costs.

- Development of costs with an accuracy in the range of +50 percent to -30 percent.

- Calculation of the present worth (capital and O&M costs) of the alternative by discounting to a base year or current year using a discount rate of 3.9 percent.

State Acceptance

RIDEM will be providing input to the FS process on an ongoing basis and would continue to do so throughout the public comment period. Assessment of the state concerns may not be completed until comments on the RI Report, FS Report, and proposed plan are received. As a result, this Draft FS does not include any additional discussion about this criterion for any of the alternatives analyzed. State concerns may be discussed, to the extent possible, in the proposed plan to be issued for public comment. The state's comments would be fully addressed in the record of decision (ROD). The state concerns that would be assessed include the following:

(1) The state's position and key concerns related to the preferred alternative and other alternatives and

(2) State comments on ARARs or the proposed use of waivers.

Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration. The community is broadly defined to include all interested parties. Community concerns would be addressed after the public comment period, which follows the release of an administrative record that includes the RI Report, FS Report, and proposed plan along with any other documents that were used by the EPA to develop the proposed remedy. As a result, this FS does not include any additional discussion about this criterion for any of the alternatives analyzed.

4.4 INDIVIDUAL ANALYSES OF SOIL ALTERNATIVES

Three remedial alternatives, including the No Action Alternative, were developed to address the contaminated soil at OFFTA. Detailed evaluations of each alternative are presented in this section and summarized in Table 4-2. Detailed cost estimates, including both capital and O&M costs, as well as assumptions for each alternative are presented in Appendix F.

4.4.1 Soil Alternative 1: No Action

Consideration of a no action alternative is required under the NCP. At a minimum, it provides a baseline against which other alternatives may be compared. No containment, removal, or treatment of soil contaminant would be conducted. The alternative would provide no mechanism to minimize potential risks to receptors except for the existing fencing and signs, which would not be maintained. No groundwater monitoring would occur, and there would be no restrictions on groundwater use. The only activities to be conducted under Alternative 1 would be review of site conditions and risks every 5 years.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: The no action alternative would not provide long-term protection of human health and the environment and would not facilitate site re-use. Alternative 1 would not achieve RAOs for the protection of human health or the environment, and several PAH and inorganic contaminants would still exist at the OFFTA site at concentrations exceeding PRG levels. Contaminants in the soil would continue to pose unacceptable risks to human health in the long-term through dermal contact, incidental ingestion, and possibly through fugitive dust inhalation, under potential future use of the site. Under the future land-use scenario, a resident exposed to existing contamination in subsurface soil would have unacceptable risk. The fencing and signs currently at the site would not be maintained and could become ineffective.

The PAHs and inorganic contaminants remaining in the soil would also have a continued potential to leach into the groundwater. Because contaminants would remain at the site, 5-year reviews would be conducted, as required by CERCLA, to assess changing conditions and potential risks. Once the 5-year review results have been evaluated, and if contaminant migration is deemed to pose human health or environmental risks, then additional response actions may be warranted.

Compliance with ARARs: Tables 4-3, 4-4, and 4-5 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 1. This alternative fails to meet ARARs because it does not address soil exceeding PRGs that have been derived from state and federal regulations. Since no action is to be taken under this alternative, there are no state or federal location-specific or action-specific ARARs or TBCs.

Long-Term Effectiveness and Permanence: Since no remedial actions would occur under Alternative 1, the unacceptable future threats to human health and the environment would remain. Potential contaminant migration pathways would not be addressed, and PAHs and metal contaminants remaining at the site would continue to pose threats to human health through various exposure pathways.

Estimated excess carcinogenic risk of approximately 2.5×10^{-5} for surface soil and 4.0×10^{-5} for subsurface soil would remain during future residential use of the site under this alternative.

Contaminants in the subsurface would also continue to potentially leach into the groundwater underlying the site and migrate off site into Coasters Harbor.

Because of the risk associated with leaving contaminated soil on site, 5-year reviews would be required. These 5-year reviews would assess whether threats or risks are increasing or abating with time and any changes in the conditions at the site.

Under the no action alternative, no additional controls would be used to manage the contaminants at the site. Therefore, the evaluation of the adequacy and reliability of new controls is not applicable.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The no action alternative would not reduce the toxicity, mobility, or volume of contamination through treatment, since no treatment is used to address the contaminated soil. As a result, no hazardous substances would be treated or destroyed, and contaminated soil would remain in place.

Alternative 1 would not satisfy the statutory preference for treatment to reduce risks posed by contaminated soil.

Short-Term Effectiveness: Since no response actions other than long-term monitoring would occur, implementation of the no action alternative would not pose additional short-term risks to the local community, base personnel, or the environment. Workers conducting long-term monitoring would be protected from contaminant-related risks by PPE and proper site safety procedures. Potential risks from soil contamination would remain unabated. None of the RAOs would be achieved.

Implementability: This alternative would require no implementation other than completion of the 5-year reviews. This activity would not require any permits, but it may require a minimal amount of coordination between regulatory agencies. Implementation of the no action alternative would not limit future implementation of additional remedial actions at the site, if deemed necessary.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 1 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	Estimated Cost
Capital Costs	$0
O&M/Long-Term Monitoring	$0
5-Year Reviews	$22,000/5 years
Present Worth	$70,000

4.4.2 Soil Alternative 2: Removal, Ex situ Treatment, and Backfill

Alternative 2 features the excavation of surface and subsurface soil exceeding PRG levels and on-site treatment of the soil using LTTS and soil washing. LTTS would remove organic contamination from soil through thermal treatment, and soil washing would address the metals. Off-gas controls would be necessary to capture organic constituents removed during thermal treatment. Treated soil would be used as backfill. Excavation would involve the removal of soil using a trackhoe or front-end loader, and excavated material would be loaded onto trucks and hauled to a centralized location on the site for treatment. The excavation would be performed in stages, where a limited area would be excavated, the soil hauled to the treatment area, and the excavation backfilled. This process would proceed from one side of the site to the other. Runoff and erosion controls would be maintained around the active excavation area.

All surface and subsurface soil exceeding PRGs in the vadose zone would be excavated. The three soil mounds at the site built of soil/construction debris require excavation and removal in order to reach contaminated soil beneath the mounds. The debris within the mounds is assumed to be acceptable for disposal as solid waste. If confirmatory sampling finds that hazardous waste is present, all soil contaminated with hazardous waste, including soil below the vadose zone, would be removed.

A Pre-Design Investigation (PDI) would be performed to gather information needed to complete the final remedial design. The PDI would include sampling to better define the extent of contamination and the percent of debris expected in the excavation. The PDI would also finalize the staging methods for performing the excavation and would define the post-excavation sampling plan.

The anticipated staging of the project would be to set up the LTTS and soil washing systems initially on the baseball field at the site. This area makes up approximately two acres, and is currently clear and level. This would allow adequate space for separate stockpiles of untreated soil, makeup soil, and material to be shipped off site as well as stockpiles of soil brought out of the operation for reuse. As stated above, contaminated soil would be brought to this area as the mounds are dismantled and

portions of the site are excavated. Each of the treatment units is typically a mobile unit that could be brought to the site using one or more trucks.

Excavation would begin on the eastern side of the site, and debris and soil would be placed in different stockpiles. Excavations would be performed in sections to ensure that the treatment process is not backed up by large stockpiles. As the excavated area progressed westward over the site, confirmation samples of the excavation would be taken and analyzed with field test kits or quick-turnaround lab testing to ensure complete removal of the contaminated soil. Once confirmation was received, that portion of the excavation would be backfilled with treated soil in the “clean” stockpile. Multiple stockpiles of treated soil would allow for treatment confirmation analyses to be processed on some piles while already-confirmed piles are being used for backfill. After the soil in and under the eastern half of the site has been treated and replaced, the soil treatment operation would be moved to the east side, and the soil under the ballfield would undergo the same process.

Temporary office space would be set up in the parking areas at Building 144 on the south boundary of the site. Decontamination facilities would be set up at access gates and within the treatment areas as needed.

Because the excavation would extend to the top of the slope along the length of shoreline, a new revetment would be placed as part of site restoration to prevent erosion of the backfilled soil. An engineered wave break and retaining wall would be constructed to prevent erosion of the treated soil at the site. The retaining wall would be designed to absorb wave action rather than reflect it so that sediment scouring would not occur at the foot of the slope. This structure would be designed in concert with any remedial actions to be conducted in the intertidal and subtidal area, as described in Section 6 of this report.

Contaminated soil would be treated in an on-site treatment system consisting of LTTS and soil washing steps. LTTS uses direct or indirect heating to thermally desorb or volatilize organic contaminants present in solids or soil. The temperatures used are contaminant- and matrix-specific with a range of approximately 200 to 1,000ºF. Typically, contaminated soil is processed through an externally fired pug mill or rotary drum system equipped with heat transfer surfaces that are heated by circulating hot oil, gases, or steam. An induced air flow conveys the desorbed organics through a secondary treatment system, such as a carbon adsorption unit, combustion afterburner, or condenser unit. The air stream is then discharged through a stack, and any water that is driven off is sent through carbon adsorption units. Residuals other than gas are soil, ash, and spent carbon.

Soil washing involves removal of contaminants by washing in an aqueous-based system. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove heavy metals. Soil washing removes contaminants sorbed onto soil particles from soil by either dissolving or suspending them in the wash solution (which is later treated by conventional water treatment methods, such as in a POTW). In the washing process, the soil is screened and then scrubbed to break up soil aggregates and liberate fines. The surfaces of the coarse particles are "washed" by abrasive action and by desorption of contaminants upon contact with the washing solution.

As the contaminants would be removed to concentrations below PRGs, long-term monitoring or 5-year reviews would not be required. However, new monitoring wells would be installed (the existing wells would be destroyed during excavation) and sampled after remediation for trend comparison with pre-remediation concentrations. Long-term groundwater monitoring at the site would be conducted in accordance with the groundwater alternatives as described in Section 5 of this FS report.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 2 would provide high overall protection of human health and the environment because all contaminated soil exceeding PRGs would be excavated and treated. The alternative provides protection against potential long-term direct exposures (dermal contact, incidental ingestion, and inhalation) to humans. The potential to leach would be minimized, and any potential impact to groundwater due to leaching would be negligible. Excavated soil would be treated to remove contaminants, and the treated soil would be used as backfill.

There would be increased short-term risks to on-site workers from potential exposures to contaminated soil during implementation because of the magnitude of excavation and treatment involved. These risks would be minimized through the use of engineering controls and proper PPE.

Once the contaminated materials have been removed and the area backfilled with treated soil, no long-term soil management measures would be required. There would be no soil restrictions limiting future activities at the property provided all the soil risks have been addressed. However, other restrictions on groundwater and sediment use may still exist as described in Sections 5 and 6 of this report.

Compliance with ARARs: Tables 4-6, 4-7, and 4-8 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 2. This alternative would comply with chemical-specific ARARs because organic and inorganic contaminants would be reduced to acceptable concentrations in the treated soil. Alternative 2 would comply with the RIDEM requirements for both direct contact and the leachability criteria.

Implementation of Alternative 2 would meet state and federal location-specific ARARs by conducting the activities in accordance with applicable and relevant and appropriate floodplain, wetland, coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to minimize adverse effects to fish, wildlife, endangered species, and historic sites.

Action-specific ARARs would be met by designing and implementing the alternative in accordance with federal and state waste treatment standards and Clean Air Act (CAA) requirements. Disposal of waste liquids from the soil washing operation would be done in accordance with applicable local, state, and federal regulations.

Long-Term Effectiveness and Permanence: Excavating and treating the soil would provide long-term effectiveness and permanence. The pilot study would assure effectiveness of the treatment process and the variables within it. The LTTS process would reduce organic concentrations to meet PRGs, and soil washing would remove inorganic concentrations to meet PRGs. This alternative would not require long-term management because contaminants above PRGs would be removed from the soil.

LTTS would be effective at removing the organic COCs from the contaminated soil. The removal efficiency would be dependent on the temperature employed, the volatility (boiling point) of the chemical, and the soil matrix. As temperature increases, removal efficiency also increases. The off-gas treatment system would then capture or destroy the contaminants. Inorganics would be removed by the soil washing treatment, and the desired removal would be achievable by adjusting the pH of the wash solution. The effectiveness of the alternative can be monitored through sampling and analysis of the excavation boundaries and the treated soil.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 2 would reduce the toxicity, mobility, and volume of organic and inorganic contaminants through removal and treatment of contaminated soil. The degree of toxicity and volume reductions would depend on the soil matrix and the treatment system parameters. A small amount of LTTS vapor treatment system and soil washing system residual material (spent carbon and liquid waste) may require treatment or off-site disposal.

Short-Term Effectiveness

The short-term risk to workers, base personnel, and the public during implementation of Alternative 2 would be controllable and would primarily result from the excavation and handling of the contaminated soil during the treatment processes. PPE, at a level commensurate with the contaminants involved, would be required during excavation and treatment operations. The risk to the environment from fugitive

emissions and erosion would be greatest during excavation activities and would diminish with time during the treatment processes. Air monitoring conducted during construction activities would indicate the need for any additional measures to address the short-term risks. The time required to reach the remedial action objectives is estimated at 6 to 8 months.

Implementability: Alternative 2 is implementable because soil excavation using a trackhoe is a standard construction practice. LTTS and soil washing are also implementable. LTTS would be reliable in meeting PRGs; however, the reliability of soil washing would be moderate, and soils may require more than one pass through the equipment to meet PRGs. Numerous vendors are available to design, construct, and operate the components of this alternative. Future remedial actions, if required, at OFFTA would be easily implementable through additional excavation and treatment. Due to the availability and proven history for the LTTS and soil washing technologies, bench scale or pilot tests are not anticipated for this alternative.

Disposal permit requirements may need to be met to dispose of liquid waste from the soil washing system and spent carbon from the LTTS system. Any required permits are expected to be obtainable.

O&M activities for this alternative would be relatively intensive but only during the period of remediation when the treatment equipment is operating. Qualified O&M personnel would be required to maintain the components of this alternative to assure reliability. The LTTS and soil washing units would require monitoring, adjustments, and periodic maintenance. The maintenance schedule would be as recommended by the equipment manufacturer and existing legal requirements or as dictated by desired flow rates and system adjustments.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 2 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate. A cost sensitivity analysis based on the amount of soil excavated is also included in Appendix F.

Cost Description	Estimated Cost
Capital Costs	$14,174,000
O&M/Long-Term Monitoring	$0
5-Year Reviews	$22,000 (year 5 only)
Present Worth	$14,192,000

4.4.3 Soil Alternative 3: Removal and Disposal

Alternative 3 would eliminate long-term management by removing the contaminated soil exceeding PRGs from the site. This alternative would offer aggressive remediation through excavation and transportation of contaminated soil to a TSDF or appropriate, permitted disposal facility.

Excavation would involve the removal of soil and debris using a trackhoe or front-end loader, and excavated material would be loaded onto trucks and hauled to an appropriate disposal facility. Backfilling would involve placement of clean fill in the excavated areas followed by contouring to the desired grade. The excavation would be performed in stages, where a limited area would be excavated, direct-loaded into trucks, and the excavation backfilled. This process would proceed from one side of the site to the other. Runoff and erosion controls would be maintained around the active excavation area. The three soil mounds at the site built of soil/construction debris require excavation and removal in order to reach contaminated soil beneath the mounds. The debris within the mounds is assumed to be non-contaminated and therefore would be disposed of as solid waste. However, if hazardous waste is identified in the mounds, the debris would be tested and decontaminated according to applicable federal and state standards before it is disposed.

Soil and debris would be tested prior to disposal to determine the appropriate disposal facility. Much of the material can be disposed of in a RCRA Subtitle D landfill, such as a municipal landfill. If hazardous waste is identified before disposal, confirmatory sampling would be conducted in the area where the waste was removed to ensure that all soil contaminated with hazardous waste, including soil below the vadose zone, is removed. The remaining material that is considered hazardous would go to a RCRA Subtitle C TSDF. TSDFs are controlled by regulations contained in, but not limited to, 40 CFR 264 and 265. It is not practical to select a specified TSDF or transporter at this time; however, potential TSDFs are available in neighboring states (e.g., Model City, New York). Excavated material would be piled into several piles, and uncontaminated debris (e.g., from the mounds) and contaminated (but non-hazardous) soil would be transported to a landfill. The hazardous soil, assumed to be approximately 10 percent of the total soil volume, would be transported to a TSDF. The landfills, TSDFs, and transporters would be selected during the remedial design phase of the remediation program from an EPA- and RIDEM-approved list of vendors.

A PDI would be performed to gather information needed to complete the final remedial design. The PDI would including sampling to better define the extent of contamination and the percent of debris expected in the excavation. The PDI would also finalize the staging methods for performing the excavation and would define the post-excavation sampling plan.

The anticipated staging of the project would be to begin excavation on the eastern side of the site. As the excavated area progressed westward over the site, confirmation samples of the excavation would be taken and analyzed with field test kits or quick-turnaround lab testing to ensure complete removal of the contaminated soil. Once confirmation was received, that portion of the excavation would be backfilled with clean fill. Excavation would continue westward until it complete. Because the excavation will extend to the top of the slope along the length of shoreline, a new revetment will be placed as part of site restoration to prevent erosion of the backfilled soil. An engineered wave break and retaining wall would be constructed to prevent erosion of the new soil at the site. The retaining wall would be designed to absorb wave action rather than reflect it so that sediment scouring would not occur at the foot of the slope. This structure would be designed in concert with any remedial actions to be conducted in the intertidal and subtidal area, as described in Section 6 of this report.

As the contaminants would be removed to concentrations below PRGs, long-term monitoring or 5-year reviews would not be required as a part of the soil alternative. However, long-term monitoring and 5-year reviews may be necessary for groundwater and sediments, as discussed in Sections 5 and 6 of this report.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 3 would provide high overall protection of human health and the environment because all contaminated soil exceeding PRGs would be excavated and removed from the site. The alternative provides protection against potential long-term direct exposures (dermal contact, incidental ingestion, and inhalation) to humans. The potential to leach would be minimized, and any potential impact to groundwater due to leaching would be negligible. Excavated soil would be disposed of at a TSDF or appropriate disposal facility, and clean soil would be used as backfill.

There would be increased short-term risks to on-site workers from potential exposures to contaminated soil during implementation because of the magnitude of excavation involved. These risks would be minimized through the use of engineering controls and proper PPE.

Once the contaminated materials have been removed and the area backfilled with clean soil, no long-term soil management measures would be required. There would be no restrictions owing to contaminated soil that would limit future activities at the property as long as all soil risks are addressed. However, continued groundwater and sediment restrictions may be retained, as described in Sections 5 and 6 of this report.

Compliance with ARARs: Tables 4-9, 4-10, and 4-11 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 3. This alternative would comply with chemical-specific ARARs because organic and inorganic contaminants above PRGs would be removed from the site. Alternative 3 would comply with the RIDEM requirements for both direct contact and the leachability criteria.

Implementation of Alternative 3 would meet state and federal location-specific ARARs by conducting the activities in accordance with applicable and relevant and appropriate floodplain, wetland, coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to minimize adverse effects to fish, wildlife, endangered species, and historic sites.

Action-specific ARARs would be met by monitoring and use of controls to minimize emissions during soil excavation and by disposing of excavated materials at a TSDF or appropriate, permitted facility.

Long-Term Effectiveness and Permanence: Excavating and disposing of the contaminated soil would provide long-term effectiveness at the site. Although removal of contaminated soil provides a permanent solution at the site, the contaminated soil may need to be effectively treated at the TSDF to provide permanent destruction or immobilization of contaminants. Only a small fraction of soil is expected to need treatment at the TSDF. The effectiveness of the remedial action would be monitored through sampling and analysis of excavation boundaries. This alternative would reduce the residual risk at the site and would not require long-term management or monitoring.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative 3 would not reduce mobility, toxicity, or volume of organic and inorganic contaminants through treatment. Some treatment of the soil could occur at an off-site TSDF, if required.

Short-Term Effectiveness: The short-term risk to workers, base personnel, and the public during implementation of Alternative 3 would be minimal and controllable and would primarily result from excavation and transportation activities. PPE, at a level commensurate with the contaminants involved, would be required during excavation. The risk to the environment would be greatest during excavation as a result of fugitive emissions. Air monitoring conducted during construction activities would indicate the need for any additional measures to address the short-term risks. Truck traffic would be increased across the bridge at Gate 1 and through the local area during the period of activity at the site. As many as 80 truckloads per day could be required if all soils were shipped off site and replaced. The time required to reach the RAOs is estimated at 4 to 6 months.

Implementability: Alternative 3 would be readily implementable, reliable, and available. Numerous vendors are available to provide earthmoving and transfer equipment and disposal services. Future remedial actions, if required, would be easily implementable at OFFTA through additional excavation activities.

Federal, state, and local permits may be required for the implementation of the alternative and are expected to be obtainable.

O&M requirements for this alternative are considered average and would consist of maintaining the earthmoving equipment during the excavation phase of the alternative. The maintenance schedule would be as recommended by the equipment manufacturer.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 3 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate. A cost sensitivity analysis based on the amount of soil excavated is also included in Appendix F.

Cost Description	Estimated Cost
Capital Costs	$9,733,000
O&M/Long-Term Monitoring	$0
5-Year Reviews	$22,000 (year 5 only)
Present Worth	$9,751,000

4.5 COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES

The soil remedial alternatives were individually assessed using the CERCLA criteria (EPA, 1988) in Section 4.4. This section contains a comparative analysis evaluating the relative merits of the soil alternatives in relation to each of the criteria. The purpose of the comparison is to provide a means of qualitatively ranking various alternatives to reveal the strengths and weaknesses of each. This comparative analysis focuses on the key differences between the alternatives and attempts to highlight critical issues of concern to the decision maker selecting the preferred remedial action. This analysis focuses on differences between alternatives with respect to the primary balancing criteria.

The main objectives for the preferred remedial action are to be protective of human health and the environment and to comply with ARARs, which are considered threshold criteria. For an alternative to be considered as final, these two threshold criteria must be met. The no action alternative has been removed from further analysis because the alternative does not meet the two threshold criteria. This alternative is shown in the summary table for comparison purposes but is not discussed in the text. The

following five criteria are the balancing criteria: (1) long-term effectiveness and permanence; (2) reduction of toxicity, mobility, or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost. The balancing criteria require the most discussion in this section because the major differences between alternatives frequently relate to one or more of these five criteria. Final comments addressing regulatory acceptance and community acceptance will be included in the ROD.

The comparative analysis for soil alternatives evaluates the relative performance of the alternatives in relation to each specific evaluation criterion and to the specific conditions representative of OFFTA, which contains widespread surface and subsurface contamination across the site. This approach is in contrast to that of the preceding detailed analyses in which each alternative was analyzed independently, without consideration of the others. A summary of the comparative analysis and costs for the soil alternatives is presented in Table 4-12.

Two alternatives are compared in this section: Alternative 2, which includes soil excavation, treatment of organic contamination by LTTS, removal of inorganic contamination by soil washing, and backfilling with clean processed soil; and Alternative 3, which includes soil excavation, disposal at a TSDF or an appropriate landfill, and backfilling with clean soil. Alternative 1 is not included in the comparison because it consists of no action.

Overall Protection of Human Health and the Environment: Alternatives 2 and 3 would both provide a high level of overall protection because of the source-removal action. Both alternatives would address the potential exposure pathways to protect human health and environment and would eliminate sources of contamination by removal. Neither alternative would require long-term monitoring as long as there is no remaining risk posed by contaminated soils below the vadose zone (such as to construction workers) that would require long-term monitoring. Both alternatives would provide high levels of protection over time because they both would involve excavation of contaminated soil; however, the exposure risk would be somewhat greater for Alternative 2 because of the on-site treatment and potential for fugitive air emissions. Additionally, residual contaminants below PRGs may remain in the treated backfilled soil under Alternative 2.

Compliance with Applicable or Relevant and Appropriate Requirements: The treatment steps in Alternative 2 would meet chemical-specific ARARs, and the excavation and removal of soil to a disposal facility in Alternative 3 would meet chemical-specific ARARs.

Implementation of either alternative would meet state and federal location-specific ARARs by conducting the activities in accordance with applicable and relevant and appropriate floodplain, wetland, coastal resource management, endangered species, fish and wildlife protection, and historic preservation

regulations and by coordinating with appropriate agencies to find ways to minimize adverse effects to fish, wildlife, endangered species, and historic sites.

The selected remedy must comply with the ARARs presented in Tables 2-1 through 2-3 that are specific to the alternative. Both Alternatives 2 and 3 would meet all identified ARARs.

Long-Term Effectiveness and Permanence: Both alternatives would provide long-term effectiveness and permanence because the contaminated material would be excavated for treatment or disposal. There would be some risk that a portion of the contaminated material exceeding PRGs would not be excavated during the implementation of the alternatives, but proper monitoring should reduce or eliminate this risk. The residual risk for both alternatives would be negligible. Alternative 3 would not generate any treatment residuals, whereas Alternative 2 would require some effort in residual management for the short term. Lack of proper monitoring in Alternative 2 could also result in release of residuals into the atmosphere. Both alternatives are considered reliable.

Neither alternative would require 5-year reviews to monitor the effectiveness of the remediation because there would be no contaminants exceeding PRGs left at the site. Alternative 2 would require adequate controls and reliable methods for residual management, while Alternative 3 would not require such controls because no residuals would be generated on site.

Reduction of Toxicity, Mobility, or Volume Through Treatment: Both alternatives would remove approximately 48,500 cy of contaminated soil and debris from OFFTA. Alternative 2 would be considered permanent, and Alternative 3 would be permanent for the site, but permanent destruction or immobilization of contaminants would depend on the amount and type of treatment considered at the TSDF. Only a minimal volume of soil is expected to require treatment prior to disposal at a TSDF. Alternative 2 would reduce contaminant toxicity, mobility, and volume through treatment, while Alternative 3 would not. Alternative 3 would generate no residuals whereas Alternative 2 would generate a small quantity of spent activated carbon and spent wash liquids. These residuals would be disposed of following applicable local, state, and federal regulations. The treatment in Alternative 2 would meet the statutory preference for treatment.

Short-Term Effectiveness: Alternatives 2 and 3 would both involve excavation, which would increase the exposure risk to the workers, community, and environment. Further, Alternative 2 would involve on-site treatment adding additional exposure risks. On-site short-term risks for both alternatives should be effectively managed through use of proper health and safety practices and engineering controls during excavation. Alternative 3, which transports a significant amount of material off and onto the site, would adversely impact the community because of additional truck traffic, noise, and vehicle emissions.

Controls would not do much to mitigate this impact. Alternative 2 would reach remedial objectives in about 6-8 months and Alternative 3 in 4-6 months.

Implementability: Alternative 2 would be less implementable than Alternative 3 because of the complexity of the treatment. The excavation portion of these alternatives would involve common technology, and well-maintained equipment would be very reliable. Future actions would be easy to undertake. The LTTS step in Alternative 2 would be reliable; however, improper functioning of the equipment might leave some of the contaminated soil untreated or partially treated. The reliability of soil washing would be moderate. Pilot tests and optimization of operating conditions would be required for Alternative 2 before the alternative could be implemented. Monitoring requirements for Alternative 3 would be limited to determining the extent of the excavation, with a failure of the monitoring system potentially allowing some contaminated material to remain in place. The LTTS and soil washing technologies in Alternative 2 would be reliable, and the monitoring requirements would include off-gas monitoring, wash solution concentrations, and sampling of treated soil as well as determining the extent of the excavation. Failure in the monitoring system, however, could allow uncontrolled air emissions and backfilling with untreated or partially treated soil. Contractors, equipment, operators, and disposal facilities are readily available for both alternatives. The large soil volumes involved would necessitate intensified management and O&M. An adequate number of contractors with equipment and experience are available for implementing both alternatives. TSDFs and disposal facilities are available for the disposal of soil in Alternative 3. Both alternatives may require federal, state, and base permits for transportation off site. The permits are readily obtainable.

Cost: Capital, O&M, present worth costs for the three soil alternatives are summarized as follows:

Costs	**Alternative 1 No Action**	**Alternative 2 Removal, Ex situ Treatment, and Backfill**	**Alternative 3 Removal and Disposal**
Capital	$0	$14,174,000	$9,733,000
O&M/Long-Term Monitoring	$0	$0	$0
5-Year Reviews	$22,000/5 year	$22,000 (year 5 only)	$22,000 (year 5 only)
PRESENT WORTH	$70,000	$14,192,000	$9,751,000

Alternative 3 would provide lower cost of present worth compared to Alternative 2. The higher costs are associated with the treatment steps involved in Alternative 2. Table 4-12 provides the capital, O&M, and total present worth project costs for each alternative.

5.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES FOR GROUNDWATER

Development and screening of alternatives is conducted to assemble an appropriate range of remedial options to achieve the site RAOs for groundwater. Remedial technologies retained for further consideration in Section 3.0 are combined to form remedial alternatives. Detailed evaluation of these alternatives is performed subsequently.

The alternatives are developed to comply with regulatory criteria applicable to the site conditions and the media of concern, as directed by the regulations and guidance presented in Section 2.0.

The remedial alternatives developed for the groundwater of the OFFTA site are summarized in Table 5-1. Figure 2-4 depicts the contaminated areas of groundwater at the site. COCs impacting the groundwater include benzene, 2-methylnaphthalene, naphthalene, lead, and manganese. Descriptions of each of the alternatives are provided in the following section.

5.1 RATIONALE FOR DEVELOPMENT OF ALTERNATIVES

In selecting remedial options, GRAs and process options chosen to be representative of the various technology types (see Section 3.0) are combined to form remedial alternatives to allow for future remedy selection. The alternatives are developed to address a range of risk reduction measures, future land use restrictions, and exposure scenarios. Alternatives are also developed that achieve compliance with ARARs and PRGs. Under limited circumstances, waivers may be required if ARARs cannot be satisfied.

The remedial alternatives developed to address groundwater contamination consist of combinations of no action, institutional controls, long-term monitoring, extraction, and treatment. The purpose of each remedial alternative is to prevent migration of and control contact with the contaminated media. A small range of remedial alternatives from no action to extraction and treatment of impacted groundwater is considered for detailed evaluation.

Three remedial alternatives have been developed for addressing contamination in the groundwater at OFFTA.

Groundwater Alternative 1:	No Action
Groundwater Alternative 2:	Limited Action (Use Restrictions/Long-Term Monitoring)
Groundwater Alternative 3:	Extraction and Ex Situ Treatment

5.2 DESCRIPTION OF ALTERNATIVES

The alternatives were developed to address groundwater that poses potential risks to humans. As discussed previously, the volume of groundwater requiring remediation is approximately 6.4 million gallons (pore volume) across the extent of the OFFTA site, with an average saturated thickness of the overburden aquifer of about 15 feet. The Groundwater Risk Evaluation identified the groundwater as posing risks to human health, and benzene, 2-methylnaphthalene, naphthalene, lead, and manganese have been identified as COCs. PRGs were calculated based on use of the groundwater as a drinking water source, though it is an implausible scenario due to the salinity of the water, the presence of a city water supply, and the classification of the groundwater as a GB aquifer. The monitoring wells with samples exceeding calculated PRGs are shown on Figure 2-4.

5.2.1 Groundwater Alternative 1: No Action

The No Action alternative, as required under the NCP, would involve no remedial response activities and would provide no additional protection of human health or the environment. However, it would provide a baseline for comparison to other alternatives. Since contamination would remain and unrestricted future use of the site would be allowed, 5-year reviews of the no action decision would be required.

Under this alternative no remedial actions would be performed, no measures would be implemented to restrict access to the OFFTA site, and no actions would be taken to warn people of the hazards. Natural attenuation might eventually reduce low concentrations of chemicals in groundwater to acceptable levels, but the progress of attenuation would not be monitored or evaluated.

5.2.2 Groundwater Alternative 2: Limited Action

Alternative 2 is a limited action alternative. Exposure to groundwater contaminants would be prevented through groundwater use restrictions. Groundwater monitoring would provide information on the continuing quality of the groundwater to assure that the aquifer is flushing and not further degraded. Elements of Alternative 2 would include:

- Groundwater use restrictions
- Long-term monitoring of use restrictions
- Long-term monitoring of groundwater
- Five-year reviews

Use restrictions are rules, directives, policies, and other measures (e.g., preventing the usage of groundwater, preventing the installation of new wells, and requiring the posting of signs) adopted by the appropriate authorities in a manner consistent with applicable Federal, state, and local laws. Land use at OFFTA will potentially be residential or recreational in the future, and groundwater use controls would be implemented as an Environmental Land Use Restriction (ELUR) to ensure that access to the groundwater is restricted (e.g., restrictions on groundwater wells) and to ensure protection of workers performing future site development work. These restrictions would be long-term to prevent construction of any new drinking water wells. The process by which the Navy establishes environmental land use restrictions is provided in Section 3.2.2.

Monitoring consists of ensuring the ELUR remains in place and periodic sampling and analysis of monitoring wells to assess contaminant concentrations in groundwater. Monitoring of the 13 wells on the OFFTA site would occur for 30 years (on a yearly basis for years 1-5 and every five years thereafter) analyzing for all the COCs (organics and metals). Depending if one of the removal alternatives is selected for the OFFTA soils, the existing monitoring wells may be destroyed during the soil remedial action. In that case, replacement wells could be installed in the same locations as the existing wells or be placed in a new configuration. For evaluation in the FS, it is assumed that 13 wells in the existing locations would be monitored.

Five-year site reviews would consist of evaluating the monitoring data for effectiveness of the remedial response and use restrictions.

5.2.3 Groundwater Alternative 3: Extraction and Ex Situ Treatment

Alternative 3 would offer active remediation through removal of contaminants from the groundwater by extraction and treatment. The impacted area to be addressed corresponds to the areal extent discussed in Section 2. To confirm the current conditions at site and fully delineate the extent of contamination, a confirmatory investigation would be performed at OFFTA, and the action based on extraction and treatment of groundwater would be implemented if the sampling still indicates the presence of contamination. Elements of Alternative 3 would include:

- Pre-design investigation to determine the current extent of groundwater contamination
- Installation of eight groundwater extraction wells
- Installation of a groundwater treatment system consisting of ion exchange and liquid-phase GAC
- Discharge of treated water to the POTW
- Long-term groundwater monitoring
- 5-Year reviews

The extraction of groundwater would be performed using eight new groundwater extraction wells located along the northern perimeter of the OFFTA site parallel to Narragansett Bay. The wells would be located approximately 40 feet on the inland side of the top of the bank to prevent excessive withdrawal of water from the bay. A pumping rate of 1.3 gallons per minute (gpm) at each well was estimated and should provide a steady-state capture zone sufficient to control a groundwater plume that covers the majority of the OFFTA site. The pumped groundwater would be piped to a centralized location on the OFFTA site where the water would be treated. The extracted groundwater would be passed through a metals treatment system (ion exchange) and a GAC adsorption system, and discharged to the local POTW under a National Pollutant Discharge Elimination System (NPDES) discharge permit.

Monitoring would involve periodic inspection of collection and treatment systems, monitoring the progress of remediation by sampling and analysis of groundwater (quarterly for years 1-5 and annually for years 6-30), and monitoring the effluent from the system to track the efficiency of treatment.

Five-year site reviews would consist of evaluating the monitoring data for effectiveness of the remedial action and groundwater use restrictions.

5.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives provides relevant information to support the future selection of a remedial action. Each alternative is more fully developed and further evaluated according to a prescribed set of criteria. The evaluation results are used to compare alternatives and identify key tradeoffs between the options, as well as to provide a basis for regulatory agency and public review of potential remediation alternatives for the site.

5.4 CRITERIA FOR DETAILED ANALYSIS

In accordance with the NCP and CERCLA guidance, the detailed analysis of alternatives was conducted in accordance with nine evaluation criteria. These criteria are divided into three groups: threshold criteria related to statutory requirements; balancing criteria that are technical in nature; and modifying criteria that are formally assessed following a public review and comment period. The aspects of each criterion with respect groundwater are presented as following:

<u>Overall Protection of Human Health and the Environment</u>: The primary concern, and one of the statutory requirements in remedy selection, is the overall protection of human health and the environment. The evaluation of protection is based on the ability of the remedy to eliminate, reduce, or control current and potential future exposure risks to human and ecological receptors through each applicable exposure

pathway. This protection may be in the form of treatment, engineering controls, and/or institutional controls. The overall assessment of protection draws on assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Furthermore, evaluation of protection considers short-term risks or cross-media impacts posed by implementation of a remedy.

This criterion will be used to evaluate the effectiveness of each alternative in eliminating, reducing, or controlling human health and environmental risks at the site from contact with groundwater.

Compliance with ARARs: Compliance with ARARs is one of the statutory requirements for selection of a remedy. This evaluation criterion is used to determine whether each alternative will meet all of its respective ARARs or whether justification exists for one of the six ARAR waivers allowed under CERCLA. Chemical-, location-, and action-specific ARARs are reviewed as they apply to each alternative. Alternatives are refined, as necessary, to ensure compliance with these requirements.

This criterion will be used to evaluate each alternative in complying with chemical-, location-, and action-specific federal and state ARARs and TBCs for protection of human health and the environment.

Long-Term Effectiveness and Permanence: Alternatives are assessed in terms of their long-term effectiveness and degree of permanence in offering protection of human health and the environment following implementation. The evaluation focuses on the extent and effectiveness of controls required to manage risks remaining on the site following completion of the remedial action. The analysis considers the magnitude of risks to human and ecological receptors from residuals (untreated waste or treatment by-products) remaining on site at the completion of remedial activities, the adequacy of engineering and/or institutional controls to manage residuals, the reliability of the controls to provide continued protection from residuals, and potential needs to maintain and/or replace technical components of an alternative.

This criterion will be used to evaluate each alternative for its ability to manage risks remaining on site following implementation. The no action, limited action, and treatment alternatives will be evaluated based on future risks associated with possible groundwater exposures made possible through installation of drinking water supply wells. Evaluation of alternatives will further address potential risks associated with residuals following groundwater treatment.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternatives are evaluated to address the statutory preference for remedies that employ treatment as a principal element to reduce toxicity, mobility, or volume of hazardous substances. The evaluation focuses on the following factors:

- Treatment processes employed by the remedy, as well as the materials they will treat.
- Amount of hazardous materials to be destroyed or treated.
- Degree of expected reduction in toxicity, mobility, or volume, including how the principal threats will be addressed.
- Degree to which the treatment will be irreversible.
- Type and quantity of treatment residuals that remain following treatment.
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

This criterion will be used to evaluate the effectiveness of alternatives for their ability to reduce mobility and/or their effectiveness in reducing risks through natural attenuation processes or removal with off-site disposal.

Short-Term Effectiveness: The short-term effectiveness criterion assesses potential effects to human health and the environment during the construction and implementation phase of a remedy until remedial response objectives are met. The analysis includes considering protection of both the community and on-site workers during remedial activities, environmental impacts that may result from construction or implementation activities, the reliability of measures to be taken to prevent or reduce potential impacts, and an estimation of time required to meet remedial response objectives.

This criterion will be used to evaluate each alternative for its ability to protect human health and the environment during implementation, as well as during any associated long-term monitoring activities. While the no action alternatives require no implementation activities, limited action alternatives will be evaluated for the protection they offer during implementation of institutional controls, access restrictions, and long-term monitoring. Evaluation of the treatment alternative will address treatment and disposal activities. The time required for each alternative to reach the groundwater cleanup goals will also be assessed.

Implementability: Implementability considerations include the technical and administrative feasibility of implementing an alternative, as well as the availability of goods and services on which the viability of the alternative depends. These considerations often affect the timeliness of undertaking an alternative.

Technical feasibility issues include:

- Ability to construct and operate an alternative as a whole
- Likelihood of a technology to meet specified process efficiencies and performance goals
- Ease of undertaking any required future remedial actions

- Ability to monitor the effectiveness of the remedy

Administrative feasibility deals with the activities needed and time required to coordinate with various federal, state, and local agencies in obtaining any necessary approvals and permits for off-site activities.

Issues related to the availability of goods and services include:

- Accessibility of adequate capacity and location of needed treatment, storage, and disposal services.
- Ease in obtaining necessary equipment and specialists, and provisions to ensure any additional resources.
- Timing and availability of technologies under consideration.
- Availability of services and materials, plus the potential for obtaining competitive bids.

These issues will be reviewed to evaluate the implementability of each remedial alternative. Issues will also be evaluated for both the ease of implementation and associated time frame required to coordinate subcontractors, activities, and required regulatory approvals.

Cost: This criterion encompasses all capital outlays, as well as O&M costs incurred over the lifetime of the remedial action. The detailed analysis of costs associated with each alternative will be based on accurate cost estimates and a net present worth cost analysis for a 30-year performance period. The 30-year period is evaluated for consistency even though not all the alternatives have a 30-year life.

State Acceptance: State acceptance, an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. State acceptance must be considered during remedy selection.

This criterion will not be evaluated until EPA and RIDEM have reviewed and provided comments on the FS report. Therefore, this criterion will not be included in the detailed analysis.

Community Acceptance: Community acceptance refers to the issues and concerns of “all interested parties,” as they relate to each of the alternatives under consideration. Community acceptance must be considered during remedy selection.

This criterion will not be evaluated until the Restoration Advisory Board (RAB) has reviewed and provided comments on the FS report and the public has been invited to ask questions and share their concerns during the public comment period. Therefore, this criterion will not be included in the detailed analysis.

5.5 INDIVIDUAL ANALYSES OF GROUNDWATER ALTERNATIVES

Three remedial alternatives were developed for the groundwater to address risks to human health and the environment associated with contaminants in the groundwater. Sections 5.2.1 through 5.2.3 contain brief descriptions of each alternative and describe the individual analyses of these alternatives. A summary of the analyses is presented in Table 5-2.

5.5.1 Groundwater Alternative 1: No Action

Consideration of a no action alternative is required under the NCP. At a minimum, it provides a baseline against which other alternatives may be compared. No containment, extraction, or treatment of groundwater contaminants would be conducted. No groundwater monitoring would occur, and there would be no restrictions on future groundwater use. The only activities to be conducted under Alternative 1 would be review of site conditions and risks every 5 years.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: The no action alternative would not provide long-term protection of human health and the environment and would not facilitate unrestricted groundwater use at the site. Alternative 1 would not achieve RAOs for the protection of human health or the environment, and several organic and inorganic contaminants would still exist at the OFFTA site at concentrations exceeding PRG levels until natural flushing of those contaminants occurred. Contaminants in the groundwater would pose unacceptable risks to human health if it were ever used for household use.

Because contaminants would remain at the site, 5-year reviews would be conducted, as required by CERCLA, to assess changing conditions and potential risks. Once the 5-year review results have been evaluated, and if contaminant migration is deemed to pose human health or environmental risks, then additional response actions may be warranted.

Compliance with ARARs: Tables 5-3, 5-4, and 5-5 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 1. This alternative fails to meet ARARs because it does not address groundwater exceeding PRGs that have been derived from state and federal regulations. Since no action is to be taken under this alternative, there are no state or federal location-specific or action-specific ARARs or TBCs.

Long-Term Effectiveness and Permanence: Since no remedial actions would occur under Alternative 1, the future threats to human health and the environment could remain. Potential contaminant migration pathways would not be known, and organic and metal contaminants remaining at the site could pose threats to human health through potential future groundwater use. Unacceptable carcinogenic risk from groundwater would remain for future household use of groundwater under this alternative. Aside from groundwater flushing or unmonitored natural attenuation, this alternative would offer no reduction in risk over time.

Because of the potential risk associated with leaving contaminated groundwater on site, 5-year reviews would be required. These 5-year reviews would assess whether threats or risks are increasing or abating with time and assess any changes in the conditions at the site.

Under the no action alternative, no additional controls would be used to manage the contaminants at the site. Therefore, the evaluation of the adequacy and reliability of new controls is not applicable.

Reduction of Toxicity, Mobility, or Volume Through Treatment: The no action alternative would not reduce the toxicity, mobility, or volume of contamination through treatment, since no treatment is used to address the contaminated groundwater. Alternative 1 would not satisfy the statutory preference for treatment to reduce risks posed by contaminated groundwater.

Short-Term Effectiveness: Since no response actions other than 5-year reviews would occur, implementation of the no action alternative would not pose additional short-term risks to the local community, base personnel, or the environment. Workers conducting any site activities associated with the 5-year reviews would be protected from contaminant-related risks by PPE and proper site safety procedures. Potential risks from groundwater contamination would remain unabated. None of the RAOs would be achieved.

Implementability: This alternative would require no implementation other than completion of the 5-year reviews. This activity would not require any permits, but it would require a minimal amount of coordination between regulatory agencies. Implementation of the no action alternative would not limit future implementation of additional remedial actions at the site, if deemed necessary.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 1 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	Estimated Cost
Capital Costs	$0
O&M/Long-Term Monitoring	$0
5-Year Reviews	$22,000/5 years
Present Worth	$70,000

5.5.2 Groundwater Alternative 2: Limited Action

Alternative 2 is a limited action option that would limit potential risks to human health through groundwater use restrictions. A long-term monitoring program and 5-year reviews would be conducted to evaluate risks to human health and the environment posed by the groundwater at the site. For the purposes of costing, it was assumed that annual monitoring of 13 wells would be conducted for the first 5 years, and then the sampling frequency would be reduced from annually to every 5 years thereafter. The actual monitoring frequency would be determined by the Navy and regulatory agencies based on the monitoring results and 5-year reviews. Depending on the OFFTA soil alternative selected, the existing monitoring wells may be destroyed during the soil remedial action, in which case, replacement wells would be installed.

Groundwater use restrictions would be implemented by the Navy in Alternative 2 as an ELUR. The restrictions would not allow the installation of wells for any consumptive use purpose, including for household use, drinking water supply, irrigation, or industrial use. The restriction would also apply to any consumptive use from the existing wells at the site, and describe protection measures for workers involved in future site development activities who may contact groundwater. The Navy would submit an annual report to RIDEM documenting that all of the restrictions were being met. This report would be submitted every year as long as the restrictions remained on the property, and the Office of Waste Management would periodically inspect the site to ensure that the provisions of the use restrictions were being met.

A continuous flushing model was developed for specific contaminants at the OFFTA site in order to estimate the time required for the natural system to flush residual contamination out of the aquifer after the overlying contaminated soils have been addressed. The flushing model was run for benzene and lead because they were both detected above MCLs in 1997, and for naphthalene, 2-methylnapthalene, arsenic and manganese because the groundwater risk evaluation indicated that these contaminants provided most of the risk in the groundwater risk evaluation (TtNUS, 2001) (even though arsenic was not selected as a COC). According to the model, the estimated cleanup times for benzene, naphthalene, arsenic, and lead are 2 years, 16 years, 19 years, 70 years, 182 years, and 676 years, respectively. The

long cleanup times for metals are due to their propensity to partition to the aquifer soils and resist flushing. However, the organic compounds, known to be related to fuels and combustion (and thus presumed to be site related), would be flushed out of the aquifer in a reasonable time frame.

The model and accompanying assumptions are provided in Appendix G. As the model shows, organic compounds will tend to flush faster than metals, which is true regardless of whether the water is naturally flowing through the aquifer, or being drawn from it under pumping conditions.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: This alternative would provide protection to human health by preventing use of the impacted groundwater via an ELUR until conditions allow. The effectiveness of the ELUR would depend on compliance with the restrictions.

This alternative would not provide direct protection of the environment, although monitoring data would provide information regarding any further degradation to the aquifer, and any impact to the marine sediment from the groundwater flow. However, this is not a primary concern for the groundwater medium, because the groundwater-to-sediment pathway analysis (Appendix A) has indicated that this is not a significant pathway for contaminant migration.

Implementation of the long-term monitoring program would document changes in groundwater quality that may affect future exposure risks. Because contaminants would remain at the site, 5-year reviews would be conducted to assess changing site conditions and potential risks. Results of the reviews would be used to determine the need to implement future remedial actions at the site or change the required frequency of long-term monitoring events.

This alternative would meet RAOs for protection of human health by preventing human exposure to the contaminated groundwater. The RAO for protection of the environment would be met over time as natural flushing of the groundwater takes place.

Compliance with ARARs: Tables 5-6, 5-7, and 5-8 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 2. This alternative meets chemical-specific ARARs because through use restrictions, it prevents exposure to groundwater exceeding PRGs that were derived from federal and state water quality standards. Several non-promulgated criteria (TBCs) were also used in assessing human health risks and developing groundwater PRGs.

Federal and state location-specific ARARs for this alternative include coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations. Any actions taken under this alternative (e.g., monitoring) that would affect the resources protected by these regulations would be conducted in accordance with the substantive requirements of the regulations.

Action-specific ARARs would be met through the monitoring program.

Long-Term Effectiveness and Permanence: This alternative would rely on use restrictions to limit access to the impacted groundwater and thereby reduce human risk associated with its use. Restrictions on groundwater use would require long-term enforcement by the state and the Navy to ensure their protectiveness. The yearly reporting requirements to RIDEM would help confirm that the restrictions were being met.

The limited action alternative would provide no long-term protection of ecological receptors or the environment. However, there is uncertainty if there is a completed exposure pathway from the groundwater contaminants to the ecological receptors, based on the groundwater-to-sediment analysis presented in Appendix A. If a soil removal alternative were implemented (the site soils are presumed to be the contaminant source), natural flushing of the groundwater would remove the remaining organics in a reasonable time frame, while institutional controls would eliminate the possibility for use of groundwater as water supply in the meantime. Annual monitoring and 5-year reviews of this alternative would be required to evaluate the effectiveness of the alternative.

Reduction in Toxicity, Mobility, or Volume through Treatment: This alternative would not include any groundwater treatment processes. Therefore, the limited action alternative would offer no reduction in contaminant toxicity, mobility, or volume through treatment. Some reduction in toxicity and volume due to natural processes in groundwater could result in lower contaminant concentrations. However, Alternative 2 would not satisfy the statutory preference for treatment to reduce risks posed by contaminated groundwater.

Short-Term Effectiveness: A slight increase in short-term risks could potentially result from the implementation of this alternative due to potential short-term impacts to workers associated with annual monitoring activities. These would be addressed through proper use of PPE and by using proper handling, storage, and disposal procedures for potentially contaminated groundwater samples. Implementation of this alternative would not pose any safety concerns to nearby communities, the environment, or on-site workers.

Each annual monitoring activity would require approximately 1 week. RAOs associated with preventing risks to human health would be addressed when the use restrictions are in place, but RAOs for protection of the environment would not be directly achieved.

Implementability: Implementation of this alternative would involve implementing groundwater use restrictions and completing a long-term monitoring program and 5-year reviews. Limited manpower is necessary for implementation of groundwater use restrictions. Consistent enforcement of the use restrictions by the Navy would be required, as would annual reports to RIDEM.

The establishment of a long-term monitoring program to assess groundwater quality would be easily implemented, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require some coordination with regulatory agencies.

Implementation of the limited action alternative would not impede execution of future remedial actions at the site, if deemed necessary.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 2 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	**Estimated Cost**
Capital Costs	$53,000
O&M/Long-Term Monitoring	$44,000/year (years 1-5 and 5-year intervals) $11,000/year (other years)
5-Year Reviews	$22,000/5 years
Present Worth	$543,000

5.5.3 Groundwater Alternative 3: Extraction and Ex Situ Treatment

Alternative 3 features the removal of contaminants from the groundwater through extraction and treatment. The extraction of groundwater would be performed using eight new groundwater extraction wells located along the northern perimeter of the OFFTA site parallel to Narragansett Bay. The wells would be located approximately 40 feet on the inland side of the top of the bank to prevent excessive withdrawal of water from the bay. Figure 5-1 shows the proposed layout of the wells. These wells would fully penetrate the overburden aquifer, which has an average saturated thickness of 15 ft. A pumping rate of 1.3 gpm at each well was estimated using the EPA's Wellhead Protection Area model and should provide a steady-state capture zone sufficient to control a groundwater plume that covers the majority of

the OFFTA site. The model output and other design calculations are provided in Appendix G. A pumping test would be performed at OFFTA to determine the site-specific hydraulic conductivity, well yield, and capture zone to support the final design of an extraction well system. The pumped groundwater would be piped to a centralized location on the OFFTA site where the water would be treated. The extracted groundwater would be passed through an ion exchange system (for metals treatment) and a granular activated carbon (GAC) adsorption system for organics. Discharge would be to the local POTW under a National Pollutant Discharge Elimination System (NPDES) discharge permit.

Ion exchange is a reversible exchange of ions between the liquid and the solid phase. Ions held by electrostatic forces to charged functional groups on the surface of the insoluble solid are replaced by ions of similar charge in a solution. Ion exchange is stoichiometric, reversible, and selective in removal of dissolved ionic species. Ion exchange materials (resins) have the capability for regeneration, chemical and physical stability, and low solubility. Cation resins contain negatively charged functional groups such as sulfonic or carboxylic acids which exchange a positively charged hydrogen ion (H+) for a cation. Similarly, anion resins contain positively charged functional groups such as quaternary amines that exchange hydroxide ion (OH-) for a negatively charged ion.

Carbon adsorption is a well-proven, reliable technology to remove organics from water. The principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As water flows through the carbon, the organic molecules occupy the surface sites on the activated carbon grains until the capacity is reached, at which time the carbon is either regenerated or disposed of.

Extracted water would be pumped to an equalization tank with a 1-hour retention time from which it would be pumped through the ion exchange unit and a carbon column. The ion exchange unit would remove the metals (lead and manganese) and associated contaminants from water. The organic contaminants and residual metal concentrations would be addressed by the liquid-phase GAC adsorption unit. Using the hydraulic data collected during the RI, the total extraction rate from the groundwater extraction wells is estimated as 10.4 gpm (1.3 gpm from eight wells, see Appendix G). Considering a 25 percent capacity factor, the minimum treatment system capacity would be 13 gpm. The ion exchange system would consist of two carbon steel ion exchange columns; one ion exchange column would be in operation and the other would be in standby. The columns would be skid-mounted with automatic valves and programmable logic controller controls. The columns would be mixed bed type consisting of a cation resin and an anion resin with an inert resin in between to separate layers during regeneration. Before the installation of the full-scale ion exchange system, a bench/pilot-scale study would be performed to determine the efficiency of the full-scale system and to determine the type of resin required for effective treatment. Following the ion exchange unit, the water would pass through a bag filter and then go to the

GAC adsorption unit. The carbon system would consist of carbon vessels in series with monitoring points in between so that breakthrough of the first vessel could be detected. It would then be taken out of service for regeneration or disposal, and the second vessel would be come the first in the series. Treated water would be discharged to a local POTW under an NPDES discharge permit. A block flow diagram of the treatment process is also presented in Appendix G. Treatment would be for a period of 30 years and would be monitored using the wells at the existing monitoring locations. Monitoring would involve periodic inspection of collection and treatment systems, monitoring the progress of remediation by sampling and analysis of groundwater (quarterly for years 1-6 and annually for years 7-30), and monitoring the efficiency of treatment.

Five-year site reviews would consist of evaluating the monitoring data for effectiveness of the remedial action.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 3 would collect and pump contaminated groundwater for treatment with ion exchange and carbon adsorption. The success of this alternative is dependent on the contaminants being removed from the ground with the groundwater. The flushing model, presented as Appendix G of this report, shows that natural recovery of the aquifer is possible in a certain number of years, based on the propensity of the contaminants to be dissolved into and removed with the groundwater. Using extraction wells to pump water from the aquifer does not necessarily accelerate this process, because the maximum pumping rate is limited by the hydrogeologic ability of the aquifer to transmit water. With the extraction wells being near the shoreline, the wells intercept the water that would normally discharge to the bay but would not necessarily increase flow through the aquifer.

Therefore, the system would be successful in removing organics from the environment, but the metals are likely to remain in the aquifer for an extended period of time, regardless of the presence of the treatment system.

This alternative would provide protection to human health, but only provide protection to the environment if the pumping rate and configuration were such that contaminants would be captured prior to impacting the marine sediment. Monitoring the groundwater would confirm that the aquifer is not further degraded.

There would also be increased short-term risks to on-site workers from potential exposures to contaminated groundwater during installation of extraction wells and the treatment system. These risks would be minimized through the use of PPE and proper safety procedures.

Implementation of the long-term monitoring program would allow assessment of the restoration of the groundwater and any changes in its quality, and a 5-year review would allow assessment of site conditions and potential risks. The results of monitoring and 5-year reviews would be used to determine whether additional remedial actions are needed at the site and whether long-term monitoring and 5-year reviews may be discontinued.

Compliance with ARARs: Tables 5-9, 5-10, and 5-11 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 3. This alternative would comply with federal and state chemical-specific ARARs (water quality standards) used to derive groundwater PRGs because groundwater exceeding the PRGs derived from these standards would extracted and treated.

Implementation of Alternative 3 would meet all state and federal location-specific ARARs by conducting the activities in accordance with coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to identify and minimize adverse effects to endangered species and historic sites.

Alternative 3 would also be conducted in accordance with all identified state and federal action-specific ARARs. The action-specific ARARs identified for this alternative include CWA requirements for discharging treated groundwater.

Long-Term Effectiveness and Permanence: Groundwater collection and treatment using ion exchange and liquid-phase GAC adsorption are proven and established technologies. The long-term reliability and effectiveness of the systems are proven. Once the treatment system is properly designed and installed, Alternative 3 would offer long-term reliability though effectiveness would be based on the success of the removal of the metals from the ground. Being an ex situ treatment, failure of the system would be easily identifiable. The performance of the system would be monitored by the wells and treated effluent.

Reduction in Toxicity, Mobility, or Volume Through Treatment: Treatment using ion exchange and liquid-phase GAC adsorption would offer reduction in toxicity, mobility, and volume. Any contamination sources in groundwater would be treated by this alternative. Therefore, Alternative 3 would meet the statutory preference for treatment.

Short-Term Effectiveness: Alternative 3 would involve pumping the groundwater from the extraction wells, designing and building an ion exchange and liquid-phase GAC adsorption facility, and discharging to the POTW. The installation of the extraction wells would involve drilling and might disturb the contaminated areas. The short-term risks to workers and the environment would be low. With proper work practices, implementation of this alternative would not pose any safety concerns to nearby communities, the

environment, or on-site workers. Dust suppression to control potential fugitive dust emissions and air monitoring would be used as necessary to ensure worker safety during remedial activities at the site. Limited O&M would be required for the ion exchange and carbon adsorption units, and no unacceptable exposure to workers is anticipated. OSHA standards would be followed during the implementation of the remedial action.

Sampling of groundwater might expose workers to hazardous substances; however, exposure to workers during sampling would be minimal and could be controlled by following standard practices. On-site workers would be protected from exposure to hazardous substances through the appropriate use of PPE and through compliance with a site-specific HASP.

Implementability: Implementation of Alternative 3 would be moderately complex to implement. Extraction wells, ion exchange, liquid-phase GAC adsorption units, and the discharge line could be installed at the site, though dedicated space, power, access, and support facilities would have to be assigned for those improvements. Ion exchange and liquid-phase GAC adsorption are established technologies and have been used extensively, and materials and labor are available for installing the ion exchange and liquid-phase GAC adsorption systems, collection system, and discharge line as well as for periodic sampling. This alternative should take about one year to implement, but would have to remain in operation for a number of years, requiring administrative management and operational efforts. Permits for installing the extraction wells; disposing sludge containing metals, spent carbon, and spent resins; and installing a discharge line to the POTW might be required. Administrative issues and coordination with other agencies or acquiring permits are achievable.

Performing long-term monitoring to assess groundwater concentrations quality would be easily implementable, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require coordination with regulatory agencies.

Implementation of this extraction and treatment alternative would not limit future implementation of additional remedial actions at the site.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 3 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	Estimated Cost
Capital Costs	$586,000
O&M/Long-Term Monitoring	$158,000/year (years 1-5) $59,000/year (other years)
5-Year Reviews	$22,000/5 years
Present Worth	$2,128,000

5.6 COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES

A comparative analysis is conducted to evaluate the significant differences between alternatives based on the threshold and balancing criteria. This analysis is provided below and summarized in Table 5-12.

A comparative analysis of groundwater alternatives is presented to address how effectively each alternative would comply with the standards listed in the guidance (USEPA, 1994). Alternative 1 (No Action) is considered for baseline purposes and is not expected to satisfy any of the requirements; therefore, this alternative is not compared with the other alternatives in assessing the relative merits.

Overall Protection of Human Health and the Environment: Alternatives 2 and 3 are both effective in protecting human health. Once the contaminant sources in soil are located and controlled, Alternatives 2 and 3 would both provide protection to human health by preventing exposure to impacted groundwater, either through use restrictions or treatment. Alternative 2 would provide immediate protection to human health through ELUR, although this is not imperative because no exposure points currently exist at the site. Alternative 3 would provide protection later, after contaminants are removed, but this would only occur after a series of years.

Alternative 3 may be considered more effective compared to Alternative 2 because it removes the contaminants from the environment, rather than allowing them to flush through the system. However, because it is based on water flushing it may not meet cleanup objectives any faster than Alternative 2. For protection of the environment, Alternative 3 is more effective because it prevents migration of groundwater to the marine sediments through the use of extraction wells, whereas Alternative 2 allows those contaminants to flush through the system and uses monitoring to identify any degradation of marine sediments. This should be adequate since groundwater was not identified as possibly impacting ecological receptors in the marine sediment (Appendix A).

Alternative 3 would provide ex situ treatment to address the contaminants and, therefore, would provide a higher degree of protection than Alternative 2, although Alternative 2 would be able to provide an adequate degree of protection at a reasonable cost.

Compliance with ARARs: Both alternatives meet chemical-specific ARARs because they prevent exposure to groundwater exceeding PRGs that were derived from federal and state water quality standards. Alternative 2 accomplishes this with groundwater use restrictions, and Alternative 3 accomplishes this through extraction and treatment.

Implementation of either alternative would meet all state and federal location-specific ARARs by conducting the activities in accordance with coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to identify and minimize adverse effects to endangered species and historic sites.

Alternative 3 would also be conducted in accordance with all identified state and federal action-specific ARARs. The action-specific ARARs identified for this alternative include CWA requirements for discharging treated groundwater. Alternative 2 does not have action-specific ARARs other than related to monitoring.

Long-Term Effectiveness and Permanence: Alternative 3 would have the higher long-term effectiveness because of the aggressive treatment and removal of contaminants from the system. The treatment technologies involved in Alternative 3 are proven reliable, although removal of metals can take a very long time. Alternative 2 would provide effectiveness by preventing exposure to groundwater through use restrictions; it would also provide some long-term reliability and effectiveness from natural flushing. Alternative 2 would provide long-term reliability and effectiveness in a cost-effective manner.

Reduction in Toxicity, Mobility, or Volume Through Treatment: Alternative 3 would provide reduction in the toxicity, mobility, or volume of waste because of its extraction and treatment. Extraction wells would reduce mobility of contaminants, and ion exchange and GAC adsorption would reduce toxicity. Alternative 2 does not provide reduction of toxicity, mobility, or volume of waste through treatment, as no active treatment is proposed.

Short-Term Effectiveness: Alternative 2 would offer the higher short-term effectiveness because the alternative does not involve any major construction activity and use restrictions could be implemented in a timely manner. Alternative 3 would require relatively extensive construction activities and would not become effective until extraction and treatment reduced contaminants below the PRGs. However, neither of these alternatives would pose any threat to local communities or on-site personnel during the implementation of the remedial action. On-site workers would be protected from exposure to hazardous substances through the appropriate use of PPE and through compliance with a site-specific HASP. OSHA standards would be followed for either alternative during the implementation of the remedy.

Implementability: Both alternatives are implementable; however, Alternative 2 would be the easier to implement because it does not involve construction or operation of a remediation system. The technologies involved in Alternative 3 are proven, and several similar systems have been installed at various locations. Construction and operational services for Alternative 3 are available. Administrative, management, and operational issues and coordination with other agencies or acquiring permits are more easily achievable for Alternative 2. Future remedial actions would not be hindered by the alternatives. Alternative 3 would take longer to implement and become effective as compared to Alternative 2.

Cost: Capital, O&M, present worth costs for the three groundwater alternatives are summarized as follows:

Costs	**Alternative 1 No Action**	**Alternative 2 Limited Action**	**Alternative 3 Extraction and Treatment**
Capital	$0	$53,000	$586,000
O&M/ Long-Term Monitoring	$0	$44,000/year (years 1-5 and 5-year intervals) $11,000/year (other years)	$158,000/year (years 1-5) $59,000/year (other years)
5-Year Reviews	$22,000/5 years	$22,000/5 years	$22,000/5 years
PRESENT WORTH	$70,000	$543,000	$2,128,000

6.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES FOR MARINE SEDIMENT

Development and screening of alternatives is conducted to assemble an appropriate range of remedial options to achieve the site RAOs for sediment. Remedial technologies retained for further consideration in Section 3.0 are combined to form remedial alternatives. Detailed evaluation of these alternatives is performed subsequently.

The alternatives are developed to comply with regulatory criteria applicable to the site conditions and the media of concern, as directed by the regulations and guidance presented in Section 2.0.

The remedial alternatives developed for the marine sediment in the shoreline and nearshore areas of the OFFTA site are summarized in Table 6-1. The alternatives are developed to apply to marine sediment located within the shoreline (intertidal zone) as well as nearshore marine sediment (sediment below the low-tide line). Affected sediment at these locations is addressed as a whole and is referred to as marine sediment. Figure 2-4 depicts the contaminated areas of marine sediment zones. COCs impacting the marine sediment include various PAHs and arsenic. Descriptions of each of these alternatives are provided in the following section.

6.1 RATIONALE FOR DEVELOPMENT OF ALTERNATIVES

In selecting remedial options, GRAs and process options chosen to be representative of the various technology types (see Section 3.0) are combined to form remedial alternatives to allow for future remedy selection. The alternatives are developed to address a range of risk reduction measures, future land use restrictions, and exposure scenarios. Alternatives are also developed that achieve compliance with ARARs and PRGs. Under limited circumstances, waivers may be required if ARARs cannot be satisfied.

The remedial alternatives developed to address marine sediment contamination consist of combinations of no action, institutional controls, long-term monitoring, removal, and disposal. The purpose of each remedial alternative is to prevent migration of and control contact with the contaminated media. A range of remedial alternatives from no action to complete removal and disposal of impacted media is considered for detailed evaluation.

The sediment contaminant concentrations are sufficiently low that the sediment would likely be acceptable for disposal in a solid waste (RCRA Subtitle D) landfill without treatment. However, to accommodate the possibility that highly contaminated sediment may be encountered during remedial

action, TSDF disposal is considered. Four remedial alternatives have been developed for addressing contamination in marine sediment at OFFTA.

Sediment Alternative 1: No Action
Sediment Alternative 2: Limited Action (Access Restrictions/ Monitoring) as an Interim Measure
Sediment Alternative 3: Limited Removal and Disposal (Beach Area)
Sediment Alternative 4: Removal and Disposal Option A
Sediment Alternative 5: Removal and Disposal Option B

6.2 DESCRIPTION OF ALTERNATIVES

The alternatives were developed to address sediment in the areas identified as posing potential risks to humans (through recreational exposures) and ecological receptors. As discussed previously, the areas requiring remediation consist of the beach area and nearshore areas near sample stations SD-410, OFF-3, OFF-5, and OFF-6. The depth interval of contamination above PRGs is approximately 2 vertical feet of sediment along the beach and 1 vertical foot in the nearshore. The beach and nearshore elevated-risk areas exceeding recommended PRGs are shown on Figure 2-4. The HHRA and marine ERA evaluations identified the marine sediment along the beach as posing risks to both human health and the environment and sediment in the nearshore as posing risk to the environment because of concentrations of PAHs and arsenic.

6.2.1 Sediment Alternative 1: No Action

The no action alternative, as required under the NCP, would involve no remedial response activities and would provide no additional protection of human health or the environment. However, it would provide a baseline for comparison to other alternatives. Since contamination would remain and unrestricted future use of the nearshore environment would be allowed, 5-year reviews of the no action decision would be required.

Under this alternative no remedial actions would be performed, no measures would be implemented to restrict access to the marine environment adjacent to OFFTA, and no actions would be taken to warn people of the hazards associated with wading in the area. However, measures currently in place would continue to provide limited protection of human health. Existing measures that provide some protectiveness include a no swimming policy for the NAVSTA Newport shorelines and fencing around the OFFTA that limits access to the shoreline.

6.2.2 Sediment Alternative 2: Limited Action

The limited action alternative would be implemented as an interim measure. This alternative would include restricting recreational access to the intertidal area and monitoring all sediment areas with COC concentrations exceeding PRGs until the effects of the selected soil alternatives on the sediments can be realized. As an interim action, the alternative can be concluded at any time and replaced with a more active alternative, rather than waiting for a five year review period to be concluded. If monitoring data shows that risks to human and ecological receptors remain the same or are increasing, then another alternative will be selected by consensus with the regulatory oversight parties.

This limited action alternative would provide some protection of human health by employing access restrictions preventing recreational activities on the beach (intertidal) area. However, the alternative would provide no removal or treatment of impacted material. Therefore, it would provide no protection of the environment or ecological receptors. It would employ a long-term monitoring program to allow evaluation of changing conditions at the site following the removal of the presumed source of the COCs. Because contamination would remain, 5-year reviews of the alternative would be required to evaluate the risks to human health and the environment posed by the site in the future.

Access restrictions (shoreline fencing, buoys, and signs) would discourage public access and recreational use of the shoreline and state-owned land in the intertidal zone, thereby increasing the effectiveness of the existing use restrictions and reducing risks to human health by changing the use of the intertidal area from a recreational/residential use scenario to a trespasser use scenario. The existing shoreline fencing would be extended to restrict access to all of the beach areas exceeding PRGs. A perimeter buoy system would be placed at 100-foot intervals approximately 10 to 20 feet seaward of the mean low water line; in order to identify areas restricted from recreational use. Warning signs would be posted on the fencing and buoys to warn people of the potential hazards associated with the use of the area. Buoys could also include such features as internal radar reflecting material and reflective markings. Buoy anchoring would likely consist of a triangular placement of ballast to minimize drift and to provide a consistent demarcation of the impacted area. Additional signs would be strategically placed along the shoreline. The fencing, signs, and buoys would be inspected quarterly. Repair/replacement would be on an as-needed basis.

The long-term monitoring program would assess the quality of the marine environment over a 30-year period to evaluate changes in human health and ecological risk. The long-term monitoring program would include sediment chemistry and toxicity. Monitoring would involve measuring parameters that were previously found to contribute to human health or ecological risk. For costing purposes, it is assumed that samples would be collected from twelve locations (six for human health risk and six for

ecological risk) in the nearshore sediment at areas selected to correspond to sample stations tested in the previous investigations. The analyses would include sediment chemistry (PAHs and arsenic), porewater chemistry (arsenic), and sediment toxicity to amphipod and arabacia.

Given the nature of sediment contamination and the slow changes in sediment quality anticipated, a single sampling event per year was assumed to be sufficient to monitor long-term sediment quality trends. For the purposes of costing, it was assumed that annual monitoring would be conducted for the first 5 years and then, assuming that the sediment quality did not change significantly, the long-term sampling frequency would be reduced from annually to every 5 years or after the occurrence of a major storm. The final long-term monitoring plan, which would specify all the details of the monitoring program, including analytical methods, sampling locations, and sampling frequency, would be developed in coordination with EPA and RIDEM.

The results of the monitoring would be compiled and an evaluation of the findings and associated risks would be conducted every 5 years, as required by CERCLA. The results of these 5-year reviews would be used to identify any changes in the contaminant concentrations and to document the need to implement future response actions at the site or change the required frequency of long-term monitoring events.

6.2.3 Sediment Alternative 3: Limited Removal and Disposal (Beach Area)

This alternative was developed to address the contaminated sediment through a combination of removal and monitoring. Subtidal sediment within the nearshore areas would remain intact while all of the impacted intertidal sediment exceeding PRGs along the beach would be removed using appropriate excavation techniques. In order to monitor the risk to the ecological receptors from the remaining sediment, and to evaluate the potential for recontamination of remediated areas, long-term monitoring would be implemented.

Removal would involve more than 94 percent of contaminated sediment at the site with an estimated volume of about 5,716 cy. (The remaining 6 percent is the 290 cy associated with the nearshore areas.) After excavation activities are complete, the beach area would be backfilled with clean materials similar to the existing substrate. The sediment removal area is shown on Figure 6-1. Elements of Alternative 3 would include:

- Pre-design investigation
- Installation of engineering controls to minimize erosion and sediment migration during construction

- Removal of 5,716 cy of contaminated sediment from the beach (intertidal) area
- Confirmation sampling of excavated areas to ensure complete removal of contaminated sediment
- Sediment dewatering
- Treatment of dewatering fluids and discharge to bay
- Disposal of sediment at TSDF
- Backfill with natural fill to original grade
- Long-term monitoring of nearshore (subtidal) areas exceeding ecological PRGs
- Monitoring the restored area to assess potential recontamination
- Five-year reviews

A PDI would be performed to gather information needed to complete the final remedial design. The PDI would include a series of shallow-core samples to confirm the nature and extent of contamination and determine the treatment requirements for fluids to be generated during excavation and dewatering. Approximately 25 borings would be advanced to confirm the extent of sediment contamination and define the area for sediment removal. Borings would also be used to gather geotechnical information needed to select the removal methods best suited for the materials present. The PDI would also include a detailed evaluation regarding any treatment requirement for the sediment prior to proper disposal.

Engineering controls would be installed around the perimeter of the area to be excavated to minimize sediment migration. A temporary cofferdam system such as a “port-a-dam” will be utilized where water depths allow so that excavations can be performed in areas where water presence can be controlled.

Impacted sediment would be excavated and segregated by size and, if required, by the type of contaminants, although this is not anticipated based on the contaminants detected in the beach sediment. Land-based excavation would be performed using conventional earth-moving equipment such as track-mounted excavators, front-end loaders, bulldozers, and dump trucks.

All excavated sediment would be staged and processed at a centralized location. Removed materials would be dewatered before being transported for final processing and staging. Water generated from sediment dewatering would be treated to meet applicable standards and then be discharged to the bay. An estimated 5,716 cy of contaminated sediment would be excavated as part of Alternative 3. Excavated sediment would be screened to remove debris and stones over approximately 6 inches in diameter. The screened material would be segregated as follows:

- For the purposes of this FS, it was assumed that approximately 20 percent of the excavated material (1,143 cy) would be over 6 inches in diameter and would be suitable for reuse after

decontamination by methods permitted under relevant hazardous waste standards. These large rocks and boulders would be decontaminated to remove any contaminated sediment and then be staged for reuse as backfill.

- Screened material less than or equal to 6 inches in diameter (4,573 cy or 80 percent of the excavated material) would be staged separately for disposal. All trash and debris such as steel and concrete would be included with this portion of the excavated material, regardless of size. Any large debris to be sent off site for recycling or disposal would first be decontaminated to remove any contaminated sediment. Water generated from rock and debris decontamination would be treated to meet applicable standards and then be discharged to the bay.

Evaluation of the existing analytical data indicates that sediment contaminant levels are low enough that the material would not require any stabilization for disposal at a TSDF or would likely meet requirements for disposal in a RCRA Subtitle D landfill without treatment. However, if the sediment requires stabilization prior to transportation to the TSDF, lime stabilization would be carried out.

Following removal operations, excavated areas would be sampled and tested using field test methods and confirmed through laboratory analysis to ensure complete removal. The areas would then be backfilled to their original grade with a mix of clean fill materials selected and placed to assist in the natural restoration of the intertidal community that would be destroyed by excavation. The proposed excavation and backfilling would remove and replace approximately 1.77 acres of existing rocky intertidal marine habitat, temporarily destroying the benthic community in the area. The proposed backfill would promote the natural restoration of the affected benthic community by providing an optimal habitat structure to support a diverse and stable benthic community. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. The long-term O&M program would include regular inspection of the backfilled areas to assess the condition of the habitat. It is anticipated that the ecological community would be reestablished within 1 to 4 years.

The backfill substrate would be placed to provide a stable and non-uniform habitat structure to promote community growth and diversity. The fill substrate would consist of graded sand, gravel, and stone sized similar to the current materials in the beach and nearshore sediment that are not impacted. Implementation of this alternative would not impact eelgrass beds located in the nearshore and offshore station areas adjacent to the site. Efforts would be taken during excavation to minimize turbidity that could result in damage to the eelgrass beds. Any slight damage to eelgrass beds is expected to be mitigated by natural restoration, which would be monitored during long-term monitoring.

Long-term monitoring would include two elements – sediments would be monitored in the area where removal actions had occurred to evaluate possible recontamination, but also sediment and biota chemistry as well as amphipod and arabacia toxicity would be monitored in the areas where sediments exceeding ecological PRGs remain to determine if the source removal action results in a reduction of these contaminants over time. Both monitoring efforts will be conducted annually for the first 5 years after the remedial action is completed, and then every five years thereafter to correspond to five year reviews.

6.2.4 Sediment Alternative 4: Removal and Disposal Option A

This alternative was developed to address contaminated beach and nearshore marine sediment through removal and disposal while providing protection to eelgrass beds. Sediment within and adjacent to the eelgrass beds would not be removed while the rest of the impacted sediment exceeding PRGs would be removed using appropriate excavation techniques. Based on current data, there are approximately 76 cy of contaminated sediment associated with eelgrass beds in the area surrounding sample SD-410. This area of eelgrass would not be removed under this alternative. In order to monitor the risk from the remaining sediment, long-term monitoring would be implemented.

Removal would involve more than 98 percent of contaminated sediment at the site with an estimated volume of about 6006 cy. (The remaining 2 percent is the 76 cy associated with the eelgrass beds.) After removal activities are complete, the areas would be backfilled with clean materials similar to the existing substrate. The sediment removal area is shown on Figure 6-2. Elements of Alternative 4 would include:

- Pre-design investigation
- Installation of engineering controls to minimize erosion and sediment migration during construction
- Removal of 5,716 cy of contaminated sediment from the beach (intertidal) area
- Removal of 214 cy of contaminated sediment from the nearshore (subtidal) areas exceeding ecological standards (not including any areas containing eelgrass)
- Use of portadams and a temporary excavator causeway to facilitate removal
- Confirmation sampling of excavated areas to ensure complete removal of contaminated sediment
- Sediment dewatering
- Treatment of dewatering fluids and discharge to bay
- Disposal of sediment at TSDF
- Backfill with natural fill to original grade

- Long-term monitoring of eelgrass beds and shellfish
- Monitoring the restored area to assess potential recontamination
- Five-year reviews

A PDI would be performed to gather information needed to complete the final remedial design. The PDI would include a series of shallow-core samples to confirm the nature and extent of contamination and determine the treatment requirements for fluids to be generated during excavation and dewatering. Approximately 25 borings would be advanced to confirm the extent of sediment contamination and define the area for sediment removal. Borings would also be used to gather geotechnical information needed to select the removal methods best suited for the materials present. If it is determined from the PDI that suction dredging would be better suited to remove the sediments near the eelgrass areas and could better protect those areas, this change will likely be made with approval of the oversight parties. The PDI would also include a detailed evaluation regarding any treatment requirement for the sediment prior to proper disposal.

Engineering controls would be installed around the perimeter of the area to be excavated to minimize sediment migration. Portadam structures (steel A-frame supports holding an impervious fabric membrane to hold back up to 9.5 feet of water) would be used for the nearshore excavations at areas OFF-3, -5, and –6 to allow the work to be performed under relatively dry conditions. The maximum depth in these areas during high tide is approximately 7.75 feet (TtNUS, 2002). The area surrounding sample SD-410 is approximately 10 feet deep during high tide, which exceeds the depth limits for the portadam. Therefore, a temporary excavator causeway may be installed for access to the areas past the low-tide line to facilitate excavation. The causeway would be constructed by placing stone into the bay perpendicular to the shoreline in the area of sample SD-410. The exact location of the causeway would be finalized after the PDI and by optimizing it to provide necessary access to the required excavation areas. A typical cross-section of the causeway is shown on Figure 6-2. Contaminated sediment and debris would be excavated from the path of the causeway as it was being built, and Rhode Island Department of Transportation (RIDOT) specified R-6 stone would be installed over the excavated portion to construct the causeway. Construction would be performed in sections by starting from the shore, excavating an area of contaminated sediment, backfilling, and then placing the stone for the road. Then, from the end of the causeway, the excavator would excavate, backfill, and place the next section. The causeway surface would typically be 1 to 2 feet above the mean high tide level and approximately 20 feet wide. Once sediment removal was complete, the excavators would then remove the causeway, recycling or disposing of the R-6 stone.

An alternative to the causeway would be the use of suction dredging in areas where water depth exceeds limits for the portadam. Suction dredging could be performed from the shoreline, and may be better

suited to removal of the sediments while protecting the eelgrass areas nearby. The determination of the use of the causeway or suction dredging will be determined after completion of the PDI. Due to the small size of the area and the complexity of the construction of the causeway, the potential cost impact for this change are not large enough to be detailed as a separate alternative.

Impacted sediment would be excavated and segregated by size and, if required, by the type of contaminants, although this is not anticipated based on the contaminants detected in the beach and nearshore marine sediment. Land-based excavation would be performed using conventional earth-moving equipment such as track-mounted excavators, front-end loaders, bulldozers, and dump trucks. A trackhoe with a long-reach arm would be able to access the required areas from the causeway.

All excavated sediment would be staged and processed at a centralized location. Removed materials would be dewatered before being transported for final processing and staging. Water generated from sediment dewatering would be treated to meet applicable standards and then be discharged to the bay. An estimated 5,930 cy of contaminated sediment would be excavated as part of Alternative 4. Excavated sediment would be screened to remove debris and stones over approximately 6 inches in diameter. The screened material would be segregated as follows:

- For the purposes of this FS, it was assumed that approximately 20 percent of the excavated material (1,186 cy) would be over 6 inches in diameter and would be suitable for reuse after decontamination by methods permitted under relevant hazardous waste standards. These large rocks and boulders would be decontaminated to remove any contaminated sediment and then be staged for reuse as backfill.

- Screened material less than or equal to 6 inches in diameter (4,744cy or 80 percent of the excavated material) would be staged separately for disposal. All trash and debris such as steel and concrete would be included with this portion of the excavated material, regardless of size. Any large debris to be sent off site for recycling or disposal would first be decontaminated to remove any contaminated sediment. Water generated from rock and debris decontamination would be treated to meet applicable standards and then be discharged to the bay.

Evaluation of the existing analytical data indicates that sediment contaminant levels are low enough that the material would not require any stabilization for disposal at a TSDF or would likely meet requirements for disposal in a RCRA Subtitle D landfill without treatment. However, if the sediment requires stabilization prior to transportation to the TSDF, lime stabilization would be carried out.

Following removal operations, excavated areas would be sampled and tested using field test methods to ensure complete removal, then backfilled to their original grade with a mix of clean fill materials selected and placed to assist in the natural restoration of the benthic community that would be destroyed by excavation. The proposed excavation and backfilling would remove and replace approximately 1.9 acres of existing rocky intertidal and subtidal marine habitat, temporarily destroying the benthic community in the area. The proposed backfill would promote the natural restoration of the affected benthic community by providing an optimal habitat structure to support a diverse and stable benthic community. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. The long-term O&M program would include regular inspection of the backfilled areas to assess the condition of the habitat. It is anticipated that the ecological community would be reestablished within 1 to 4 years.

The backfill substrate would be placed to provide a stable and non-uniform habitat structure to promote community growth and diversity. The fill substrate would consist of graded sand, gravel, and stone sized similar to the current materials in the nearshore sediment that are not impacted. Implementation of this alternative would not impact eelgrass beds located in the nearshore and offshore station areas adjacent to the site. Efforts would be taken during excavation to minimize turbidity that could result in damage to the eelgrass beds. Slight damage to eelgrass beds would be mitigated by natural restoration, which would be monitored during long-term monitoring.

Long-term monitoring would include two elements – sediments would be monitored in the area where removal actions had occurred to evaluate possible recontamination, but also sediment and biota chemistry as well as amphipod and arabacia toxicity would be monitored in the one area where sediments exceeding ecological PRGs remain to determine if the source removal action results in a reduction of these contaminants over time. Both monitoring efforts will be conducted annually for the first 5 years after the remedial action is completed, and then every five years thereafter to correspond to five year reviews.

6.2.5 Sediment Alternative 5: Removal and Disposal Option B

This alternative was developed to provide a remedial action that reduces or eliminates the on-site toxicity, mobility, and volume of contaminated beach and nearshore marine sediment through removal and disposal. Sediment would be removed from the nearshore area using appropriate excavation techniques. Removal would be conducted over the nearshore marine sediment area shown in Figure 6-4. These areas include those presented in Section 6.2.4 and eelgrass beds near sample station SD-410. Elements of Alternative 5 include:

- Pre-design investigation
- Installation of engineering controls to minimize erosion and sediment migration during construction
- Removal of 5,716 cy of contaminated sediment from the beach (intertidal) area
- Removal of 290 cy of contaminated sediment from the nearshore (subtidal) area exceeding ecological standards (including any areas containing eelgrass)
- Use of portadams and a temporary excavator causeway to facilitate removal
- Confirmation sampling of excavated areas to ensure complete removal of contaminated sediment
- Sediment dewatering
- Treatment of dewatering fluids and discharge to bay
- Disposal of sediment at TSDF
- Backfill with natural fill to original grade
- Assisted restoration of benthic community
- Natural restoration of eelgrass beds (0.05 acre)
- Long-term monitoring as required
- Monitoring the restored area to assess potential recontamination
- Five-year review

The approach for removal and disposal of contaminated sediment would be similar to the Removal alternative presented in Section 6.2.4. The primary differences are that the quantity of contaminated sediment removed as part of Alternative 5 would be slightly larger, and contaminated sediment present in the eelgrass bed areas would also be excavated. After removal activities are complete, the areas would be backfilled with clean materials similar to the existing substrate, and eelgrass beds would be restored to the extent possible.

Details of removal would be similar to those presented in Section 6.2.4. A PDI would be performed to gather information needed to complete the final remedial design. Approximately 25 borings would be advanced to confirm the extent of sediment contamination and define the area for sediment removal. Borings would also be used to gather geotechnical information needed to select the removal methods best suited for the materials present. If it is determined from the PDI that suction dredging would be better suited to remove the sediments within and near the eelgrass areas and could better protect those areas, this change will likely be made with approval of the regulatory oversight parties. The PDI would also include a detailed evaluation regarding any treatment requirement for the sediment prior to proper disposal.

Engineering controls would be installed around the perimeter of the area to be excavated to minimize sediment migration. Portadams and a temporary excavator causeway would be installed for access to the areas past the low-tide line to facilitate excavation, as described in Section 6.2.4. Excavation of contaminated sediment in the nearshore areas would be carried out to a depth of 1 foot.

Contaminated sediment would be excavated and segregated by size and, if required, by the type of contaminants, although this is not anticipated based on the contaminants detected in the beach and nearshore marine sediment. Land-based excavation would be performed using conventional earth-moving equipment such as track-mounted excavators, front-end loaders, bulldozers, and dump trucks. A trackhoe with a long-reach arm would be able to access the required areas from the causeway.

An alternative to the causeway would be the use of suction dredging in the area of SD-410. Suction dredging could be performed from the shoreline, and may be better suited to removal of the sediments within and near the eelgrass while protecting the other eelgrass areas nearby. The determination of the use of the causeway or suction dredging will be determined after completion of the PDI. Due to the small size of the area and the complexity of the construction of the causeway, the potential cost impact for this change are not large enough to be detailed as a separate alternative.

All excavated sediment would be staged and processed at a centralized location. Removed materials would be dewatered before being transported for final processing and staging. Water generated from sediment dewatering would be treated to meet applicable standards and then be discharged to the bay.

An estimated 6,006 cy of contaminated sediment would be removed as part of Alternative 5. Excavated sediment would be screened to remove debris and stones over approximately 6 inches in diameter. The screened material would be segregated as follows:

- For the purposes of this FS, it was assumed that approximately 20 percent of the excavated material (1,201 cy) would be over 6 inches in diameter and would be suitable for reuse after decontamination by methods permitted under relevant hazardous waste standards. These large rocks and boulders would be decontaminated to remove any contaminated sediment and staged for reuse as backfill.

- Screened material less than or equal to 6 inches in diameter (4,805 cy or 80 percent of the excavated material) would be staged separately for disposal. All trash and debris such as steel and concrete would be included with this portion of the excavated material, regardless of size. Any large debris to be sent off site for recycling or disposal would first be decontaminated to

remove any contaminated sediment. Water generated from rock and debris decontamination would be treated to meet applicable standards and then discharged to the bay.

Evaluation of the existing analytical data indicates that sediment contaminant levels are low enough that the material would not require any stabilization prior to TSDF disposal or would likely meet requirements for disposal in a RCRA Subtitle D landfill without treatment. If stabilization is required, sediment would be stabilized with lime prior to disposal in a TSDF.

Following removal operations, excavated areas would be sampled and tested using field test methods to ensure complete removal, then backfilled to their original grade with a mix of clean fill materials selected and placed to assist in the natural restoration of the benthic community that would be destroyed by excavation. The proposed excavation and backfilling would remove and replace approximately 1.95 acres of existing rocky intertidal and subtidal marine habitat, temporarily destroying the benthic community in the area. The proposed backfill would promote the natural restoration of the affected benthic community by providing an optimal habitat structure to support a diverse and stable benthic community. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. The long-term O&M program would include regular inspection of the backfilled areas to assess the condition of the habitat. It is anticipated that the ecological community would be reestablished within 1 to 4 years.

The backfill substrate would be placed to provide a stable and non-uniform habitat structure to promote community growth and diversity. The fill substrate would consist of graded sand, gravel, and stone sized materials similar to the that in the nearshore sediment that are not impacted. Implementation of this alternative would also impact eelgrass beds present around offshore sampling station SD-410. New eelgrass beds (0.05 acre) would have to be developed either on site, or if that is impracticable, off site.

Long-term monitoring would include two elements – first, sediments would be monitored in the area where removal actions had occurred to evaluate possible recontamination. This effort will be conducted annually for the first 5 years after the remedial action is completed, and then every five years thereafter to correspond to five year reviews.

6.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives provides relevant information to support the future selection of a remedial action. Each alternative is more fully developed and further evaluated according to a prescribed set of criteria. The evaluation results are used to compare alternatives and identify key

tradeoffs between the options, as well as to provide a basis for regulatory agency and public review of potential remediation alternatives for the site.

6.4 CRITERIA FOR DETAILED ANALYSIS

In accordance with the NCP and CERCLA guidance, the detailed analysis of alternatives was conducted in accordance with nine evaluation criteria. These criteria are divided into three groups: threshold criteria related to statutory requirements; balancing criteria that are technical in nature; and modifying criteria that are formally assessed following a public review and comment period. The criteria used to support the detailed analysis are presented in Section 4.0. The aspects of each criterion with respect to shoreline and nearshore marine sediment are presented as following:

Overall Protection of Human Health and the Environment: The primary concern, and one of the statutory requirements in remedy selection, is the overall protection of human health and the environment. The evaluation of protection is based on the ability of the remedy to eliminate, reduce, or control current and potential future exposure risks to human and ecological receptors through each applicable exposure pathway. This protection may be in the form of treatment, engineering controls, and/or institutional controls. The overall assessment of protection draws on assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Furthermore, evaluation of protection considers short-term risks or cross-media impacts posed by implementation of a remedy.

This criterion will be used to evaluate the effectiveness of each alternative in eliminating, reducing, or controlling human health and environmental risks at the nearshore (includes shoreline) sediment. The effectiveness issues related to alternatives for the marine sediment will be based on human health risks (wading in shoreline sediment) and environmental risks to marine biota.

Compliance with ARARs: Compliance with ARARs is one of the statutory requirements for selection of a remedy. This evaluation criterion is used to determine whether each alternative will meet all of its respective ARARs or whether justification exists for one of the six ARAR waivers allowed under CERCLA. Chemical-, location-, and action-specific ARARs are reviewed as they apply to each alternative. Alternatives are refined, as necessary, to ensure compliance with these requirements.

This criterion will be used to evaluate each alternative in complying with chemical-, location-, and action-specific federal and state ARARs and TBCs for protection of human health and the environment. Alternatives requiring sediment removal coupled with subsequent disposal or treatment activities will also be evaluated for compliance with action-specific ARARs related to sediment handling, sediment

treatment and/or disposal, as well as treatment and discharge of water generated from sediment dewatering activities.

Long-Term Effectiveness and Permanence: Alternatives are assessed in terms of their long-term effectiveness and degree of permanence in offering protection of human health and the environment following implementation. The evaluation focuses on the extent and effectiveness of controls required to manage risks remaining on the site following completion of the remedial action. The analysis considers the magnitude of risks to human and ecological receptors from residuals (untreated waste or treatment by-products) remaining on site at the completion of remedial activities, the adequacy of engineering and/or institutional controls to manage residuals, the reliability of the controls to provide continued protection from residuals, and potential needs to maintain and/or replace technical components of an alternative.

This criterion will be used to evaluate each alternative for its ability to manage risks remaining on site following implementation. The no action, limited action, and removal alternatives will be evaluated based on future risks associated with leaving contaminated sediment on site. The removal alternatives will be evaluated in relation to the management of residuals formed as a result of sediment excavation operations, dewatering activities, and disposal. Evaluation of alternatives will further address potential risks associated with residuals following sediment treatment.

Reduction of Toxicity, Mobility, or Volume through Treatment: Alternatives are evaluated to address the statutory preference for remedies that employ treatment as a principal element to reduce toxicity, mobility, or volume of hazardous substances. The evaluation focuses on the following factors:

- Treatment processes employed by the remedy, as well as the materials they will treat.
- Amount of hazardous materials to be destroyed or treated.
- Degree of expected reduction in toxicity, mobility, or volume, including how the principal threats will be addressed.
- Degree to which the treatment will be irreversible.
- Type and quantity of treatment residuals that remain following treatment.
- Whether the alternative satisfies the statutory preference for treatment as a principal element.

This criterion will be used to evaluate the effectiveness of alternatives for their ability to reduce mobility and/or their effectiveness in reducing risks through natural attenuation processes or removal with off-site disposal.

Short-Term Effectiveness: The short-term effectiveness criterion assesses potential effects to human health and the environment during the construction and implementation phase of a remedy until remedial response objectives are met. The analysis includes considering protection of both the community and on-site workers during remedial activities, environmental impacts that may result from construction or implementation activities, the reliability of measures to be taken to prevent or reduce potential impacts, and an estimation of time required to meet remedial response objectives.

This criterion will be used to evaluate each alternative for its ability to protect human health and the environment during implementation, as well as during any associated long-term monitoring activities. While the no action alternatives require no implementation activities, limited action alternatives will be evaluated for the protection they offer during implementation of institutional controls, access restrictions, and long-term monitoring. Evaluation of the remaining alternatives will address sediment removal and dewatering activities. The time required for each alternative to reach the sediment cleanup goals will also be assessed.

Implementability: Implementability considerations include the technical and administrative feasibility of implementing an alternative, as well as the availability of goods and services on which the viability of the alternative depends. These considerations often affect the timeliness of undertaking an alternative.

Technical feasibility issues include:

- Ability to construct and operate an alternative as a whole
- Likelihood of a technology to meet specified process efficiencies and performance goals
- Ease of undertaking any required future remedial actions
- Ability to monitor the effectiveness of the remedy

Administrative feasibility deals with the activities needed and time required to coordinate with various federal, state, and local agencies in obtaining any necessary approvals and permits for off-site activities.

Issues related to the availability of goods and services include:

- Accessibility of adequate capacity and location of needed treatment, storage, and disposal services.
- Ease in obtaining necessary equipment and specialists, and provisions to ensure any additional resources.
- Timing and availability of technologies under consideration.
- Availability of services and materials, plus the potential for obtaining competitive bids.

These issues will be reviewed to evaluate the implementability of each remedial alternative. Issues will also be evaluated for both the ease of implementation and associated time frame required to coordinate subcontractors, activities, and required regulatory approvals.

Cost: This criterion encompasses all capital outlays, as well as O&M costs incurred over the lifetime of the remedial action. The detailed analysis of costs associated with each alternative will be based on accurate cost estimates and a net present worth cost analysis for a 30-year performance period. The 30 year period is evaluated because not all the alternatives have a 30 year life.

State Acceptance: State acceptance, an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. State acceptance must be considered during remedy selection.

This criterion will not be evaluated until RIDEM has reviewed and provided comments on the FS report. Therefore, this criterion will not be included in the detailed analysis.

Community Acceptance: Community acceptance refers to the issues and concerns of "all interested parties," as they relate to each of the alternatives under consideration. Community acceptance must be considered during remedy selection.

This criterion will not be evaluated until the Restoration Advisory Board (RAB) has reviewed and provided comments on the FS report and the public has been invited to ask questions and share their concerns during the public comment period. Therefore, this criterion will not be included in the detailed analysis.

6.5 INDIVIDUAL ANALYSES OF MARINE SEDIMENT ALTERNATIVES

Five remedial alternatives were developed for the marine sediment to address risks to human health (wading and direct contact) and the environment associated with contaminants in the sediment. Sections 6.2.1 through 6.2.5 contain brief descriptions of each alternative and describe the individual analyses of these alternatives. A summary of the analyses is presented in Table 6-2.

6.5.1 Sediment Alternative 1: No Action

Consideration of a no action alternative is required under the NCP. At a minimum, it provides a baseline for comparison with other alternatives. This alternative would involve no remedial response activities with respect to impacted nearshore sediment at the site. No containment, removal, or treatment of

contaminated sediment would be conducted, and no erosion control actions would be implemented to prevent potential migration of contaminated sediment into Narragansett Bay and connecting waterways. The alternative would provide no mechanism to reduce potential risks to human health or the environment. Because contaminated sediment would remain on site and unlimited use of the nearshore area would be allowed, a 5-year review of site conditions and risks would be required under the NCP.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: This alternative would not achieve the RAOs for protection of human health and the environment identified in Section 2.0. It would offer no additional protection of human health and the environment because it would not address potential risks through the elimination, reduction, or control of exposures to impacted sediment. Contaminated sediment would not be contained or removed, and no access restrictions would be installed to discourage future access to the area for recreational use. Potential risks to human health and the environment at levels estimated in the RI (TtNUS, 2001) would remain at the site. Therefore, 5-year reviews would be conducted, as required by CERCLA, to assess changing site conditions and potential risks. Results of the reviews would be used to determine the need to implement future remedial actions at the site.

Compliance with ARARs: Tables 6-3, 6-4, and 6-5 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 1. This alternative fails to meet chemical-specific ARARs because it does not address sediment exceeding PRGs that were derived from federal and state water quality standards. Several non-promulgated criteria (TBCs) were used in assessing human health risks and developing sediment PRGs. Since no action is to be taken under this alternative, there are no state or federal location-specific or action-specific ARARs or TBCs.

Long-Term Effectiveness and Permanence: Existing restrictions on access would continue to provide some long-term protection of human health for the foreseeable future, as long as the controls remain in effect and are implemented effectively. The no action alternative would offer no additional long-term effectiveness or permanence in addressing sediment contamination at the site. The existing risks to human health and the environment would remain, and no controls would be provided to manage future exposures to sediment contaminants. Potential contaminant migration pathways would not be addressed, and contaminated sediment could migrate to adjacent marine environments. Because of the risk associated with leaving contaminated sediment on site, 5-year reviews would be required.

Reduction of Toxicity, Mobility, or Volume through Treatment: This alternative would not include any sediment treatment processes and would not involve removal of contaminated sediment. Therefore, the alternative would offer no reduction in toxicity, mobility, or volume of contamination through treatment.

Short-Term Effectiveness: Since no remedial activities are associated with implementation of this alternative, no short-term effects would occur. No increase or reduction in short-term risks would be offered to the local community, base personnel, or the environment. RAOs for protection of human health and the environment would not be achieved by this alternative.

Implementability: This alternative would require no implementation other than completion of the 5-year reviews. This activity would not require any permits, but it may require a minimal amount of coordination between regulatory agencies. Implementation of the no action alternative would not limit future implementation of additional remedial actions at the site, if deemed necessary.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 1 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	Estimated Cost
Capital Costs	$0
O&M/Long-Term Monitoring	$0
5-Year Reviews	$22,000/5 years
Present Worth	$70,000

6.5.2 Sediment Alternative 2: Limited Action

Alternative 2 is provided as an interim measure that will limit potential risks to human health through the placement of shoreline fencing, signs, and a perimeter buoy system. A long-term monitoring program and 5-year reviews would be conducted to evaluate risks to human health and the environment posed by the site. This alternative would provide no direct remedial response activities. No containment, removal, and/or treatment of contaminated marine sediment would be conducted. For the purposes of costing, it was assumed that annual monitoring would be conducted for the first 5 years, and then the sampling frequency would be reduced from annually to every 5 years. The actual monitoring frequency would be determined by the Navy and regulatory agencies based on the monitoring results and 5-year reviews. An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: This alternative would provide a limited degree of protection of human health by discouraging access to, and use of, the impacted beach areas. Through the placement of fencing, signs, and a perimeter buoy system, this alternative would increase public awareness of the hazards associated with the contaminated sediment in the area, thereby

discouraging and reducing shoreline use. The effectiveness of the access restrictions would depend on individual compliance with the restrictions and Navy and state enforcement of these restrictions on Navy and state-owned property, respectively.

As an interim measure, this alternative will document any changes to sediment quality following the removal of the suspected source of the COCs. This alternative would provide no direct protection against potential disruption and/or migration of contaminated sediment due to wave or storm action, and it would not reduce risks to ecological receptors. However, by monitoring changes over time, the alternative provides an opportunity to document reduction of contaminant concentrations following source removal without removal of the habitat present.

Implementation of the long-term monitoring program would not provide protection of either human health or the environment, although, through annual monitoring, it would document changes in sediment quality that may affect future exposure risks. Because contaminants would remain at the site, 5-year reviews would be conducted to assess changing site conditions and potential risks. As an interim measure, results of the monitoring could be used to determine the need to implement other alternatives for future remedial actions at the site or change the required frequency of long-term monitoring events.

This alternative would partially meet RAOs for protection of human health by limiting human exposure to the contaminated beach sediment. This alternative does not meet the RAOs for the protection of the environment, though it protects the benthic community from immediate destruction.

Compliance with ARARs: Tables 6-6, 6-7, and 6-8 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 2. This alternative fails to meet chemical-specific ARARs because it does not prevent exposure to sediment exceeding PRGs that were derived from federal and state water quality standards. Several non-promulgated criteria (TBCs) were used in assessing human health risks and developing sediment PRGs.

Federal and state location-specific ARARs for this alternative include wetland and floodplain regulations, as well as coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations. Alternative 2 does not satisfy federal ARARs for the protection of wetlands and floodplains because the action to be taken does not address the risk to the wetland and floodplain environment posed by the contamination. Additionally, state hazardous waste standards for facilities within a floodplain are not satisfied. Any actions taken under this alternative (installation of fencing and buoys, and monitoring) that would affect the resources protected by these regulations would be conducted in accordance with the substantive requirements of the regulations.

Long-Term Effectiveness and Permanence: Because this alternative is an interim action, long term effectiveness and permanence would not be defined until a final decision is reached. If monitoring indicates not removal actions are required, then the limited action alternative will provide protection of the ecological community from being temporarily destroyed by dredging. However, if removal of the source area has no positive impact on the sediments and excavation is required, then the limited action alternative would provide no long-term protection of ecological receptors or the environment and would have to be replaced with a more active alternative. Ecological receptors would continue to be exposed to contaminants in sediment and porewater, potential contaminant migration pathways would not be addressed, and contaminated sediment could migrate to adjacent marine environments. Since contaminated sediment would remain on site above levels allowing for unlimited use and unrestricted exposure, annual monitoring and 5-year reviews of this alternative would be required to evaluate the effectiveness of the alternative.

Effectiveness of protection of human health under this alternative would rely on physical barriers, warning signs, and use restrictions to limit access to the impacted sediment and thereby reduce human risk associated with direct contact. Although the shoreline fencing and a perimeter buoy system would help to minimize access, they may not be totally effective in prohibiting access to the area of concern. Regular maintenance and periodic replacement of the fencing and buoys by the Navy would be necessary to ensure their long-term effectiveness in deterring access and warning the public of the potential hazards. Restrictions on recreational use of the shoreline would require long-term enforcement by the state and the Navy to ensure their protectiveness.

Reduction in Toxicity, Mobility, or Volume through Treatment: This alternative would not include any sediment treatment processes. Therefore, the limited action alternative would offer no reduction in contaminant toxicity, mobility, or volume through treatment.

Short-Term Effectiveness: As stated above, short term effectiveness will depend on outcome of the monitoring. A very slight increase in short-term risks could potentially result from the implementation of this alternative. Installation of the shoreline fencing and signs could result in minimal suspension and migration of contaminated sediment around the boundaries of the designated beach and nearshore area. However, common engineering controls (the use of silt fences, silt curtains, and/or other features) would leave any potential short-term impacts nearly negligible. Potential exposures of on-site workers to contaminated sediment during installation activities would be limited through the use of PPE. There would also be potential short-term impacts to workers associated with annual monitoring activities. These would be addressed through proper use of PPE and by using proper handling, storage, and disposal procedures for potentially contaminated sediment samples.

On-site installation activities are estimated to require less than 1 month. Each annual monitoring activity would require less than 1 week. RAOs associated with preventing risks to human health would be partially addressed when installation of fencing, signs, and buoys is complete, but RAOs for protection of the environment would not be achieved.

Implementability: Implementation of this alternative would involve installing shoreline fencing, signs, and a perimeter buoy system and completing a long-term monitoring program and 5-year reviews.

The purchase and deployment of buoys and installation of shoreline fencing and signs would be easily implemented given the availability of qualified contractors, marine supplies, and boats within the Newport area. Consistent enforcement of the shoreline access restrictions as well as long-term maintenance of the fencing and buoy system by the Navy would be required. Because the buoys and a portion of the fence would be installed on state-owned land below the high tide line, coordination with the State of Rhode Island would be required for placing fencing and buoys and enforcing access restrictions prohibiting recreational use of the shoreline.

The establishment of a long-term monitoring program to assess sediment quality would be easily implemented, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require some coordination with regulatory agencies.

Implementation of the limited action alternative would not impede execution of future remedial actions at the site, if deemed necessary.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 2 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	Estimated Cost
Capital Costs	$10,000
O&M/Long-Term Monitoring	$70,000/year (years 1-5 and 5-year intervals) $9,000/year (other years)
5-Year Reviews	$22,000/5 years
Present Worth	$653,000

6.5.3 Sediment Alternative 3: Limited Removal and Disposal (Beach Area)

Alternative 3 involves removing contaminated marine sediment along the beach (intertidal) area. Sediment within the nearshore (subtidal) areas would be monitored on a long term basis to determine if

the onshore and beach removal actions result in a reduction of COC concentrations in sediment to meet PRG levels. The monitoring aspects would be similar to those presented for Alternative 2. Excavated sediment would be disposed of at a TSDF. This alternative would limit potential risks to human health and the environment through implementation of monitoring and limited removal and disposal of contaminated sediment.

Contaminated sediment and debris removed as part of this remedial action would be screened and segregated in a dedicated staging area. All trash and debris such as steel and concrete would be sent for recycling or disposal. Any large debris to be sent off site for recycling or disposal would first be decontaminated in accordance with relevant hazardous waste standards. Long-term monitoring would be conducted for the sediment in the nearshore areas.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 3 would achieve RAOs for protection of human health and the environment to some extent by removing and properly disposing of a portion of the contaminated sediment and monitoring the remaining contaminated sediment. This alternative also protects the eelgrass beds. The removal of 5,716 cy, or 94 percent of the contaminated sediment exceeding PRGs, would decrease the volume and the lateral extent of contaminants remaining in the area, thereby providing additional protection to human health and the environment.

Implementation of this alternative would result in some increased short-term risks, including the destruction of existing biota within the impacted area and suspension of contaminated sediment. However, these impacts would be at least partially mitigated through proper implementation of turbidity control measures and selection of appropriate backfill materials. Excavation would temporarily destroy the benthic community in the filled area below the high tide line. The proposed fill design would assist natural restoration of these communities by providing a habitat structure that would promote colonization of the species indigenous to the area. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. It is anticipated that the benthic community destroyed by the remedial action would be reestablished within 1 to 4 years. In addition, habitats adjacent to the site may be affected by turbidity. These habitats would have to be monitored to determine the need for mitigation measures.

Damage to the eelgrass beds is expected to be slight (principally due to increased turbidity caused by resuspension of sediment during excavation along the beach). Because the sediment in the beach area is relatively coarse and operations in the area near the eelgrass beds would be conducted over a

relatively short duration, standard turbidity control measures such as silt curtains are expected to effectively control turbidity and minimize damage to the eelgrass beds.

There would also be increased short-term risks to on-site workers from potential exposures to contaminated sediment during excavation and handling activities. There may also be some risks associated with disposal of the excavated materials. These risks would be minimized through the use of PPE and proper safety procedures.

Implementation of the long-term monitoring program would allow assessment of changes in sediment quality. Five-year reviews would be conducted to assess site conditions and potential risks. Results would be used to determine whether additional remedial actions are needed at the site.

Compliance with ARARs: Tables 6-9, 6-10, and 6-11 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 3. This alternative would not completely comply with federal and state chemical-specific ARARs (water quality standards) used to derive sediment PRGs at all locations because about 6 percent of the total contaminated sediment would be still in place.

Implementation of Alternative 3 would meet all other state and federal location-specific ARARs by conducting the activities in accordance with applicable and relevant and appropriate floodplain, wetland, coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to minimize adverse effects to fish, wildlife, endangered species, and historic sites. ARARs require that the alternative chosen be the least damaging practicable alternative. To satisfy the Clean Water Act (CWA) Section 404 requirements, damaged marine habitats would have to be restored.

Alternative 3 would be conducted in accordance with all identified state and federal action-specific ARARs. The action-specific ARARs identified for this alternative include RCRA requirements for identifying, listing, and disposing of hazardous wastes; CWA requirements for discharges to surface water; and CAA requirements for emissions monitoring of dewatering processes.

Long-Term Effectiveness and Permanence: Alternative 3 would partially eliminate the risks to potential human health and ecological receptors posed by exposure to contaminated marine sediment and porewater. Ecological risk would still exist from contaminated sediment left around the eelgrass areas.

The long-term monitoring program (which would include annual sediment and biota monitoring) would be conducted to ensure that contaminated sediment concentrations are decreasing after the source removal and that the remediated areas are not being recontaminated. Since contaminated sediment would

remain on site above levels allowing for unlimited use and unrestricted exposure, monitoring and 5-year reviews would be required to evaluate the protectiveness of the remedy.

Reduction in Toxicity, Mobility, or Volume through Treatment: Alternative 3 would not include treatment; therefore, it would provide no reduction in the toxicity, mobility, or volume of contaminants through treatment.

Short-Term Effectiveness: Implementation of Alternative 3 would result in increases in short-term risks to human and ecological receptors due to disruption and handling of contaminated sediment during site preparation and sediment removal. Potential exposures of on-site workers to contaminated sediment during excavation and handling activities would be minimized through the use of PPE and proper safety procedures. The time required to reach the remedial action objectives is estimated at 3 to 4 months.

Resuspension of contaminated sediment would occur during the excavation operations. Migration and resettling of suspended sediment may harm marine biota and enlarge the area impacted by site contaminants. Engineering controls, such as silt curtains, would minimize potential environmental impacts associated with contaminant migration; however, adverse effects may not be completely eliminated. Additional data regarding sediment grain size and excavation techniques are needed to predict the degree of effectiveness of sedimentation controls.

Excavation would remove the resident shellfish and temporarily disrupt the marine habitat in the excavated areas along the beach below the high tide line. Because the resident shellfish would be removed, the area would not function as a feeding area for some marine organisms, birds, and mammals, and it would not serve product export functions such as provision of nutrients for other systems. The lost functions and values of the habitat would not be completely replaced until the benthic community was fully reestablished. Placement of fill materials similar to the existing sand/gravel/rock substrate of the area would provide a foundation for reestablishment of the benthic community, serving as a habitat for plants and animals to root and breed. Natural recolonization of the area would occur as waterborne algae spores and animal larvae were continually swept into the area by tidal currents and wave action.

The natural restoration of the area may take several years to complete. However, observations in a nearby site, McAllister Point Landfill, indicate that natural restoration of the benthic community in the area occurs at a fairly rapid pace (in about 2 years) (TtNUS, 1999). Based on these observations and recovery reported for similar habitats it is anticipated that the benthic community destroyed by the remedial action would be reestablished within 1 to 4 years. In addition, habitats adjacent to the site may

be temporarily affected by turbidity produced during excavation activities. These habitats would have to be monitored to determine the need for mitigation measures.

Damage to the eelgrass beds is expected to be slight because excavation would be carried out on the beach away from these areas. Standard turbidity control measures such as silt curtains are expected to effectively control turbidity and minimize damage to the eelgrass beds.

Implementability: Implementation of Alternative 3 would require significant efforts, both administratively and technically. The complexity of implementation is a function of the location of the area to be excavated. All of the area along the beach would be able to be accessed by standard excavation equipment and a port-a-dam structure to control water.

Implementation of this alternative would require qualified contractors with personnel trained in hazardous waste site operations, who are qualified to handle contaminated sediment excavation, grading, and erosion control operations in a marine environment and who are capable of completing construction in a timely and effective manner. Wave action, the influence of local currents and tides, and weather conditions could result in scheduling delays related to site accessibility.

Implementation of this alternative would require coordination with regulatory agencies regarding marine excavation and filling operations; water treatment and discharge from sediment dewatering activities into the bay; materials handling/off-base disposal issues; and potential effects on fisheries, endangered species, and the marine habitat. Agreements with regulatory agencies would have to be reached regarding mitigation for altering marine habitats and establishing the periods for excavation and filling activities along the beach. Obtaining agreements with regulatory agencies is not expected to pose a problem. The State of Rhode Island generally requires dredging projects to be conducted between November 1 and January 15 to protect sensitive species. The Navy will investigate the use of marine habitats on site by sensitive species to determine potential impacts from excavating during different times of the year.

If it is determined that material would be suitable for disposal in RCRA Subtitle D solid waste facilities, multiple facilities, including local landfills such as Central Landfill in Johnston, Rhode Island, would likely be able to accept the material. Otherwise, disposal would take place at a permitted TSDF.

Performing long-term monitoring to assess sediment quality would be easily implementable, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require coordination with regulatory agencies.

Implementation of the removal and disposal alternative would not limit future implementation of additional remedial actions at the site.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 3 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate. The results of the detailed cost estimate are presented below.

Cost Description	Estimated Cost
Capital Costs	$3,032,000
O&M/Long-Term Monitoring	$73,000/year (years 1 through 5 and 5-year intervals thereafter)
5-Year Reviews	$22,000/5 years
Present Worth	$3,605,000

6.5.4 Sediment Alternative 4: Removal and Disposal Option A

Alternative 4 involves removing contaminated marine sediment at all locations except those areas with eelgrass beds. Sediment associated with eelgrass beds would be monitored on a long-term basis to determine if the onshore removal actions result in a reduction of COC concentrations in sediment to meet PRG levels. The monitoring aspects would be similar to those presented for Alternative 3. Excavated sediment would be disposed of at a TSDF. This alternative would limit potential risks to human health and the environment through implementation of monitoring and limited removal and disposal of contaminated sediment.

At a technical meeting held on May 30, 2002, the Navy and regulatory review parties discussed the value of excavation of the contaminants within the eelgrass areas that exceed PRGs versus the value that this habitat provides to the local ecological communities. At that meeting it was determined that if additional sediment samples support the findings regarding concentrations of COCs present and areal extent of those COCs above PRGs, then the eelgrass should not be interrupted for the sake of removing those contaminants exceeding PRGs. However, if the areal extent is found to be larger, or the concentrations are found to be higher, then the issue will have to be revisited.

Contaminated sediment and debris removed as part of this remedial action would be screened and segregated in a dedicated staging area. All trash and debris such as steel and concrete would be sent for recycling or disposal. Any large debris to be sent off site for recycling or disposal would first be decontaminated in accordance with relevant hazardous waste standards. Long-term monitoring would be conducted for the sediment in the eelgrass beds.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 4 would achieve RAOs for protection of human health and the environment to some extent by removing and properly disposing of the majority of the contaminated sediment and monitoring the remaining contaminated sediment. This alternative also protects the eelgrass beds. The removal of 5,930 cy, or 98 percent of the contaminated sediment exceeding PRGs, would decrease the volume and the lateral extent of contaminants remaining in the area, thereby providing additional protection to human health and the environment.

Implementation of this alternative would result in some increased short-term risks, including the destruction of existing biota within the impacted area and suspension of contaminated sediment. However, these impacts would be at least partially mitigated through proper implementation of turbidity control measures and selection of appropriate backfill materials. Excavation would temporarily destroy the benthic community in the affected area below the high tide line. The proposed fill design would assist natural restoration of these communities by providing a habitat structure that would promote colonization of the species indigenous to the area. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. It is anticipated that the benthic community destroyed by the remedial action would be reestablished within 1 to 4 years. In addition, habitats adjacent to the site may be affected by turbidity. These habitats would have to be monitored to determine the need for mitigation measures.

Damage to the eelgrass beds is expected to be slight (principally due to increased turbidity caused by resuspension of sediment during excavation around the beds). Because the sediment in the beach and nearshore areas is relatively coarse and operations in the area adjacent to the eelgrass beds would be conducted over a relatively short duration, standard turbidity control measures such as silt curtains are expected to effectively control turbidity and minimize damage to the eelgrass beds.

There would also be increased short-term risks to on-site workers from potential exposures to contaminated sediment during excavation and handling activities. There may also be some risks associated with disposal of the excavated materials. These risks would be minimized through the use of PPE and proper safety procedures.

Implementation of the long-term monitoring program would allow assessment of changes in sediment quality. Five-year reviews would be conducted to assess site conditions and potential risks. Results would be used to determine whether additional remedial actions are needed at the site.

Compliance with ARARs: Tables 6-12, 6-13, and 6-14 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 4. This alternative would not comply with federal and state chemical-specific ARARs (water quality standards) used to derive sediment PRGs at all locations because less than 2 percent of the total contaminated sediment would be still in place

Implementation of Alternative 4 would meet all other state and federal location-specific ARARs by conducting the activities in accordance with applicable and relevant and appropriate floodplain, wetland, coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to minimize adverse effects to fish, wildlife, endangered species, and historic sites. However, if ARARs cause more harm than benefit derived from implementing the ARARs, the ARARs may be waived. To satisfy the Clean Water Act (CWA) Section 404 requirements, damaged marine habitats would have to be restored.

Alternative 4 would be conducted in accordance with all identified state and federal action-specific ARARs. The action-specific ARARs identified for this alternative include RCRA requirements for identifying, listing, and disposing of hazardous wastes; CWA requirements for discharges to surface water; and CAA requirements for emissions monitoring of dewatering processes.

Long-Term Effectiveness and Permanence: Alternative 4 would partially eliminate the risks to potential human health and ecological receptors posed by exposure to contaminated marine sediment and porewater. Ecological risk would still exist from contaminated sediment left around the eelgrass areas.

The long-term monitoring program (which would include annual sediment and biota monitoring) would be conducted to ensure that the remediated areas are not being recontaminated. Since contaminated sediment would remain on site above levels allowing for unlimited use and unrestricted exposure, monitoring and 5-year reviews would be required to evaluate the protectiveness of the remedy.

Reduction in Toxicity, Mobility, or Volume through Treatment: Alternative 4 would not include treatment; therefore, it would provide no reduction in the toxicity, mobility, or volume of contaminants through treatment.

Short-Term Effectiveness: Implementation of Alternative 4 would result in increases in short-term risks to human and ecological receptors due to disruption and handling of contaminated sediment during site preparation and sediment removal. Potential exposures of on-site workers to contaminated sediment during excavation and handling activities would be minimized through the use of PPE and proper safety procedures. The time required to reach the remedial action objectives is estimated at 6 to 8 months.

Resuspension of contaminated sediment would occur during the excavation operations. Migration and resettling of suspended sediment may harm marine biota and enlarge the area impacted by site contaminants. Engineering controls, such as silt curtains, would minimize potential environmental impacts associated with contaminant migration; however, adverse effects may not be completely eliminated. Additional data regarding sediment grain size and excavation techniques are needed to predict the degree of effectiveness of sedimentation controls.

Excavation would remove the resident plants and shellfish and temporarily disrupt the marine habitat in the excavated areas below the high tide line. Because the resident plants and shellfish would be removed, the area would not function as a feeding area for some marine organisms, birds, and mammals, and it would not serve product export functions such as provision of nutrients for other systems. The lost functions and values of the habitat would not be completely replaced until the benthic community was fully reestablished. Placement of fill materials similar to the existing sand/gravel/rock substrate of the area would provide a foundation for reestablishment of the benthic community, serving as a habitat for plants and animals to root and breed. Natural recolonization of the area would occur as waterborne algae spores and animal larvae were continually swept into the area by tidal currents and wave action.

The rehabitation of the area may take several years to complete. However, observations in a nearby site, McAllister Point Landfill, indicate that natural rehabitation of the benthic community in the area occurs at a fairly rapid pace (in about 2 years) (TtNUS, 1999). Based on these observations and recovery reported for similar habitats it is anticipated that the benthic community destroyed by the remedial action would be reestablished within 1 to 4 years. In addition, habitats adjacent to the site may be temporarily affected by turbidity produced during excavation activities. These habitats would have to be monitored to determine the need for mitigation measures.

Damage to the eelgrass beds is expected to be slight because excavation would not be carried out in the beds. Standard turbidity control measures such as silt curtains are expected to effectively control turbidity and minimize damage to the eelgrass beds.

Implementability: Implementation of Alternative 4 would require significant efforts, both administratively and technically. The complexity of implementation is a function of the location of the area to be excavated. All of the areas, including those reached via the temporary excavator causeway, would be able to be accessed by a long arm trackhoe.

Implementation of this alternative would require qualified contractors with personnel trained in hazardous waste site operations, who are qualified to handle contaminated sediment excavation, grading, and

erosion control operations in an aqueous environment and who are capable of completing construction in a timely and effective manner. Wave action, the influence of local currents and tides, and weather conditions could result in scheduling delays related to site accessibility.

Implementation of this alternative would require coordination with regulatory agencies regarding marine excavation and filling operations; water treatment and discharge from sediment dewatering activities into the bay; materials handling/off-base disposal issues; and potential effects on fisheries, endangered species, and the marine habitat. Agreements with regulatory agencies would have to be reached regarding mitigation for altering marine habitats and establishing the periods for excavation and filling activities in the bay. Obtaining agreements with regulatory agencies is not expected to pose a problem. The State of Rhode Island generally requires dredging projects to be conducted between November 1 and January 15 to protect sensitive species. The Navy will investigate the use of marine habitats on site by sensitive species to determine potential impacts from excavating during different times of the year.

If it is determined that material would be suitable for disposal in RCRA Subtitle D solid waste facilities, multiple facilities, including local landfills such as Central Landfill in Johnston, Rhode Island, would likely be able to accept the material. Otherwise, disposal would take place at a permitted TSDF.

Performing long-term monitoring to assess sediment quality would be easily implementable, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require coordination with regulatory agencies.

Implementation of the removal and disposal alternative would not limit future implementation of additional remedial actions at the site.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 4 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate. The results of the detailed cost estimate are presented below.

Cost Description	**Estimated Cost**
Capital Costs	$3,496,000
O&M/Long-Term Monitoring	$52,000/year (years 1 through 5 and 5-year intervals thereafter)
5-Year Reviews	$22,000/5 years
Present Worth	$3,922,000

6.5.5 Sediment Alternative 5: Removal and Disposal Option B

Alternative 5 includes removal of all contaminated sediment exceeding PRGs including in areas with eelgrass beds, dewatering the removed materials, treating and discharging dewatering fluids to the bay, disposing of the solids in the appropriately permitted off-base TSDF, refilling the excavated area back to the original grade, and restoration of the damaged eelgrass beds. These actions would eliminate potential risks to human health and the environment by removing contaminated sediment from the beach and nearshore areas and disposing of it in appropriately secured facilities.

Evaluation of the existing analytical data indicates that most of the sediment has contaminant levels low enough that it likely does not require disposal as a hazardous waste. Removed material would be tested to determine whether it should be disposed of in a TSDF or a RCRA Subtitle D solid waste facility.

Long-term operation and maintenance would not be required because all contaminants exceeding the PRGs would be removed from the beach and nearshore areas. However, long term monitoring would be required to assure the remediated areas are not being recontaminated. Additionally, periodic inspections of the area to verify marine habitat recovery would be included in the monitoring program.

An analysis of this alternative with respect to the evaluation criteria is as follows:

Overall Protection of Human Health and the Environment: Alternative 5 would achieve RAOs for protection of human health and the environment by removing and appropriately disposing of contaminated sediment, thereby preventing potential exposure to and migration of impacted sediment. Removal activities would eliminate potential risks to human health and prevent risks to ecological receptors posed by exposure to contaminated marine sediment.

Because all sediment with contaminant concentrations exceeding the recommended PRGs would be removed from the shoreline and nearshore areas, long-term protection and permanence of the alternative would ultimately depend on the treatment at the TSDF.

Implementation of this alternative would result in some increased short-term risks, including the temporary destruction of the existing benthic community within the removal area and suspension of contaminated sediment, which could impact the benthic community in the surrounding area. These impacts may be partially mitigated through proper implementation of turbidity control measures and selection of appropriate backfill materials. Sediment removal and backfilling would temporarily destroy the benthic community in the area below the high tide line. The proposed backfill material would assist natural restoration of these communities by providing habitat structure that would promote colonization

by the species indigenous to the area. Natural recolonization of the area would occur as waterborne algae spores and animal larvae are swept into the area by tidal currents and wave action. Based on the studies at similar sites, it is anticipated that the benthic community destroyed by the remedial action would be reestablished within 1 to 4 years. In addition, habitats adjacent to the site may be temporarily affected by turbidity produced during excavation activities. These habitats would have to be monitored to determine the need for mitigation measures.

Removal activities would impact eelgrass beds located near sample location SD-410. During the PDI, if it is concluded that the eelgrass beds would suffer significant damage, it may be necessary to reconsider this alternative and evaluate assisted restoration.

There would also be increased short-term risks to on-site workers from potential exposures to contaminated sediment during excavation and handling activities. These risks would be minimized through the use of PPE and proper safety procedures.

Implementation of the long-term monitoring program would allow assessment of the restoration of the marine habitat and any changes in sediment quality, and a 5-year review would allow assessment of site conditions and potential risks. The results of monitoring and 5-year reviews would be used to determine whether additional remedial actions are needed at the site and whether long-term monitoring and 5-year reviews may be discontinued.

Compliance with ARARs: Tables 6-12, 6-13, and 6-14 summarize chemical-, location-, and action-specific ARARs and TBCs, respectively, for Alternative 5. This alternative would comply with federal and state chemical-specific ARARs (water quality standards) used to derive sediment PRGs because sediment exceeding the PRGs derived from these standards would be removed by excavation.

Implementation of Alternative 5 would meet all state and federal location-specific ARARs by conducting the activities in accordance with floodplain and wetland regulations, as well as coastal resource management, endangered species, fish and wildlife protection, and historic preservation regulations and by coordinating with appropriate agencies to find ways to identify and minimize adverse effects to fish, wildlife, endangered species, and historic sites.

Alternative 5 would be conducted in accordance with all identified state and federal action-specific ARARs. The action-specific ARARs identified for this alternative include RCRA requirements for identifying, listing, and disposing of hazardous wastes; CWA requirements for discharging to surface water; and CAA requirements for monitoring emissions of dewatering processes.

Long-Term Effectiveness and Permanence: Alternative 5 would eliminate the potential human health risks and risks to ecological receptors posed by exposure to contaminated marine sediment and porewater. The risk reduction offered by this alternative would be accomplished through removing the contaminated sediment from the beach and nearshore areas, thereby permanently eliminating the risks posed by these materials. Disposal, or treatment and disposal, of contaminated sediment would eliminate the need for long-term management of untreated sediment within the nearshore area. The long-term effectiveness of this alternative would depend on the long-term management and integrity of the disposal facilities. Long term monitoring would be conducted to assure that the remediated areas are not being recontaminated.

Reduction in Toxicity, Mobility, or Volume Through Treatment: Alternative 5 would not use treatment to reduce the toxicity, mobility, or volume at the site so very little overall reduction in contaminant toxicity, mobility, or volume would be offered.

Short-Term Effectiveness: Implementation of Alternative 5 would result in increased short-term risks to human and ecological receptors due to the disruption of the contaminated sediment during remedial activities. Potential exposures of on-site workers to impacted sediment during excavating and handling activities would be minimized through the use of PPE and proper workplace safety practices. Ecological risks are not as easily mitigated. Adjacent areas may be impacted by migrating sediment. All of the benthic community in the removal area will be temporarily destroyed. The time required to reach the remedial action objectives is estimated at 6 to 8 months.

Resuspension of contaminated sediment would occur during the excavation operations. Migration and resettling of suspended sediment may harm marine biota and enlarge the area impacted by site contaminants. Engineering controls, such as silt curtains, would minimize potential environmental impacts associated with contaminant migration; however, adverse effects may not be completely eliminated. Additional data regarding sediment grain size and excavation techniques are needed to predict the degree of effectiveness of sedimentation controls.

Excavation would remove the resident plants and shellfish and temporarily remove the benthic community in the excavated and filled areas below the high tide line. Some of the habitat functions and values would be temporarily lost as a result of the remedial actions. The remediation area would temporarily cease to function as a feeding area for some marine organisms, birds, or mammals, and it would not serve product export functions such as provision of nutrients for other systems. The lost functions and values of the habitat would not be completely replaced until the benthic community was fully reestablished. Placement of fill materials similar to the existing sand/gravel/rock substrate of the area would provide a foundation for reestablishment of the benthic community, serving as a habitat for

plants and animals to root and breed. Natural recolonization of the area would occur as waterborne algae spores and animal larvae were continually swept into the area by tidal currents and wave action.

The natural restoration of the area may take several years to complete. However, observations from similar sites indicate that natural restoration of the benthic community occurs at a fairly rapid pace (TtNUS, 1999). Based on these observations and recovery reported for similar habitats, it is anticipated that the benthic community would be reestablished within 1 to 4 years.

Sediment removal activities would destroy a small area of eelgrass beds. It may be necessary to consider assisted restoration for this area. Monitoring of adjacent areas would be conducted to determine the need for any mitigation measures.

Implementability: Implementation of Alternative 5 would require significant efforts, both administratively and technically. The complexity of implementation is a function of the location of the area to be excavated and backfilled and the depth and nature of the materials to be removed. The excavation would be implemented by land-based equipment using a trackhoe with long reach arm or through use of suction dredging equipment. Access for conventional equipment in the deeper areas near SD-410 would be through a temporary excavator causeway that would be constructed in the nearshore zone, however, even a temporary feature such as this may change hydrodynamics enough to cause scouring in the nearby eelgrass areas, indicating a need for use of suction dredging in this area. This will be determined following the predesign investigation during the remedial work plan stage.

Implementation of this alternative would require qualified contractors with personnel trained in hazardous waste site operations, who are qualified to handle contaminated sediment excavation, grading, and erosion control operations in an aqueous environment and who are capable of completing construction in a timely and effective manner. Wave action, the influence of local currents and tides, and weather conditions could result in scheduling delays related to site accessibility.

Implementation of the sediment dewatering and water treatment operations may also increase the complexity of implementing this alternative. The nature and grain size distribution of the sediment could greatly impact the success of the proposed gravity separation process.

Implementation of this alternative would require coordinating with regulatory agencies regarding marine excavation and filling operations; water treatment and discharge from sediment dewatering activities into the bay; materials handling/off-base disposal issues; and potential effects on fisheries, endangered species, and the marine habitat. Agreements with regulatory agencies would have to be reached regarding mitigation for altering marine habitats and establishing the periods for excavation and filling

activities in the bay. Obtaining agreements with regulatory agencies is not expected to pose a problem. The State of Rhode Island generally requires dredging projects to be conducted between November 1 and January 15 to protect sensitive species. The Navy will investigate the use of marine habitats on site by sensitive species to determine potential impacts from excavating during different times of the year.

If it is determined that the excavated material would be suitable for disposal in RCRA Subtitle D solid waste facilities, multiple facilities, including local landfills such as Central Landfill in Johnston, Rhode Island, would likely be able to accept the material. Otherwise, disposal would take place at a permitted TSDF.

Natural restoration of eelgrass is readily implementable because natural recovery is the main process employed. Eelgrass is present in healthy stands in the subtidal area, indicating that conditions are appropriate for recovery and growth. Assisted restoration of the eelgrass, if required, would be more difficult. Should this action be necessary, further restoration options would be evaluated employing habitat modifications that would structurally enhance eelgrass restoration, e.g., sand bottom and flatness. This effort would rely on the experience gained in other restoration projects for optimal location and restoration procedures.

Performing long-term monitoring to assess sediment quality would be easily implementable, given the availability of consulting/environmental firms and laboratories qualified to conduct such activities. These activities may require coordination with regulatory agencies.

Implementation of the removal and disposal alternative would not limit future implementation of additional remedial actions at the site.

Cost: A detailed estimate of capital, O&M, and present-worth costs for Alternative 5 is provided in Appendix F and is summarized below. Present-worth costs were developed for a 30-year period at a 3.9 percent discount rate.

Cost Description	**Estimated Cost**
Capital Costs	$3,775,000
O&M/Long-Term Monitoring	$44,000/year (years 1 through 5, and every 5 years thereafter)
Present Worth	$4,095,000

6.6 COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES

A comparative analysis is conducted to evaluate the significant differences between alternatives based on the threshold and balancing criteria. This analysis is provided below and summarized in Table 6-15.

Overall Protection of Human Health and the Environment: Because no actions would be taken under Alternative 1, this alternative would provide no additional protection of human health or the environment. Existing risks would remain to human health and to marine biota from contact with sediment contaminants. In addition, no mechanism would be in place to prevent erosion and subsequent migration of the contaminants into Narragansett Bay and connecting waterways.

Alternative 2 would provide limited protection of human health through implementation of access restrictions to discourage use of the site for recreation, while providing temporary protection to the marine receptors from removal, but no protection form existing COCs. However, as an interim measure, the need to protect the ecological receptors from COCs will be periodically evaluated and another alternative may be selected for implementation at a later date.

Alternative 3 would provide higher overall protection compared to Alternatives 1 and 2 mainly due to removing 5,716 cy of contaminated sediment and disposing in a secured landfill. This would result in a smaller area and volume of contaminated sediment remaining in the area. Alternatives 4 and 5 would also provide a high level of overall protection, because 98 percent of the contaminated sediment would be removed under Alternative 4, and all contaminated sediment would be removed in Alternative 5. All three of the action alternatives permanently reduce risks to human health associated with contaminated sediment through removal. Alternative 5 eliminates the need for long-term receptor monitoring because all the contaminated sediment would be removed. However, monitoring to assure affected areas do not become decontaminated will still be required. The short-term impacts to the marine environment would be somewhat greater for Alternatives 4 and 5 than Alternative 3 because of the additional excavation required. Habitat restoration would likely occur in the same time frame for all three action alternatives.

Excavation in Alternatives 3 and 4 would protect eelgrass beds, because none of the sediment in the beds would be removed and engineering controls would be used to minimize sediment migration. Under Alternative 5, approximately 0.05 acre of eelgrass beds would be impacted because of the excavation. Natural restoration of the eelgrass beds would occur in Alternative 5. The healthy stands of eelgrass present in the subtidal area indicate that conditions are appropriate for recovery and growth, although the process may be slow. Assisted restoration, if required, would be more difficult.

RAOs would not be achieved under Alternative 1. RAOs associated with preventing risks to human health would be addressed by installing fencing, signs, and buoys under Alternative 2, but RAOs for protection of the environment would only be achieved if the source removal results in a reduction of contaminants exceeding the ecological PRGs. Alternatives 3 and 4 would achieve success for protecting human health and additional partial success in protecting the environment. Alternative 5 would achieve RAOs for the protection of human health and the environment, but would result in the destruction of a section of eelgrass beds.

Compliance with ARARs: Alternatives 1 and 2 would fail to meet chemical-specific ARARs (water quality standards) used to derive sediment PRGs because they do not adequately address sediment exceeding PRGs.

Alternative 3 would comply with federal and state chemical-specific ARARs used to derive sediment PRGs only if the onshore removal action results in a decrease in the concentrations of the COCs in the sediment in the nearshore areas. Alternative 4 would comply if the onshore removal action results in a decrease the COC concentrations in the 0.05-acre eelgrass area.

Alternative 5 would comply with federal and state chemical-specific ARARs used to derive sediment PRGs because all sediment exceeding the PRGs derived from these standards would be removed by excavation. For all five alternatives, several non-promulgated criteria (TBCs) were used in assessing human health risks and developing sediment PRGs.

There are no location-specific or action-specific ARARs for Alternative 1. Alternative 2 does not satisfy federal location-specific ARARs for the protection of wetlands and floodplains.

Alternatives 3 and 4 would meet all state and federal location-specific ARARs and all state and federal action-specific ARARs by conducting the activities in accordance with the identified requirements. To satisfy the CWA Section 404 requirements, damaged marine habitats would have to be restored; no permanent losses would be anticipated. Alternatives 3 and 4 would protect eelgrass beds; however, they require long-term monitoring of contaminated sediment associated with the beds. Alternative 5 would excavate all areas of contamination including those associated with eelgrass beds and restore the eelgrass beds after remediation is complete.

Long-Term Effectiveness and Permanence: Alternative 1 would provide no additional long-term effectiveness and permanence in addressing sediment contamination at the site. Risks to environmental receptors would not be reduced. This no action alternative, along with the limited action (Alternative 2) and limited removal (Alternative 3) alternatives, would require 5-year reviews since the contaminated

sediment would remain on site. Alternative 4 would also require 5-year reviews for the contaminated sediment that would remain in the small area of eelgrass.

Confirmation of permanence of alternatives that are based on removal of sediment requires monitoring, as there is the potential for sediment movement to cause recontamination of the action areas. For instance, the PRGs that apply to the intertidal area are lower than those for the subtidal areas are. Therefore, subtidal contaminants that are moved to the intertidal area after remedial actions may bring the concentrations back to an actionable level. Monitoring after removal actions will attempt to address this possibility.

Alternative 2 would provide limited effectiveness in minimizing human health risks by discouraging/deterring and therefore reducing site access due to the placement of physical barriers and use restrictions. However, it would not be effective in preventing human health risks without proper enforcement of the existing use and access restrictions. Properly enforced, Alternative 2 would be effective in reducing human health exposures, but it would only be effective in limiting any potentially adverse environmental impacts if the source removal action reduces contaminant presence in this area. However, as an interim action, the need to implement an alternative with direct action will be evaluated regularly.

Alternative 3 would provide a higher level of long-term effectiveness than would Alternative 2. By removing a significant portion of the contaminated sediment, future risks to human health and the ecological receptors would be minimized. Since limited removal of contaminated sediment in this alternative would decrease the area and volume of contaminated sediment remaining, long-term risks would be lower than for Alternative 2, which removes no contaminated sediment. Alternative 4 would provide even better long-term effectiveness than Alternatives 2 and 3 because 98 percent of the contaminated sediment is removed.

Alternative 5 would be the most effective alternative in eliminating long-term risks to human health and the environment by removing the contaminated media from the marine environment. Provided that all sediment with contaminant concentrations above the PRGs is removed from the area, this alternative would not require long-term monitoring and 5-year reviews. However, a section of the protected eelgrass beds would be destroyed under this alternative. Although habitat restoration could be implemented if necessary, similar efforts have been met with limited success at other sites in Narragansett Bay in the past.

Reduction in Toxicity, Mobility, or Volume through Treatment: None of the alternatives would provide any reduction of toxicity, mobility, or volume through treatment, since none of the alternatives proposed involve treatment.

Short-Term Effectiveness: The no action alternative would offer no change in short-term risks. For alternative 2, the benthic community would be protected from destruction until monitoring data demonstrates removal of the source area does not provide long term protection to the sediments and additional removal actions are warranted. Following implementation (1 to 2 months), RAOs associated with minimizing human health risks would be partially achieved, but impacts to environmental receptors from existing COCs would not be addressed.

Alternative 3 would potentially result in increases in short-term risks due to disruption and suspension of contaminated sediment during site preparation and limited sediment removal activities, estimated to require 2 months. However, measures to minimize and/or contain sediment suspension would reduce short-term risks to the marine environment by limiting discharge to offshore waters, and the use of PPE would protect on-site workers from potential exposures. Intertidal and subtidal marine habitat functions and values would be temporarily lost during sediment removal. The lost functions and values would not be completely replaced until the benthic community in the area is fully reestablished through natural recolonization (an estimated 1 to 4 years), assisted by the placement of appropriate substrate. Following implementation (3 to 4 months), RAOs associated with minimizing risks to human health would be achieved. RAOs associated with protecting the environment would be achieved after disturbed habitats were restored.

Implementation of Alternatives 4 and 5 would result in short-term human and environmental risks from excavation and handling operations. Proper use of PPE would minimize human risks from direct contact with contaminated media. Engineering controls would minimize, but may not eliminate, environmental impacts caused by sediment resuspension during removal of contaminated sediment and debris. Intertidal and subtidal benthic habitat functions and values would be temporarily lost during excavation and filling and would not be completely replaced until the benthic community in the area is fully re-established through natural recolonization (an estimated 1 to 4 years), assisted by placement of appropriate substrate. Under Alternative 5, the eelgrass beds would need to be reestablished. Following implementation (6 to 8 months), RAOs associated with minimizing risks to human health would be achieved. RAOs associated with protecting the environment would be achieved after disturbed habitats were restored.

Implementability: The no action alternative is the most readily implementable; it would require no construction activities. Implementation would include completing the 5-year reviews only. Furthermore,

implementation would not limit the ease of undertaking future remedial actions at the site, if deemed necessary.

Limited actions associated with Alternative 2 would also be readily implemented. Technical feasibility issues would be minimal, since they would only include sampling activities for long-term monitoring and limited construction activities for installation of fencing and placement of buoys. Administrative feasibility would require some initial coordination/agreement between the landowner (US Navy) and with the owner of the intertidal zone, the State of Rhode Island, to establish access restrictions. Perhaps, however, the most cumbersome component in implementing this alternative is providing continual enforcement of the access and use restrictions on state-owned land and the continued maintenance of the fencing and buoy system, which would be required to ensure protection of human health. It is anticipated that the Navy will cover all costs for this effort and the State of Rhode Island will only require notification of the existing restrictions. Implementation would not limit conducting future remedial actions at the site, if deemed necessary.

Implementation of Alternatives 3, 4, and 5 would be more difficult due to removal of contaminated sediment. Site preparation and excavation would be affected by access limitations. These alternatives would also result in temporary loss of marine habitat that would require restoration. Natural restoration would be implemented by placement of appropriate substrate and restoration to the original grade.

Implementation of Alternatives 2 through 5 would all require similar coordination with regulatory agencies regarding potential effects on fisheries, endangered species, and the marine habitat; and marine excavation (Alternatives 3, 4, and 5 only). Agreements would have to be reached with regulatory agencies regarding mitigation for altering marine habitats, restoring eelgrass beds (for Alternative 5 only), and establishing the periods for excavation and filling activities in the bay.

Cost: Capital, O&M, present worth costs for the five sediment alternatives are summarized as follows:

Costs	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Limited Removal and Disposal (Beach Area)	Alternative 4 Removal and Disposal Option A	Alternative 5 Removal and Disposal Option B
Capital	$0	$10,000	$3,032,000	$3,421,000	$3,590,000
O&M/ Long-Term Monitoring	$0	$70,000/year (years 1-5 and 5-year intervals) $9,000/year (other years)	$73,000/year (years 1-5 and 5-year intervals) $0/year (other years)	$52,000/year(years 1-5 and 5-year intervals) $0/year (other years)	$44,000/year (years 1-5 and 5-year intervals) $0/year (other years)
5-Year Reviews	$22,000/5 years	$22,000/5 years	$22,000/5 years	$22,000/5 years	$22,000/5 years
PRESENT WORTH	$70,000	$653,000	$3,605,000	$3,922,000	$4,095,000

TABLES

TABLE 1-1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Media	Scenario/Receptor	RME or CTE	Media >1E-04 or HI>1	Total Cancer Risks	Total Noncancer Risks
On-Site Surface soils	Current/Future Child Recreational User	RME	NO	2.44E-06	0.0658
	Current/Future Youth Recreational User	RME	NO	2.02E-06	0.0221
	Current/Future Adult Recreational User	RME	NO	9.32E-07	0.00487
	Current/Future Lifetime Recreational User	RME	NO	5.40E-06	
	Future Child Resident	RME	NO	1.61E-05	0.299
	Future Adult Resident	RME	NO	8.75E-06	0.0411
	Future Lifetime Resident	RME	NO	2.48E-05	
On-Site Subsurface soils	Future Child Resident	RME	NO	2.57E-05	0.661
	Future Adult Resident	RME	NO	1.41E-05	0.0865
	Future Lifetime Resident	RME	NO	3.98E-05	
	Future Adult Excavation Worker	RME	NO	1.38E-06	0.232

RME- Reasonable Maximum Exposure
CTE- Central Tendency Exposure

TABLE 1-2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Media	Scenario/Receptor	RME or CTE	Media >1E-04 or HI>1	Total Cancer Risks	Total Noncancer Risks
Shoreline Sediment	Future Child Resident	RME	NO	1.17E-05	0.164
	Future Adult Resident	RME	NO	1.05E-05	0.0235
	Future Lifetime Resident	RME	NO	2.22E-05	
	Current/Future Child (Age 1-4) Shoreline Visitor	RME	NO	4.43E-07	0.00949
	Current/Future Youth (Age 5-12) Shoreline Visitor	RME	NO	6.79E-07	0.00569
	Current/Future Youth (Age 1-12) Shoreline Visitor	RME	NO	1.12E-06	
Lobster	Future Adult Subsistence Fisherman	RME CTE	YES	1.41E-03 5.28E-04	27.2 27.2
	Future Child Recreational User	RME	YES	2.94E-05	2.27
	Future Adult Recreational User	RME	YES	8.45E-05	1.63
	Future Lifetime Recreational User	RME CTE	YES	1.14E-04 4.15E-05	
Clams	Future Adult Subsistence Fisherman	RME CTE	YES	1.72E-03 6.45E-04	33.1 27.7
	Future Child Recreational User	RME CTE	YES	3.59E-05 1.20E-05	2.78 2.31
	Future Adult Recreational User	RME CTE	YES	1.03E-04 3.87E-05	2 1.66
	Future Lifetime Recreational User	RME CTE	YES	1.39E-04 5.07E-05	
Blue Mussels	Future Adult Subsistence Fisherman	RME CTE	YES	4.36E-04 1.64E-04	24.5 21.9
	Future Child Recreational User	RME	YES	9.11E-06	2.05
	Future Adult Recreational User	RME	YES	2.62E-05	1.47
	Future Lifetime Recreational User	RME	NO	3.53E-05	

RME- Reasonable Maximum Exposure
CTE- Central Tendency Exposure

TABLE 1-3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR GROUNDWATER
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Media	Scenario/Receptor	RME or CTE	Media >1E-04 or HI>1	Total Cancer Risks	Total Noncancer Risks
On-Site Groundwater	Future Child Resident	RME	YES	4.92E-04	62.2
	Future Adult Resident	RME	YES	8.03E-04	52
	Future Lifetime Resident	RME	YES	1.29E-03	NC
	Future Child Resident	CTE	YES	9.66E-06	10.6
	Future Adult Resident	CTE	YES	1.56E-05	42.2
	Future Lifetime Resident	CTE	YES	2.56E-05	NC

RME- Reasonable Maximum Exposure
CTE- Central Tendency Exposure
NC - Not Calculated

TABLE 2-1
POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
Federal Regulatory Requirements	EPA Region IX Risk-Based Concentrations (Oct 1997)	To Be Considered	Risk Based Concentrations (RBCs) are human-health-based allowable exposure guidance levels developed for carcinogenic and non-carcinogenic compounds, using reference doses and carcinogenic potency slopes obtained from EPA's Integrated Risk Information System (IRIS) database, EPA's Health Effects Assessment Summary Tables (HEAST), and standard exposure scenarios. RBCs are chemical concentrations corresponding to a fixed level of risk in various media.	RBCs from Region III are used in the RI and future data will be compared with Region IX for human health risk evaluation to identify and select contaminants of potential concern.
	EPA Human Health Assessment Cancer Slope Factors (CSFs).	To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Will be used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
	Clean Water Act, Section 304 33 USC 1314; 40 CFR 122.44	Relevant and Appropriate	Establish Ambient Water Quality Criteria (AWQC): Guidelines established for the protection of human health and/or the aquatic organisms.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. Sediments exceeding PRGs must be adequately addressed to meet these standards.
	OSWER Directive 9200.4-26, Approaches for Addressing Dioxins in Soil at CERCLA and RCRA Sites (Apr. 13, 1998)	To Be Considered	This Directive provides guidance in establishing cleanup levels for dioxins. A 1 μg/kg (ppb) concentration of dioxins (as 2,3,7,8-TCDD TE) has been established for surficial soils involving residential exposure scenarios. A cleanup range of 5 to 20 μg/kg of dioxin (as 2,3,7,8-TCDD TE) has been established for commercial and industrial exposure scenarios.	This OSWER policy aids in the establishment of dioxin PRGs for soil and sediment to be used in the remedial action.

TABLE 2-1 (cont'd)
POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
State Regulatory Requirements	State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations), CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	Relevant and Appropriate	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	The Remediation Regulations are used in the establishment of PRGs for soil to be used in the remedial action.
	Water Pollution Control. RIGL 46-12 *et seq.*; ENVM 112-88.97-1	Relevant and Appropriate	Establishes water use classification and water quality criteria for waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. Sediments exceeding PRGs must be adequately addressed to meet these standards.
	State of Rhode Island Rules and Regulations for Hazardous Waste Management, DEM-DAHM-WMB-01-92, as amended April 1992	Applicable	These regulations are intended to minimize environmental hazards associated with the generation, transportation, treatment, storage, and disposal of hazardous wastes.	The Hazardous Waste Management Regulations aid in the establishment of PRGs for soil and sediment to be used in the remedial action.
	State of Rhode Island Oil Contaminated Soil Policy, Division of Air and Hazardous Materials September 1991	Applicable	This policy statement applies to soil that has been contaminated with petroleum products but does not meet the definition of a hazardous waste. Material contaminated with virgin petroleum products may be processed in state, but material contaminated with unknown or waste petroleum products must be disposed of out of state.	Soil contaminated with petroleum products may be removed from the site and would be subject to this policy statement.
	Rhode Island Air Quality Regulations, RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of contaminants at rates that would result in ground level concentrations greater than acceptable ambient levels or levels as set in the regulations.	Alternatives may involve treatment of soil. Treatment activities will be carried out in a manner that will comply with the air quality regulations.

TABLE 2-2
POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
Federal Regulatory Requirements	Floodplain Management (Executive Order 11988-40 CFR 6.302(b) and Statement of procedures on Floodplain Management and Wetlands Protection (40 CFR 6, App. A)	Applicable	Federal agencies are required to avoid impacts associated with the occupancy and modification of a floodplain and avoid support of floodplain development wherever there is a practicable alternative. Requires owner to solicit comments regarding how the selected remedy meets the standard for being the least damaging practicable alternative.	The expected impacts of each alternative will be evaluated, in terms of the intent of this provision, and considered during the preferred alternative selection process. Adverse impacts should be mitigated where feasible or necessary. Comments sought through FS, PRAP and ROD submittals.
	Rivers and Harbors Act (33 U.S.C. Section 403); Section 10	Applicable	These regulations set forth criteria from the Army Corps of Engineers (ACOE) for placing dams/structures in navigable waters of the United States.	Excavation, dredging, and habitat restoration will comply with the Act's substantive environmental standards.
	Clean Water Act - Section 404(b)(1) Guidelines for specification of disposal sites for dredged or fill material (40 CFR Part 230)	Applicable	These guidelines outline requirements for the discharge of dredged or fill materials into surface waters.	Alternatives may involve discharge of dredged material and/or excavation of marine sediments. Filling or discharge of dredged material will only occur where there is no other practicable alternative and any adverse impacts will be mitigated.
	Fish and Wildlife Coordination Act (16 U.S.C. 661), Fish and Wildlife protection (40 CFR Section 6.302(g))	Applicable	This regulation requires that any federal agency proposing to modify a body of water must consult with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and other related state agencies. That federal agency must consult with the appropriate government entity and also take action to prevent, mitigate, or compensate for project-related losses of endangered species, fish and wildlife resources.	Alternatives may modify potential endangered species, fish and wildlife habitats. All appropriate state and federal agencies, such as the USFWS, will be consulted to ensure that losses of these resources will be prevented, mitigated, or compensated.

TABLE 2-2 (cont'd)
POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
Federal Regulatory Requirements (Cont'd)	Executive Order 11990 RE: Protection of Wetlands 40 CFR Part 6, Appendix A	Applicable	This Order requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order.	Restoration and preservation of the wetlands may be altered by the removal action. Actions will be conducted so that the wetlands' natural and beneficial values can be realized. Implementation of the Order will be considered and incorporated into any plan or action, wherever feasible.
	Endangered Species Act 16 USC 1531 *et seq.*, 50 CFR Part 200, 50 CFR Part 402	Applicable	If a location contains a federal endangered or threatened species or its critical habitat, and an action may impact the species or its habitat, the U.S. Fish & Wildlife Service or the National Marine Fisheries Service must be consulted.	The federally endangered loggerhead turtle (*Caretta caretta*) and federally threatened Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species and its habitat.
	National Historic Preservation Act 16 USC 470 *et seq.*, 26 CFR Part 800	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks	Historic vessels may be sunken in the area. Remedial actions may involve actions that might cause potential harm to historic sites. Such actions would be prevented.
	Coastal Zone Management Act (16 USC Section 1451 et seq.)	Applicable	This act regulates activities affecting the coastal zone including lands thereunder and adjacent shoreline.	For remedial actions in a coastal zone, requires determination that all activities are consistent to the maximum extent practicable with the State Coastal Zone Management Plan.

TABLE 2-2 (cont'd)
POTENTIAL LOCATION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
State Regulatory Requirements	Coastal Resources Management RIGL 46-23-1 *et seq.*	Applicable	This law creates the Coastal Resources Management Council and authorizes promulgation of regulations for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed. All actions will be consistent, to the extent practicable, with the Coastal Zone Management Plan.
	Endangered Species Act, RIGL 20-37-1 *et seq.*	Applicable	Regulates activities affecting state-listed endangered or threatened species or their critical habitat.	The state listed loggerhead turtle (*Caretta caretta*) and Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species and its habitat.
	Rhode Island Historical Preservation Act, RIGL 42-45 *et seq*.	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks	Historic vessels may be sunken in the area. Remedial actions may involve actions that might cause potential harm to historic sites. Such actions would be prevented.

TABLE 2-3
POTENTIAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
Federal Regulatory Requirements	Clean Water Act, Section 402; EPA administered permit programs: the NPDES (40 CFR Part 122), criteria and standards for the NPDES (40 CFR Part 125), Water quality standards (40 CFR Part 131)	Applicable	Contains discharge limitations, monitoring requirements, and best management practices. Substantive requirements under NPDES are written such that state and federal ambient water quality criteria (AWQC) are met. Permits are required for off-site discharges	Alternatives may involve substantial activities in Narragansett Bay, including dewatering sediment activities that may disturb sediments. Discharge of any contaminated groundwater during soil excavation in either a POTW or Narragansett Bay will meet applicable standards.
	Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS 42 USC 7411, 7412; 40 CFR Part 61	Applicable	NESHAPS are a set of emission standards for specific chemicals, including naphthalene, arsenic, cadmium, chromium, lead, mercury, nickel, PCBs, DDE, and hexachlorobenzene. Certain activities are regulated including site remediation.	Alternatives may involve excavation and treatment of soil and sediment. Monitoring of air emissions will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner that will minimize potential air releases.
State Regulatory Requirements	Hazardous Waste Management Act (RI General Laws 23-19.1-6, 23-19.1-7, and 23-19.1-10); Section 5, Generators	Applicable	These regulations apply to all generators of hazardous waste. They include requirements for identification, storage, shipment and labeling of waste.	Alternatives may involve the generation of hazardous waste via excavation, and /or generation of contaminated filters or treatment byproducts. Excavation and generation of treatment byproducts and related activities will comply with this regulation. All excavated soil will be tested for hazardous characteristics prior to disposal. If soil or sediment is identified through this testing, follow up will be conducted to assure hazardous materials are removed from the site.
	Remediation Regulations DEM-DSR-01-93 Section 8.01, A to D.	To Be Considered	Sets levels for monitoring of contaminated groundwater when more stringent than federal standards.	Standards were considered in development of GW PRGs based on the implausible use of the groundwater as a water supply.

TABLE 2-3 (cont'd)
POTENTIAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AUTHORITY	REQUIREMENT	STATUS	REQUIREMENT SYNOPSIS	CONSIDERATION
	Water Pollution (RI General Laws 46-12), Environmental Management (RI General Laws 42-17.1, Water Quality Regulations (R.I. Code R. 112-88.97-1), Rule #18	Applicable	Regulations designed to protect state surface water resources. Establishes water use classification and water quality criteria for waters of the state.	Alternatives will include provisions for the protection of Narragansett Bay where construction activities occur in these waters. Remedial actions including dredging and filling will be conducted to minimize degradation to the bay.
State Regulatory Requirements (Cont'd)	Clean Air Act - Emissions Detrimental to Persons or Property RIGL 23-23 *et seq.*; CRIR 12-31-07	Relevant and Appropriate	Prohibits emissions of contaminants which may be injurious to humans, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property	Alternatives may involve removal, processing, and temporary storage of debris, soil, and sediments involving the release of contaminants.
	Clean Air Act - Air Toxics RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels as set in the regulations	Alternatives may involve removal, processing, and temporary storage of debris, soil, and sediments involving the release of contaminants.
	Clean Air Act - Fugitive Dust Control RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Alternatives with removal, processing, and temporary storage of debris, soil, and sediments might generate fugitive dust. Controls would be implemented to prevent material from becoming airborne.
	Clean Air Act - Air Pollution Control RIGL 23-23 *et seq.*; CRIR 12-31-09	Applicable	Establishes guidelines for the construction, installation, or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Alternatives may involve processing of debris, soil, and sediment, and treatment of dewatering liquid, releasing contaminants and in such instances this regulation will be complied with.
	RI Air Pollution Control Regulation #5, Fugitive Dust	Applicable	Regulations designed to control releases of airborne particulate in the State of Rhode Island, including those caused by earth moving activities.	Alternatives may include earth-moving activities and land clearing where there is a possibility of fugitive dust and in such instances this regulation will be complied with.

TABLE 2-4
RISK-BASED COPC SELECTION FOR SURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	Risk-Based Conc. (cancer)	Risk-Based Conc. (noncancer)	COPC Requiring Further Consideration?
SURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS RESULTS						
4-Chloro-3-Methylphenol	ug/kg	3 / 71	140 J			No
Benzo(a)anthracene	ug/kg	43 / 71	9100	910		Yes
Benzo(a)pyrene	ug/kg	42 / 71	7100	91		Yes
Benzo(b)fluoranthene	ug/kg	52 / 71	9700	910		Yes
Benzo(k)fluoranthene	ug/kg	15 / 71	3500 J	9100		No
Carbazole	ug/kg	9 / 65	930 J	33000		No
Chrysene	ug/kg	46 / 71	8100	91000		No
Dibenzo(a,h)anthracene	ug/kg	11 / 71	610	91		Yes
Indeno(1,2,3-cd)pyrene	ug/kg	30 / 71	4100	910		Yes
SURFACE SOILS - PESTICIDES/PCBs RESULTS						
Aroclor-1254	ug/kg	2 / 39	530	320	1800	Yes
SURFACE SOILS - METALS RESULTS						
Arsenic	mg/kg	76 / 76	10.4	0.60	35	Yes
Chromium	mg/kg	76 / 76	37.9	150	380	No
Lead	mg/kg	75 / 76	2970		400	Yes
Manganese	mg/kg	76 / 76	750		9100	No
Nickel	mg/kg	66 / 76	221		2500	No
SURFACE SOILS - DIOXINS/FURANS RESULTS						
Total 2,3,7,8-TCDD Equivalents	ug/kg	7 / 7	0.0164	0.006		Yes

[1]Chemical selected as COPC requiring further action if the maximum detected concentration exceeds either the cancer or noncancer risk-based concentration.
Data qualifiers:
J = estimated

TABLE 2-5
RISK-BASED COPC SELECTION FOR SUBSURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	Risk-Based Conc. (cancer)	Risk-Based Conc. (noncancer)	COPC Requiring Further Consideration?
SUBSURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS RESULTS						
4,6-Dinitro-2-Methylphenol	ug/kg	1 / 32	320 J			No
Benzo(a)anthracene	ug/kg	35 / 43	3400	910		Yes
Benzo(a)pyrene	ug/kg	32 / 42	4000	91		Yes
Benzo(b)fluoranthene	ug/kg	34 / 42	2800	910		Yes
Benzo(k)fluoranthene	ug/kg	22 / 43	2500 J	9100		No
Carbazole	ug/kg	1 / 21	170 J	33000		No
Chrysene	ug/kg	37 / 43	3200 J	91000		No
Dibenzo(a,h)anthracene	ug/kg	19 / 37	820 J	91		Yes
Indeno(1,2,3-cd)pyrene	ug/kg	29 / 39	2300 J	910		Yes
SUBSURFACE SOILS - PESTICIDES/PCBs RESULTS						
delta-BHC	ug/kg	1 / 33	2.4 J			No
Dieldrin	ug/kg	2 / 33	44 J	62	6300	No
SUBSURFACE SOILS - METALS RESULTS						
Antimony	mg/kg	9 / 39	39.2 J		51	No
Arsenic	mg/kg	50 / 50	74.4 J	0.60	36	Yes
Chromium	mg/kg	50 / 50	61.9	150	380	No
Lead	mg/kg	49 / 49	7820 J		400	Yes
Manganese	mg/kg	50 / 50	1110 J		9100	No
Mercury	mg/kg	26 / 37	2.2 J		13	No
Vanadium	mg/kg	47 / 50	57		880	No
Zinc	mg/kg	47 / 50	4240		38000	No

[1]Chemical selected as COPC requiring further action if the maximum detected concentration exceeds either the cancer or noncancer risk-based concentration.
Data qualifiers:
J = estimated

TABLE 2-6
RIDEM-BASED COPC SELECTION FOR SURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SURFACE SOILS - VOLATILE ORGANIC COMPOUNDS RESULTS						
1,1,1-Trichloroethane	ug/kg	1 / 67	2 J	540000	160000	No
1,2-Dichloroethene (total)	ug/kg	1 / 67	17	630000	60000	No
2-Butanone	ug/kg	15 / 67	13	10000000		No
2-Hexanone	ug/kg	1 / 67	32			No
Acetone	ug/kg	23 / 67	320 J	7800000		No
Bromomethane	ug/kg	2 / 67	1 J	800		No
Carbon Disulfide	ug/kg	1 / 67	2 J	120000		No
Chloromethane	ug/kg	3 / 67	1 J	490		No
Methylene Chloride	ug/kg	37 / 67	4 J	45000		No
Tetrachloroethene	ug/kg	3 / 67	16	12000	4200	No
Toluene	ug/kg	5 / 67	4 J	190000	54000	No
Trichloroethene	ug/kg	1 / 67	1 J	13000	20000	No
Vinyl Chloride	ug/kg	1 / 67	3 J	20		No
Xylenes (total)	ug/kg	6 / 67	3 J	110000		No
SURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS RESULTS						
2-Methylnaphthalene	ug/kg	9 / 71	660	123000		No
4-Chloro-3-Methylphenol	ug/kg	3 / 71	140 J			No
9H-Carbazole	ug/kg	7 / 33	690	32000		No
Acenaphthene	ug/kg	12 / 71	940	43000		No
Acenaphthylene	ug/kg	6 / 71	140 J	23000		No
Anthracene	ug/kg	21 / 71	3800	35000		No
Benzo(a)anthracene	ug/kg	43 / 71	9100	900		Yes
Benzo(a)pyrene	ug/kg	42 / 71	7100	400		Yes
Benzo(b)fluoranthene	ug/kg	52 / 71	9700	900		Yes
Benzo(g,h,i)perylene	ug/kg	29 / 71	4300	800		Yes
Benzo(k)fluoranthene	ug/kg	15 / 71	3500 J	900		Yes
bis(2-ethylhexyl)Phthalate	ug/kg	15 / 71	3200 J	46000		No
Carbazole	ug/kg	9 / 65	930 J	32000		No

TABLE 2-6 (cont'd)
RIDEM-BASED COPC SELECTION FOR SURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS (continued)						
Chrysene	ug/kg	46 / 71	8100	400		Yes
di-N-Butylphthalate	ug/kg	17 / 71	170 J	7800000		No
di-N-Octylphthalate	ug/kg	1 / 71	54 J	1600000		No
Dibenzo(a,h)anthracene	ug/kg	11 / 71	610	400		Yes
Dibenzofuran	ug/kg	8 / 71	650	164000		No
Fluoranthene	ug/kg	56 / 71	15000	20000		No
Fluorene	ug/kg	13 / 71	1200	28000		No
Hexachlorobenzene	ug/kg	2 / 71	210 J	400		No
Indeno(1,2,3-cd)pyrene	ug/kg	30 / 71	4100	900		Yes
N-Nitroso-Diphenylamine	ug/kg	1 / 71	150 J	94000		No
Naphthalene	ug/kg	7 / 71	740	54000		No
Pentachlorophenol	ug/kg	1 / 71	350	5300		No
Phenanthrene	ug/kg	45 / 71	9700	40000		No
Phenol	ug/kg	1 / 71	60 J	6000000		No
Pyrene	ug/kg	59 / 71	12000	13000		No
SURFACE SOILS - PESTICIDES/PCBs RESULTS						
4,4'-DDD	ug/kg	21 / 39	17	2700		No
4,4'-DDE	ug/kg	36 / 39	42	1900		No
4,4'-DDT	ug/kg	36 / 39	74	1900		No
Aldrin	ug/kg	3 / 39	1.5 J	38		No
alpha-BHC	ug/kg	4 / 39	1.7 J	100		No
alpha-Chlordane	ug/kg	14 / 39	14	500		No
Aroclor-1254	ug/kg	2 / 39	530	10000	10000	No
beta-BHC	ug/kg	3 / 39	0.99 J	340		No
Dieldrin	ug/kg	17 / 39	11 J	40		No
Endosulfan I	ug/kg	7 / 39	9.4	2300		No
Endosulfan II	ug/kg	18 / 39	25	2300		No

TABLE 2-6 (cont'd)
RIDEM-BASED COPC SELECTION FOR SURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SURFACE SOILS - PESTICIDES/PCBs (continued)						
Endosulfan Sulfate	ug/kg	11 / 39	33			No
Endrin	ug/kg	27 / 39	74	5000		No
Endrin Aldehyde	ug/kg	18 / 33	25 NJ			No
Endrin Ketone	ug/kg	1 / 39	2.9 J			No
gamma-BHC	ug/kg	9 / 39	2.4	490		No
gamma-Chlordane	ug/kg	13 / 39	7.8	500		No
Heptachlor	ug/kg	3 / 39	0.74 J	140		No
Heptachlor Epoxide	ug/kg	24 / 39	8.1	70		No
Methoxychlor	ug/kg	8 / 39	10 J	7800		No
SURFACE SOILS - METALS RESULTS						
Antimony	mg/kg	10 / 76	9.1 J	10		No
Arsenic	mg/kg	76 / 76	10.4	1.7		Yes
Barium	mg/kg	72 / 76	282	5500		No
Beryllium	mg/kg	60 / 76	0.6	0.4		Yes
Cadmium	mg/kg	3 / 76	0.94	39		No
Chromium	mg/kg	76 / 76	37.9	390		No
Lead	mg/kg	75 / 76	2970	150		Yes
Manganese	mg/kg	76 / 76	750	390		Yes
Mercury	mg/kg	32 / 76	0.61	23		No
Nickel	mg/kg	66 / 76	221	1000		No
Selenium	mg/kg	8 / 76	0.66 J	390		No
Silver	mg/kg	22 / 76	26.5 J	200		No
Vanadium	mg/kg	76 / 76	41.2	550		No
Zinc	mg/kg	75 / 76	1910 J	6000		No

TABLE 2-6 (cont'd)
RIDEM-BASED COPC SELECTION FOR SURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SURFACE SOILS - DIOXINS/FURANS RESULTS						
Total 2,3,7,8-TCDD Equivalents	ug/kg	7 / 7	0.016388			Yes

[1]Chemical selected as COPC requiring further action if the maximum detected concentration exceeds either the cancer or noncancer risk-based concentration.
Data qualifiers:
J = estimated
NJ = presumptively present at an estimated level

TABLE 2-7
RIDEM-BASED COPC SELECTION FOR SUBSURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SUBSURFACE SOILS - VOLATILE ORGANIC COMPOUNDS RESULTS						
2-Butanone	ug/kg	3 / 37	1100 J	10000000		No
Carbon Disulfide	ug/kg	3 / 38	11	120000		No
Chloroethane	ug/kg	1 / 35	1 J			No
Ethylbenzene	ug/kg	3 / 37	630 J	71000	62000	No
Methylene Chloride	ug/kg	6 / 53	1800	45000		No
Toluene	ug/kg	10 / 39	67	190000	54000	No
Total VOCs	ug/kg	3 / 3	3			No
Xylenes (total)	ug/kg	5 / 37	1200	110000		No
SUBSURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS RESULTS						
2-Methylnaphthalene	ug/kg	13 / 35	11000	123000		No
4,6-Dinitro-2-Methylphenol	ug/kg	1 / 32	320 J			No
9H-Carbazole	ug/kg	6 / 12	220 J	32000		No
Acenaphthene	ug/kg	14 / 37	4900	43000		No
Acenaphthylene	ug/kg	10 / 33	640	23000		No
Anthracene	ug/kg	32 / 43	4800	35000		No
Benzo(a)anthracene	ug/kg	35 / 43	3400	900		Yes
Benzo(a)pyrene	ug/kg	32 / 42	4000	400		Yes
Benzo(b)fluoranthene	ug/kg	34 / 42	2800	900		Yes
Benzo(g,h,i)perylene	ug/kg	22 / 39	1900 J	800		Yes
Benzo(k)fluoranthene	ug/kg	22 / 43	2500 J	900		Yes
Benzoic Acid	ug/kg	1 / 2	48 J	340000		No
bis(2-ethylhexyl)Phthalate	ug/kg	3 / 44	110 J	46000		No
Butylbenzylphthalate	ug/kg	1 / 33	120 J	330000		No
Carbazole	ug/kg	1 / 21	170 J	32000		No
Chrysene	ug/kg	37 / 43	3200 J	400		Yes
di-N-Butylphthalate	ug/kg	3 / 40	1400 *	7800000		No
Dibenzo(a,h)anthracene	ug/kg	19 / 37	820 J	400		Yes
Dibenzofuran	ug/kg	11 / 34	4000	160000		No

TABLE 2-7 (cont'd)
RIDEM-BASED COPC SELECTION FOR SUBSURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SUBSURFACE SOILS - SEMIVOLATILE ORGANIC COMPOUNDS (continued)						
Fluoranthene	ug/kg	43 / 47	16000	20000		No
Fluorene	ug/kg	17 / 36	3400	28000		No
Hexachlorobenzene	ug/kg	1 / 33	370 J	400		No
Indeno(1,2,3-cd)pyrene	ug/kg	29 / 39	2300 J	900		Yes
Naphthalene	ug/kg	10 / 34	4000	54000		No
Phenanthrene	ug/kg	43 / 47	14000	40000		No
Phenol	ug/kg	3 / 22	490	6000000		No
Pyrene	ug/kg	45 / 49	5300	13000		No
Total BNAs	ug/kg	8 / 8	20890			No
Total Carcinogenic PAHs	ug/kg	4 / 4	3950			No
Total PAHs	ug/kg	16 / 16	21100			
SUBSURFACE SOILS - PESTICIDES/PCBs RESULTS						
4,4'-DDD	ug/kg	5 / 33	89 J	2700		No
4,4'-DDE	ug/kg	8 / 33	67 J	1900		No
4,4'-DDT	ug/kg	11 / 33	370	1900		No
alpha-BHC	ug/kg	4 / 33	2.5 J	100		No
alpha-Chlordane	ug/kg	2 / 33	10 NJ	500		No
Aroclor-1254	ug/kg	2 / 33	190 J	10000	10000	No
Aroclor-1260	ug/kg	1 / 33	39 J	10000	10000	No
delta-BHC	ug/kg	1 / 33	2.4 J			No
Dieldrin	ug/kg	2 / 33	44 J	40		Yes
Endosulfan I	ug/kg	3 / 33	5.4 J	2300		No
Endosulfan II	ug/kg	12 / 33	13 J	2300		No
Endosulfan Sulfate	ug/kg	3 / 33	17 J			No
Endrin	ug/kg	6 / 33	120 J	5000		No
Endrin Aldehyde	ug/kg	3 / 33	16 J			No
gamma-BHC	ug/kg	3 / 33	3.1 NJ	490		No

TABLE 2-7 (cont'd)
RIDEM-BASED COPC SELECTION FOR SUBSURFACE SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Det. Freq.	Maximum Detected	RIDEM Direct Exposure Residential	RIDEM GB Leachability	COPC Requiring Further Consideration?[1]
SUBSURFACE SOILS - PESTICIDES/PCBs (continued)						
gamma-Chlordane	ug/kg	3 / 33	2.5 J	500		No
Heptachlor	ug/kg	1 / 33	1.4 J	140		No
Heptachlor Epoxide	ug/kg	10 / 33	43	70		No
Methoxychlor	ug/kg	1 / 33	4 NJ	7800		No
SUBSURFACE SOILS - TOTAL PETROLEUM HYDROCARBONS RESULTS						
TPH	mg/kg	11 / 14	21000 J	500	2500	Yes
SUBSURFACE SOILS - METALS RESULTS						
Antimony	mg/kg	9 / 39	39.2 J	10		Yes
Arsenic	mg/kg	50 / 50	74.4 J	1.7		Yes
Barium	mg/kg	50 / 50	220	5500		No
Beryllium	mg/kg	23 / 39	0.48 B1	0.4		Yes
Cadmium	mg/kg	11 / 38	8.1	39		No
Chromium	mg/kg	50 / 50	61.9	390		No
Lead	mg/kg	49 / 49	7820 J	150		Yes
Manganese	mg/kg	50 / 50	1110 J	390		Yes
Mercury	mg/kg	26 / 37	2.2 J	23		No
Nickel	mg/kg	50 / 50	64.1	1000		No
Selenium	mg/kg	18 / 40	1.7 B1	390		No
Vanadium	mg/kg	47 / 50	57	550		No
Zinc	mg/kg	47 / 50	4240	6000		No

[1]Chemical selected as COPC requiring further action if the maximum detected concentration exceeds either the cancer or noncancer risk-based concentration.

Data qualifiers:
J = estimated
NJ = presumptively present at an estimated level
B = greater than Instrument Detection Level (IDL) but less that Contract Required Detection Limit (CRL)
* = qualifier changed as a result of data validation

TABLE 2-8
SELECTION OF SOIL COPCs REQUIRING FURTHER CONSIDERATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Selected by Risk-Based Process	Selected by RIDEM-Based Process
SEMIVOLATILE ORGANIC COMPOUNDS		
Benzo(a)anthracene	X	X
Benzo(a)pyrene	X	X
Benzo(b)fluoranthene	X	X
Benzo(g,h,i)perylene		X
Benzo(k)fluoranthene		X
Chrysene		X
Dibenzo(a,h)anthracene	X	X
Indeno(1,2,3-cd)pyrene	X	X
PESTICIDES/PCBs		
Aroclor-1254	X	
Dieldrin		X
TOTAL PETROLEUM HYDROCARBONS		
TPH		X
METALS		
Antimony		X
Arsenic	X	X
Beryllium		X
Lead	X	X
Manganese		X
DIOXINS/FURANS		
Total 2,3,7,8-TCDD Equivalents	X	X

TABLE 2-9
SOIL PRELIMINARY REMEDIATION GOALS
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Risk-Based PRG	RIDEM Residential Direct Exposure Criteria	RIDEM GB Leachability Criteria	ARAR/TBC	Background Concentration	Selected Soil PRG	Basis for Selection
SEMIVOLATILE ORGANIC COMPOUNDS								
Benzo(a)anthracene	ug/kg	910	900				900	RIDEM
Benzo(a)pyrene	ug/kg	91	400 (a)				400	RIDEM
Benzo(b)fluoranthene	ug/kg	910	900				900	RIDEM
Benzo(g,h,i)perylene	ug/kg	(b)	800				800	RIDEM
Benzo(k)fluoranthene	ug/kg	(b)	900				900	RIDEM
Chrysene	ug/kg	(b)	400				400	RIDEM
Dibenzo(a,h)anthracene	ug/kg	91	400 (a)				400	RIDEM
Indeno(1,2,3-cd)pyrene	ug/kg	910	900				900	RIDEM
PESTICIDES/PCBs								
Aroclor-1254	ug/kg	320	10000		1000(c)		1000	TBC
Dieldrin	ug/kg	(b)	40				40	RIDEM
TOTAL PETROLEUM HYDROCARBONS								
TPH	mg/kg		500	2500			500	RIDEM
METALS								
Antimony	mg/kg	(b)	10			0.42	10	RIDEM
Arsenic	mg/kg	0.60	1.7			6.2(d)	6.2	Background
Beryllium	mg/kg	(b)	0.4			0.439	0.4 (e)	RIDEM
Lead	mg/kg	400	150		400(f)	15.4	150	RIDEM
Manganese	mg/kg	(b)	390			372	390	RIDEM
DIOXINS/FURANS								
Total 2,3,7,8-TCDD Equivalents	ug/kg	0.0060	0.0043		1(g)		1	TBC

(a) Based on quantitation limits. Because the quantitation limit is 400 ug/kg for these chemicals, the lower risk-based value is not chosen.
(b) No value presented -- not a COPC based on Risk-Based COPC Selection method.
(c) Soil action level from EPA Directive 9355.4-01, A Guide on Remedial Actions at Superfund Sites with PCB Contamination.
(d) Calculated by RIDEM, see Section 2.2.2.2.
(e) RIDEM Direct Exposure concentration is below background level. However, to be conservative, the RIDEM concentration was selected.
(f) Screening level from EPA Directive 9355.4-12, Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities.
(g) Residential value from EPA Directive 9200.4-26, Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites.

TABLE 2-10
SELECTION OF SOIL COCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Soil PRG	Maximum Detected	Selected as COC?
SEMIVOLATILE ORGANIC COMPOUNDS				
Benzo(a)anthracene	ug/kg	900	9100	Yes
Benzo(a)pyrene	ug/kg	400	7100	Yes
Benzo(b)fluoranthene	ug/kg	900	9700	Yes
Benzo(g,h,i)perylene	ug/kg	800	4300	Yes
Benzo(k)fluoranthene	ug/kg	900	3500 J	Yes
Chrysene	ug/kg	400	8100	Yes
Dibenzo(a,h)anthracene	ug/kg	400	820 J	Yes
Indeno(1,2,3-cd)pyrene	ug/kg	900	4100	Yes
PESTICIDES/PCBs				
Aroclor-1254	ug/kg	1000	530	No
Dieldrin	ug/kg	40	44 J	Yes
TOTAL PETROLEUM HYDROCARBONS				
*TPH**	*mg/kg*	*500*	*21000 J*	*No**
METALS				
Antimony	mg/kg	10	39.2 J	Yes
Arsenic	mg/kg	6.2	74.4 J	Yes
Beryllium	mg/kg	0.4	0.48 B1	Yes
Lead	mg/kg	150	7820 J	Yes
Manganese	mg/kg	390	1110 J	Yes
DIOXINS/FURANS				
Total 2,3,7,8-TCDD Equivalents	ug/kg	1	0.016388	No

Data qualifiers:
J = estimated
B = greater than IDL but less than CRDL
* TPH is not a CERCLA Based COC, however, it will be used with the COCs on this Table in accordance with RIDEM regulations as a cleanup criteria.

TABLE 2-11
SURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft)		Parameter	Concentration	qual	units	Soil PRG
	top	bottom					
B-8	0	1	Arsenic	6.3	J	mg/kg	6.2
B-9	0	1	Beryllium	0.43		mg/kg	0.4
B-11	0	1	Arsenic	6.6	J	mg/kg	6.2
B-11	0	1	Manganese	439	J	mg/kg	390
B-12	0	1	Arsenic	6.6	J	mg/kg	6.2
B-12	0	1	Benzo(a)pyrene	2800		ug/kg	400
B-12	0	1	Benzo(g,h,i)perylene	980		ug/kg	800
B-12	0	1	Dibenz(a,h)anthracene	610		ug/kg	400
B-12	0	1	Indeno(1,2,3-cd)pyrene	1200		ug/kg	900
B-12	0	1	Manganese	439	J	mg/kg	390
B-13	0	1	Arsenic	10	J	mg/kg	6.2
B-14	0	1	Arsenic	8.5		mg/kg	6.2
B-15	0	1	Arsenic	7		mg/kg	6.2
B-15	0	1	Benzo(a)anthracene	2400		ug/kg	900
B-15	0	1	Benzo(a)pyrene	2600		ug/kg	400
B-15	0	1	Benzo(b)fluoranthene	3900		ug/kg	900
B-15	0	1	Benzo(g,h,i)perylene	1300	J	ug/kg	800
B-15	0	1	Chrysene	2400		ug/kg	400
B-15	0	1	Indeno(1,2,3-cd)pyrene	1100	J	ug/kg	900
B-15	0	1	Manganese	506	J	mg/kg	390
B-16	0	1	Arsenic	7.3		mg/kg	6.2
B-16	0	1	Benzo(a)pyrene	410		ug/kg	400
B-16	0	1	Chrysene	450		ug/kg	400
B-16	0	1	Manganese	554		mg/kg	390
B-17	0	1	Manganese	404	J	mg/kg	390
MW-7	0	1	Beryllium	0.46		mg/kg	0.4
MW-8	0	1	Chrysene	450		ug/kg	400
MW-9	0	1	Benzo(a)pyrene	890		ug/kg	400
MW-9	0	1	Benzo(b)fluoranthene	1600		ug/kg	900
MW-9	0	1	Beryllium	0.43		mg/kg	0.4
MW-9	0	1	Chrysene	750		ug/kg	400
MW-9	0	1	Manganese	451		mg/kg	390
MW-10	0	1	Arsenic	7		mg/kg	6.2
MW-10	0	1	Lead	372		mg/kg	150
MW-10	0	1	Manganese	697	J	mg/kg	390
MW-11	0	1	Lead	2970		mg/kg	150
SS1	0	0.5	Arsenic	6.2		mg/kg	6.2
SS1	0	0.5	Beryllium	0.47		mg/kg	0.4
SS3	0	0.5	Beryllium	0.41		mg/kg	0.4
SS5	0	0.5	Beryllium	0.48		mg/kg	0.4

TABLE 2-11 (continued)
SURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft) top	Sample Depth (ft) bottom	Parameter	Concentration	qual	units	Soil PRG
SS6	0	0.5	Arsenic	8.9		mg/kg	6.2
SS6	0	0.5	Benzo(a)anthracene	3300		ug/kg	900
SS6	0	0.5	Benzo(a)pyrene	2700		ug/kg	400
SS6	0	0.5	Benzo(b)fluoranthene	2800		ug/kg	900
SS6	0	0.5	Benzo(k)fluoranthene	3100		ug/kg	900
SS6	0	0.5	Chrysene	2800		ug/kg	400
SS6	0	0.5	Manganese	750		mg/kg	390
SS-10	0	0.5	Beryllium	0.43		mg/kg	0.4
SS-11	0	0.5	Beryllium	0.5		mg/kg	0.4
SS-12	0	1	Beryllium	0.44		mg/kg	0.4
SS-13	0	1	Beryllium	0.46		mg/kg	0.4
SS-14	0	1	Arsenic	6.3	J	mg/kg	6.2
SS-15	0	1	Arsenic	6.3	J	mg/kg	6.2
SS-19	0	1	Arsenic	6.7	J	mg/kg	6.2
SS-19	0	1	Beryllium	0.41		mg/kg	0.4
SS-20	0	1	Arsenic	7.4	J	mg/kg	6.2
SS-20	0	1	Benzo(a)anthracene	1200		ug/kg	900
SS-20	0	1	Benzo(a)pyrene	960		ug/kg	400
SS-20	0	1	Benzo(b)fluoranthene	1800		ug/kg	900
SS-20	0	1	Chrysene	1100		ug/kg	400
SS-23	0	1	Arsenic	8.5	J	mg/kg	6.2
SS-28	0	1	Arsenic	6.2	J	mg/kg	6.2
SS-301	0	1	Manganese	478	J	mg/kg	390
SS-302	0	1	Arsenic	7.3	J	mg/kg	6.2
SS-304	0	1	Arsenic	6.4		mg/kg	6.2
SS-304	0	1	Benzo(a)pyrene	430	J	ug/kg	400
SS-305	0	1	Arsenic	7.8		mg/kg	6.2
SS-305	0	1	Beryllium	0.6		mg/kg	0.4
SS-306	0	1	Arsenic	7.6	J	mg/kg	6.2
SS-307	0	1	Arsenic	8.1	J	mg/kg	6.2
SS-308	0	1	Arsenic	9.1		mg/kg	6.2
SS-309	0	1	Arsenic	6.5	J	mg/kg	6.2
SS-310	0	1	Arsenic	9	J	mg/kg	6.2
SS-311	0	1	Arsenic	8	J	mg/kg	6.2

TABLE 2-11 (continued)
SURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft) top	Sample Depth (ft) bottom	Parameter	Concentration	qual	units	Soil PRG
SS-312	0	1	Arsenic	6.2		mg/kg	6.2
SS-312	0	1	Benzo(a)anthracene	1400	J	ug/kg	900
SS-312	0	1	Benzo(a)pyrene	1300	J	ug/kg	400
SS-312	0	1	Benzo(b)fluoranthene	1700	J	ug/kg	900
SS-312	0	1	Benzo(g,h,i)perylene	840	J	ug/kg	800
SS-312	0	1	Beryllium	0.43		mg/kg	0.4
SS-312	0	1	Chrysene	1400	J	ug/kg	400
SS-312	0	1	Manganese	490		mg/kg	390
SS-313	0	1	Benzo(a)pyrene	790	J	ug/kg	400
SS-313	0	1	Benzo(b)fluoranthene	1100	J	ug/kg	900
SS-313	0	1	Benzo(g,h,i)perylene	1000	J	ug/kg	800
SS-313	0	1	Chrysene	930	J	ug/kg	400
SS-313	0	1	Manganese	688		mg/kg	390
SS-314	0	1	Benzo(a)anthracene	9100		ug/kg	900
SS-314	0	1	Benzo(a)pyrene	7100		ug/kg	400
SS-314	0	1	Benzo(b)fluoranthene	9700		ug/kg	900
SS-314	0	1	Benzo(g,h,i)perylene	4300		ug/kg	800
SS-314	0	1	Benzo(k)fluoranthene	3500	J	ug/kg	900
SS-314	0	1	Chrysene	8100		ug/kg	400
SS-314	0	1	Indeno(1,2,3-cd)pyrene	4100		ug/kg	900
SS-315	0	1	Arsenic	6.9		mg/kg	6.2
SS-315	0	1	Benzo(a)anthracene	1100	J	ug/kg	900
SS-315	0	1	Benzo(a)pyrene	920	J	ug/kg	400
SS-315	0	1	Benzo(b)fluoranthene	1000	J	ug/kg	900
SS-315	0	1	Chrysene	910	J	ug/kg	400
SS-316	0	1	Beryllium	0.51		mg/kg	0.4
SS-320	0	1	Beryllium	0.41		mg/kg	0.4
SS-321	0	1	Beryllium	0.46		mg/kg	0.4
SS-323	0	1	Beryllium	0.42		mg/kg	0.4
SS-324	0	1	Arsenic	6.7	J	mg/kg	6.2
SS-325	0	1	Arsenic	10.4		mg/kg	6.2
SS-326	0	1	Arsenic	10.1		mg/kg	6.2
SS-326	0	1	Beryllium	0.47		mg/kg	0.4

TABLE 2-11 (continued)
SURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft) top	Sample Depth (ft) bottom	Parameter	Concentration	qual	units	Soil PRG
SS-327	0	1	Arsenic	7.7	J	mg/kg	6.2
SS-327	0	1	Benzo(a)anthracene	2500		ug/kg	900
SS-327	0	1	Benzo(a)pyrene	1900		ug/kg	400
SS-327	0	1	Benzo(b)fluoranthene	2400		ug/kg	900
SS-327	0	1	Benzo(g,h,i)perylene	1200	J	ug/kg	800
SS-327	0	1	Benzo(k)fluoranthene	930	J	ug/kg	900
SS-327	0	1	Chrysene	2300		ug/kg	400
SS-327	0	1	Indeno(1,2,3-cd)pyrene	1100	J	ug/kg	900
SS-328	0	1	Arsenic	10.3		mg/kg	6.2
SS-329	0	1	Arsenic	7.2		mg/kg	6.2
SS-330	0	1	Arsenic	8.7	J	mg/kg	6.2
SS-331	0	1	Arsenic	6.8	J	mg/kg	6.2
SS-332	0	1	Arsenic	7.9		mg/kg	6.2
TP1	1	2	Benzo(a)pyrene	440		ug/kg	400
TP-04	1	2	Arsenic	9.4	J	mg/kg	6.2
TP-04	1	2	Benzo(a)pyrene	500		ug/kg	400
TP-04	1	2	Lead	152	J	mg/kg	150

Data qualifiers:
J = estimated

TABLE 2-12
SUBSURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft)		Parameter	Concentration	qual	units	Soil PRG
	top	bottom					
B-1	6	8	Arsenic	9.6	J*	mg/kg	6.2
B-1	6	8	Lead	529		mg/kg	150
B-2	2	4	Manganese	492	J*	mg/kg	390
B-2	6	8	Arsenic	8.6		mg/kg	6.2
B-2	6	8	Manganese	584	J*	mg/kg	390
B-2	8	10	Manganese	646	J*	mg/kg	390
B-3	6	8	Benzo(a)pyrene	660		ug/kg	400
B-3	6	8	Chrysene	770		ug/kg	400
B-5	4	6	Manganese	960	J*	mg/kg	390
B-7	4	6	Benzo(a)anthracene	1300	J	ug/kg	900
B-7	4	6	Benzo(a)pyrene	1000	J	ug/kg	400
B-7	4	6	Benzo(b)fluoranthene	1300	J	ug/kg	900
B-7	4	6	Chrysene	1000	J	ug/kg	400
B-7	6	8	Benzo(a)pyrene	490		ug/kg	400
B-7	6	8	Chrysene	540		ug/kg	400
B-8	8	10	Arsenic	6.4	J	mg/kg	6.2
B-8	8	10	Benzo(a)anthracene	2200		ug/kg	900
B-8	8	10	Benzo(a)pyrene	1700		ug/kg	400
B-8	8	10	Benzo(b)fluoranthene	2800		ug/kg	900
B-8	8	10	Chrysene	2100		ug/kg	400
B-8	8	10	Lead	189		mg/kg	150
B-8	8	10	Manganese	540	J	mg/kg	390
B-11	4	6	Arsenic	10	J	mg/kg	6.2
B-11	4	6	Lead	314		mg/kg	150
B-11	4	6	Manganese	627	J	mg/kg	390
B-12	2	4	Manganese	551	J	mg/kg	390
B-13	4	6	Arsenic	6.3	J	mg/kg	6.2
B-14	15	17	Arsenic	9.2		mg/kg	6.2
B-14	15	17	Chrysene	460	J	ug/kg	400
B-14	15	17	Lead	252		mg/kg	150

TABLE 2-12 (continued)
SUBSURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft)		Parameter	Concentration	qual	units	Soil PRG
	top	bottom					
B-15	10	12	Benzo(a)anthracene	1200		ug/kg	900
B-15	10	12	Benzo(a)pyrene	730		ug/kg	400
B-15	10	12	Benzo(b)fluoranthene	1300		ug/kg	900
B-15	10	12	Chrysene	1100		ug/kg	400
B-15	17	19	Benzo(a)anthracene	1300		ug/kg	900
B-15	17	19	Benzo(a)pyrene	760		ug/kg	400
B-15	17	19	Benzo(b)fluoranthene	1400		ug/kg	900
B-15	17	19	Chrysene	1100		ug/kg	400
B-15	17	19	Lead	292		mg/kg	150
B-15	17	19	Manganese	419	J	mg/kg	390
B-16	2	4	Benzo(a)anthracene	1200		ug/kg	900
B-16	2	4	Benzo(a)pyrene	1200		ug/kg	400
B-16	2	4	Benzo(b)fluoranthene	1900		ug/kg	900
B-16	2	4	Chrysene	1400		ug/kg	400
B-17	2	4	Beryllium	0.44	B	mg/kg	0.4
B-17	2	4	Manganese	477	J	mg/kg	390
MW-2	6	8	Arsenic	6.3	J*	mg/kg	6.2
MW-2	6	8	Benzo(a)anthracene	1800	J	ug/kg	900
MW-2	6	8	Benzo(a)pyrene	1600	J	ug/kg	400
MW-2	6	8	Benzo(b)fluoranthene	1400	J	ug/kg	900
MW-2	6	8	Benzo(k)fluoranthene	1400	J	ug/kg	900
MW-2	6	8	Chrysene	1700	J	ug/kg	400
MW-2	6	8	Lead	777	J*	mg/kg	150
MW-3	12	14	Beryllium	0.48		mg/kg	0.4
MW-7	2	4	Arsenic	6.2	S	mg/kg	6.2
MW-7	2	4	Benzo(a)anthracene	1300		ug/kg	900
MW-7	2	4	Benzo(a)pyrene	1000		ug/kg	400
MW-7	2	4	Benzo(b)fluoranthene	1800		ug/kg	900
MW-7	2	4	Chrysene	1100		ug/kg	400
MW-7	2	4	Manganese	396	J	mg/kg	390
MW-11	2	4	Dieldrin	44	J	ug/kg	40
MW-11	2	4	Lead	554		mg/kg	150
MW-11	2	4	Manganese	401	J	mg/kg	390
MW-10	4	6	Arsenic	7		mg/kg	6.2
MW-10	4	6	Manganese	588	J	mg/kg	390

TABLE 2-12 (continued)
SUBSURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft) top	bottom	Parameter	Concentration	qual	units	Soil PRG
MW-101	6	8	Arsenic	9.3	J	mg/kg	6.2
MW-101	6	8	Chrysene	430		ug/kg	400
MW-101	6	8	Total Petroleum Hydrocarbons	1900	J	mg/kg	500
MW-102	6	8	Antimony	12	J	mg/kg	10
MW-102	6	8	Arsenic	53.6	J	mg/kg	6.2
MW-102	6	8	Benzo(a)anthracene	3400		ug/kg	900
MW-102	6	8	Benzo(a)pyrene	4000		ug/kg	400
MW-102	6	8	Benzo(b)fluoranthene	2700	J	ug/kg	900
MW-102	6	8	Benzo(g,h,i)perylene	1900	J	ug/kg	800
MW-102	6	8	Benzo(k)fluoranthene	2200	J	ug/kg	900
MW-102	6	8	Chrysene	3200	J	ug/kg	400
MW-102	6	8	Dibenz(a,h)anthracene	820	J	ug/kg	400
MW-102	6	8	Indeno(1,2,3-cd)pyrene	2300	J	ug/kg	900
MW-102	6	8	Lead	5400		mg/kg	150
MW-102	6	8	Manganese	562	J	mg/kg	390
MW-102	6	8	Total Petroleum Hydrocarbons	8200	J	mg/kg	500
TP1	3.5	4	Benzo(a)pyrene	660	J	ug/kg	400
TP1	3.5	4	Lead	475	J	mg/kg	150
TP2	2	2	Benzo(a)pyrene	460	J	ug/kg	400
TP2	2	2	Chrysene	580	J	ug/kg	400
TP3	3	3	Benzo(a)pyrene	630	J	ug/kg	400
TP3	3	3	Chrysene	640	J	ug/kg	400
TP3	7	7	Benzo(a)anthracene	2400	J	ug/kg	900
TP3	7	7	Benzo(a)pyrene	2900	J	ug/kg	400
TP3	7	7	Benzo(b)fluoranthene	2300	J	ug/kg	900
TP3	7	7	Benzo(g,h,i)perylene	1700	J	ug/kg	800
TP3	7	7	Benzo(k)fluoranthene	2500	J	ug/kg	900
TP3	7	7	Chrysene	2500	J	ug/kg	400
TP3	7	7	Dibenz(a,h)anthracene	780	J	ug/kg	400
TP3	7	7	Indeno(1,2,3-cd)pyrene	1700	J	ug/kg	900
TP3	7	7	Manganese	413	J	mg/kg	390
TP3	7	8	Arsenic	16.3	J	mg/kg	6.2
TP3	7	8	Chrysene	690	J	ug/kg	400
TP3	7	8	Lead	3090	J	mg/kg	150
TP-05	7	8	Arsenic	14.3	J	mg/kg	6.2
TP-05	7	8	Benzo(a)pyrene	690		ug/kg	400
TP-05	7	8	Chrysene	810		ug/kg	400
TP-05	7	8	Lead	540	J	mg/kg	150
TP-05	7	8	Manganese	698	J	mg/kg	390

TABLE 2-12 (continued)
SUBSURFACE SOIL CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Sample Depth (ft)		Parameter	Concentration	qual	units	Soil PRG
	top	bottom					
TP-06	6	7	Benzo(a)pyrene	500		ug/kg	400
TP-06	6	7	Chrysene	650		ug/kg	400
TP-06	6	7	Manganese	410	J	mg/kg	390
TP-07	7	8	Arsenic	6.2	J	mg/kg	6.2
TP-07	7	8	Manganese	417	J	mg/kg	390
TP-08	3	4	Arsenic	13.8	J	mg/kg	6.2
TP-08	3	4	Manganese	478	J	mg/kg	390
TP-11	5	6	Arsenic	8.3		mg/kg	6.2
TP-11	5	6	Chrysene	460		ug/kg	400
TP-11	5	6	Lead	563		mg/kg	150
TP-11	5	6	Total Petroleum Hydrocarbons	7500		mg/kg	500
TP12	3.5	4	Benzo(a)pyrene	660	J	ug/kg	400
TP12	3.5	4	Chrysene	730	J	ug/kg	400
TP12	3.5	4	Lead	475	J	mg/kg	150
TP-12	4	5	Lead	283	J	mg/kg	150
TP-12	4	5	Manganese	516	J	mg/kg	390
TP-12	4	5	Total Petroleum Hydrocarbons	4100	J	mg/kg	500
TP-13	6	7	Antimony	39.2	J	mg/kg	10
TP-13	6	7	Arsenic	18.3	J	mg/kg	6.2
TP-13	6	7	Lead	7820	J	mg/kg	150
TP-13	6	7	Manganese	898	J	mg/kg	390
TP-13	6	7	Total Petroleum Hydrocarbons	7400	J	mg/kg	500
TP-14	3	4	Arsenic	10.5		mg/kg	6.2
TP-14	3	4	Total Petroleum Hydrocarbons	4800		mg/kg	500
TP-15	5	6	Arsenic	9.9	J	mg/kg	6.2
TP-15	5	6	Benzo(a)anthracene	1200	J	ug/kg	900
TP-15	5	6	Benzo(a)pyrene	970	J	ug/kg	400
TP-15	5	6	Chrysene	1700	J	ug/kg	400
TP-15	5	6	Lead	766	J	mg/kg	150
TP-15	5	6	Total Petroleum Hydrocarbons	21000	J	mg/kg	500
TP-16	10	11	Arsenic	74.4	J	mg/kg	6.2
TP-16	10	11	Lead	3350		mg/kg	150
TP-16	10	11	Manganese	1110	J	mg/kg	390
TP-16	10	11	Total Petroleum Hydrocarbons	6400	J	mg/kg	500
TP-17	8	9	Arsenic	8.2		mg/kg	6.2

Data qualifiers:
J = estimated
B = greater than IDL but less than CRDL
S = value obtained using Method of Standard Addition
* = qualifier changed as a result of data validation

TABLE 2-13
GROUNDWATER PRELIMINARY REMEDIATION GOALS
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Federal MCL	Risk-Based PRG	RIDEM GA Groundwater Objective	Selected PRG	Basis for Selection
VOLATILE ORGANIC COMPOUNDS						
Benzene	ug/L	5	2.56	5	5	MCL
SEMIVOLATILE ORGANIC COMPOUNDS						
2-Methylnaphthalene	ug/L		128		128	Risk-Based
Dibenzofuran	ug/L		23		23	Risk-Based
Naphthalene	ug/L		179	20	20	RIDEM
METALS						
Aluminum	ug/L		No Risk		none	no data
Arsenic	ug/L	50	0.1		50	MCL
Barium	ug/L	2000	884	2000	2000	MCL
Cadmium	ug/L	5	6	5	5	MCL
Chromium	ug/L	100	30	100	100	MCL
Cobalt	ug/L		No Risk		none	no data
Copper	ug/L	300	No Risk		1300	MCL
Iron	ug/L		No Risk		none	no data
Lead	ug/L	15	No Risk	15	15	MCL
Manganese	ug/L		291		291	Risk-Based
Vanadium	ug/L		81		81	Risk-Based
Zinc	ug/L		4015		4015	Risk-Based

TABLE 2-14
SELECTION OF GROUNDWATER COCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Units	Groundwater PRG	Maximum Detected	Selected as COC?
VOLATILE ORGANIC COMPOUNDS				
Benzene	ug/L	5	33	Yes
SEMIVOLATILE ORGANIC COMPOUNDS				
2-Methylnaphthalene	ug/L	128	190	Yes
Dibenzofuran	ug/L	23	8 J	No
Naphthalene	ug/L	20	150	Yes
METALS				
Aluminum	ug/L	none	13000 J	No
Arsenic	ug/L	50	49.8	No
Barium	ug/L	2000	390	No
Cadmium	ug/L	5	3.4 J	No
Chromium	ug/L	100	39.9	No
Cobalt	ug/L	none	87	No
Copper	ug/L	300	166 J	No
Iron	ug/L	none	129000 J	No
Lead	ug/L	15	207 J	Yes
Manganese	ug/L	291	12500 J	Yes
Vanadium	ug/L	81	37.5	No
Zinc	ug/L	4015	1570 J	No

Data qualifiers:
J = estimated

TABLE 2-15
GROUNDWATER CONCENTRATIONS EXCEEDING PRGs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Location	Parameter	Concentration	qual	units	Groundwater PRG
MW-1R	Manganese	1580	J	ug/L	291
MW-2D	Manganese	6390	J	ug/L	291
MW-2S	Lead	19.4	J	ug/L	15
MW-2S	Manganese	396	J	ug/L	291
MW-3S	Lead	207	J	ug/L	15
MW-3S	Manganese	3560	J	ug/L	291
MW-4S	Manganese	12500		ug/L	291
MW-7S	Manganese	11800	J	ug/L	291
MW-8R	Manganese	1780	J	ug/L	291
MW-9R	Manganese	832		ug/L	291
MW-10S	Manganese	4450	J	ug/L	291
MW-11R	Manganese	3460	J	ug/L	291
MW11-S	Manganese	1340	J	ug/L	291
MW-101	2-Methylnaphthalene	190		ug/L	128
MW-101	Benzene	8	J	ug/L	5
MW-101	Manganese	441	J	ug/L	291
MW-101	Naphthalene	150		ug/L	20
MW-102	Benzene	33		ug/L	400
MW-102	Lead	27.6	J	ug/L	15
MW-102	Manganese	1180	J	ug/L	291

TABLE 2-16
SUMMARY OF SEDIMENT COPC SELECTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	COPC Based on Human Health Direct Contact	COPC Based on Human Health Shellfish Ingestion	COPC Based on Ecological Risk [(1)]
SEMIVOLATILE ORGANIC COMPOUNDS			
2-Methylnaphthalene			X
Acenaphthylene			X
Anthracene			X
Benzo(a)anthracene	X	X	
Benzo(a)pyrene	X	X	X
Benzo(b)fluoranthene	X	X	
Benzo(b,j,k)fluoranthene			X
Benzo(g,h,i)perylene			X
Chrysene			X
Dibenzo(a,h)anthracene	X	X	
Fluoranthene			X
Fluorene			X
Indeno(1,2,3-cd)pyrene		X	X
Phenanthrene			X
Pyrene			X
Sum PAHs			X
PESTICIDES/PCBs			
Total PCB Congeners		X	
METALS			
Arsenic	X	X	
Copper			X
Cadmium		X	
Chromium		X	
Lead			X
Mercury		X	
Silver			X
Zinc			X

[(1)] Contaminants exceeding water quality screening value (WQSV), Appendix B, Table B-3.6.

TABLE 2-17
SUMMARY OF SEDIMENT PRELIMINARY REMEDIATION GOALS
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Beach Sediment	Nearshore and Offshore Marine Sediment	
	PRG Based on Human Health Direct Contact	PRG Based on Human Health Shellfish Ingestion	PRG Based on Ecological Risk
SEMIVOLATILE ORGANIC COMPOUNDS (ug/kg)			
2-Methylnaphthalene			185
Acenaphthylene			697
Benzo(a)anthracene	1338	34270	
Benzo(a)pyrene	134	9360	
Benzo(b)fluoranthene	1338	51296	
Dibenzo(a,h)anthracene	134	6742	2434
Indeno(1,2,3-cd)pyrene		72519	5633
PESTICIDES/PCBs (ug/kg)			
Total PCB Congeners		175	
METALS (mg/kg)			
Arsenic	6.2	5.48	
Cadmium		10	
Chromium		3708	
Mercury		2.3	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)			
TPH	500		

TABLE 2-18
SELECTION OF SEDIMENT COCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Pathway and Parameter	Units	Sediment PRG	Maximum Detected	Selected as COC?
HUMAN RECREATIONAL EXPOSURE TO SEDIMENT (1)				
Benzo(a)anthracene	ug/kg	1338	1900 J	Yes
Benzo(a)pyrene	ug/kg	134	1400 J	Yes
Benzo(b)fluoranthene	ug/kg	1338	1700 J	Yes
Dibenzo(a,h)anthracene	ug/kg	134	290 J	Yes
Arsenic	mg/kg	6.2	7.1	Yes
HUMAN INGESTION OF SHELLFISH (2)				
Benzo(a)anthracene	ug/kg	34270	9300	No
Benzo(a)pyrene	ug/kg	9360	9500	No*
Benzo(b)fluoranthene	ug/kg	51296	12000	No
Dibenzo(a,h)anthracene	ug/kg	6742	3410 J	No
Indeno(1,2,3-cd)pyrene	ug/kg	72519	7390	No
Total PCB Congeners	ug/kg	175	106.9	No
Cadmium	mg/kg	10	1.29	No
Chromium	mg/kg	3708	73.7	No
Mercury	mg/kg	2.3	1.9	No
ECOLOGICAL EXPOSURE TO SEDIMENT (3)				
2-Methylnaphthalene	ug/kg	185	330 J	Yes
Acenaphthylene	ug/kg	697	1500 J	Yes
Dibenzo(a,h)anthracene	ug/kg	2434	3410 J	Yes
Indeno(1,2,3-cd)pyrene	ug/kg	5633	7390	Yes

NOTES:
(1) - Route of exposure applicable to intertidal (beach) sediment only. Data set is presented in Appendix D, Table 4.1A
(2) - Route of exposure applicable to low tide and subtidal sediment only. Data set is presented in Appendix D, Table 4.1-B
(3) - Route of exposure applicable to all marine sediment - intertidal and subtidal. Data set is presented in Appendix D, Table 4.1C
* - Not selected until verified through phase 2 predesign sample collections
J - Data qualifier indicating an estimated value

TABLE 2-19
DATA FOR SELECTED SEDIMENT COCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Pathway and Parameter	Units	Sediment PRG	Stations Exceeding PRG	Concentration / Data Qualifier		Comment
HUMAN RECREATIONAL EXPOSURE TO SEDIMENT [(1)]						
Benzo(a)anthracene	ug/kg	1338	SD-412	1400		
			SD-414	4900	J	
			SD-432	2800		
			SD-439	1400		
			SD-442	2900		
			SSD-334	1900	J	
			SSD-335	1800	J	
Benzo(a)pyrene	ug/kg	134	OFF-5E	648		
			SD-411	680	J	
			SD-412	1000		
			SD-413	320	J	
			SD-414	3900	J	
			SD-417	810		
			SD-424	230	J	
			SD-425	640	J	
			SD-432s	240/370		s=0-6 inches, Duplicate results
			SD-432d	2000		d=18-24 inches
			SD-439s	550/500		s=0-6 inches, Duplicate results
			SD-439m	710		m=6-12 inches
			SD-439d	440		d=18-24 inches
			SD-442s	2400	J	s=0-6 inches
			SD-442d	290	J	d=18-24 inches
			SD-445s	500		s=0-6 inches
			SD-445d	470	J	d=18-24 inches
			SSD-333	770J/910	J	Duplicate results
			SSD-334	1400	J	
			SSD-335	1300	J	
			SSD-336	520	J	
Benzo(b)fluoranthene	ug/kg	1338	SD-414	5100	J	
			SD-432	2600		
			SD-439m	1400		m=6-12 inches
			SD-442	3200	J	
			SSD-335	1700	J	
Dibenzo(a,h)anthracene	ug/kg	134	SD-432	240		
			SD-442	280		
			SSD-334	290		
Arsenic	mg/kg	6.2	OFF-5E	7.3	J	
			SD-414	6.7	J	
			SD-425	10.6	J	
			SD-439m	14.9		m=6-12 inches
			SD-442s	7.2	J	s=0-6 inches
			SD-442d	9.1	J	d=18-24 inches
			SD-445d	7.2	J	d=18-24 inches
			SSD-337	7.1		

TABLE 2-19 (cont.)
DATA FOR SELECTED SEDIMENT COCs
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Pathway and Parameter	Units	Sediment PRG	Stations Exceeding PRG	Concentration / Data Qualifier		Comment
ECOLOGICAL EXPOSURE TO SEDIMENT [2]						
2-Methylnaphthalene	ug/kg	185	SD-410	470		
			SD-414	1500	J	
			SD-432d*	760		d=18-24 inches
			SD-442	870		
			OFF-5	330	J	
			OFF-6	280		8-10 inches
			OFF-18d*	210		d=1.6 - 1.8 feet
Acenapthalene	ug/kg	697	SD-414	1500	J	
			SD-432d*	760		d=18-24 inches
			SD-442	870		
Dibenzo(a,h)anthracene	ug/kg	2434	OFF-3	2810	J	
			OFF-5	3410	J	
Indeo(1,2,3-cd)pyrene	ug/kg	5633	OFF-3	6560		
			OFF-5	7390		

NOTES:
(1) - Route of exposure applicable to intertidal (beach) sediment only. Data set is presented in Appendix D, Table 4.1A
(2) - Route of exposure applicable to all marine sediment - intertidal and subtidal. Data set is presented in Appendix D, Table 4.1C
* - Exceedance discounted due to isolated incidence at depth
J - Data qualifier indicating an estimated value

TABLE 3-1
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
No Action	No Action	Not Applicable	No Action	Retained. Used as baseline for comparison with other options as required by NCP.
Limited Action	Institutional Controls	Deed Restrictions	Administrative action used to restrict future site activities on individual properties. Restrictions would prevent activities such as excavation or residential development.	Retained for protection of human health. Not protective of ecological receptors or groundwater. Does not allow unrestricted residential reuse.
	Access Restrictions	Fencing	Barrier erected to restrict access to contaminated properties.	Retained for protection of human health. Not protective of ecological receptors or groundwater. Does not allow unrestricted residential reuse.
		Post Signs	Post "No Trespassing" or hazard warning signs.	Retained for protection of human health. Not protective of ecological receptors or groundwater. Does not allow unrestricted residential reuse.
	Long-Term Monitoring	Monitoring	Periodic monitoring events to determine whether the soil is a continuing source of contamination.	Retained to ensure effectiveness of any remedial action taken. As a stand-alone option, does not allow unrestricted residential reuse.
Containment	Horizontal Barriers	Impermeable Cap	Asphalt, concrete, geosynthetics, or multi-media materials are used to form an impermeable barrier to prevent direct contact with contaminated soil and to minimize leaching of contaminants from soil to groundwater.	Retained for protection of human health and the environment. Does not allow unrestricted residential reuse because of contaminants left in the subsurface.
		Permeable Cover	Soil, crushed stone, geosynthetics and vegetative cover used to prevent direct contact with contaminated soil and minimize erosion and surface migration of contaminated soil.	Retained for protection of human health. Does not allow unrestricted residential reuse because of contaminants left in the subsurface..

TABLE 3-1 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Removal	Excavation	Bulk Excavation	Use of common construction equipment to remove contaminated soil. Able to address all soil above the groundwater table.	Retained for protection of human health and protection of ecological receptors. Effective for all site contaminants.
Disposal	Disposal	Off-Base Landfill	Transport and disposal of untreated soil to an approved off-base landfill.	Retained as potentially effective. Must be reviewed in concert with excavation technology.
		On-Base Landfill	Transport and disposal of untreated soil to a new or existing on-base landfill.	Eliminated. No landfill currently available. Extensive permitting for a new landfill.
		On-Site Backfill	Backfill of treated soil to the excavated areas. Clean fill from off site can also be used.	Retained. Must be reviewed in concert with excavation technology and possibly treatment technology.
		Treatment, Storage, or Disposal Facility (TSDF)	Transport and disposal of untreated soil to an approved off-base TSDF.	Retained as potentially effective. Must be reviewed in concert with excavation technology.
Treatment	Immobilization	Solidification/ Stabilization	Soil mixing equipment used to mix reagents with contaminated soil to physically and/or chemically decrease the mobility of contaminants. Potential reagents include cement, pozzolanic material, thermoplastics, polymers and asphalt. Treatment may be done in situ or ex situ.	Retained as potentially effective. Demonstrated to be effective with metals and other inorganic and organic contaminants.
		Microencapsul-ation	Contaminated material is encapsulated by containers or inert and impervious coatings that will minimize leaching. Treatment will be done ex situ.	Eliminated. Effectively isolates all site contaminants but no treatment occurs. Not feasible in cases involving large quantities of contaminated material.

Eliminated process option (see screening comment)

TABLE 3-1 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (Cont'd)	Thermal Treatment	Incineration	Destruction of organic contaminants by subjecting them to high temperatures under controlled conditions in a combustion chamber. Treatment would be done ex situ.	Retained. Effective for organic contaminants but not effective for inorganic contaminants. Not easily undertaken on base.
		Pyrolysis	Chemical decomposition of organic contaminants by heating the material in the absence of oxygen. Treatment would be done ex situ.	Eliminated. Effective for organic contaminants but not effective for inorganic contaminants. Not easily undertaken on base. Not readily available.
		Low-Temperature Thermal Stripping	Air, heat and mechanical agitation are used to volatilize organic contaminants from soil into a vapor stream. Vapor is usually further treated. Treatment would be done ex situ.	Retained for potential use on site. Effective for organic contaminants but not effective for inorganic contaminants. May be used as part of a treatment train.
		Supercritical Water Oxidation	Contaminated soil is exposed to water in a high temperature, high pressure environment. Under such conditions, organic substances are oxidized.	Eliminated. Effective for some organic contaminants (SVOCs) but not effective for inorganic contaminants.
		Vitrification	Melting of contaminated material to volatilize or pyrolyze organics and entrain inorganics in a stable vitreous residual. Treatment may be done in situ or ex situ.	Retained. Potentially effective for all site contaminants.

Eliminated process option (see screening comment)

TABLE 3-1 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (Cont'd)	Physical Treatment	Soil Flushing	Contaminants sorbed to soil are mobilized or dissolved in an aqueous flushing solution in situ. The flushing solution is then extracted from the subsurface and treated. Flushing solution may be augmented by chemicals that increase the mobilization or dissolution of organics and some heavy metals from the soil. Treatment would be done in situ.	Retained. Potentially effective for organics and some inorganics, but repeated flushing may be necessary. Difficult to ensure capture of flushing solution due to shallow water table. More difficult in cases involving multiple types of contaminants.
		Soil Washing	Process reduces the amount of contaminated material by two means. Finer particles, which contain the bulk of contaminants, are separated from more coarse material. Contaminants sorbed to soil are dissolved in an aqueous washing solution. The wash water may be augmented by chemicals which increase the leaching of organics and some heavy metals from the soil. Treatment would be done ex situ.	Retained. Potentially effective for organics and some inorganics, but multiple washing steps may be necessary. Washing solution would need to be recovered and treated. More difficult in cases involving multiple types of contaminants. May be used as part of a "treatment train." Can be done on or off base.
		Liquefied Gas Solvent Extraction	Liquefied gas solvents, such as propane, are used to extract organics from soil. Treatment would be done ex situ.	Eliminated. Technology is not commercially available and effectiveness is not well established. Cost information not available.

Eliminated process option (see screening comment)

TABLE 3-1 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (Cont'd)	Physical Treatment	Soil Vapor Extraction	In situ technology in which vacuum blowers and extraction wells are used to strip volatile organic compounds from unsaturated soil. Treatment would be done in situ.	Eliminated. Only effective for volatile organic compounds (VOCs) in non-saturated soil. Not effective for SVOCs or inorganics.
		Electrokinetics	Electrodes are used to manipulate soil conditions to recover or destroy organics and metals. Treatment would be done in situ.	Eliminated. Potentially effective for organic and some inorganics. Less effective in cases involving shallow water table.
	Chemical Treatment	Chemical Dechlorination	Chlorine atoms are stripped from chlorinated contaminants through chemical reactions to produce less toxic byproducts. These byproducts are generally more amenable to biodegradation. Treatment will be done ex situ.	Eliminated. Only addresses chlorinated compounds. Not effective for non-chlorinated organics (SVOCs) or inorganics.
		Solvent Extraction	Chemical desorption and dissolution of organic and some inorganic contaminants by washing soil with a solvent solution. Treatment would be done ex situ.	Retained. May not be effective for wastes with multiple contaminant types. Solvent solution would need to be recovered and treated.
	Biological Treatment	Aerobic Biodegradation	Microorganisms degrade organic contaminants to carbon dioxide and water. Oxygen is used as an electron acceptor in the degradation process. Treatment would be done ex situ.	Retained, but effectiveness is limited to certain organic contaminants. Inorganics are generally not amenable to biological treatment.

Eliminated process option (see screening comment)

TABLE 3-1 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (Cont'd)	Biological Treatment (Cont'd)	Anaerobic Biodegradation	An electron acceptor other than oxygen is used in the process in which microorganisms degrade organic contaminants. Treatment may be done in situ or ex situ.	Eliminated. While this technology is commonly used in the wastewater treatment industry to effectively treat solid organic waste, applications in hazardous waste treatment are limited. Effectiveness is limited to certain organic contaminants. Inorganics are generally not amenable to biological treatment.
		Phytoremedia-tion	Plants are used to naturally remediate contaminants via three mechanisms: direct uptake and accumulation of contaminants in plant tissue, release of enzymes that stimulate microbial activity and biochemical transformation, and enhancement of mineralization in plants' roots. Effective for destruction of some VOCs and SVOCs and effective for absorbing many inorganics. Treatment would be done in situ.	Eliminated. Potentially effective for metals, SVOCs. Root systems of plants may not extend deep enough to remediate contaminants at depth. Plants would require harvesting, proper disposal, and replanting.

Eliminated process option (see screening comment)

TABLE 3-2
REPRESENTATIVE PROCESS OPTIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION (GRA)	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	REPRESENTATIVE PROCESS OPTION	RATIONALE
No Action	No Action	Not Applicable	No Action	Required
Limited Action	Long-Term Monitoring	Monitoring	Monitoring	Used for 5-year reviews to ensure remediation is complete
Removal	Excavation	Bulk Excavation	Bulk Excavation	Most effective means of removal
Disposal	Disposal	Off-Base Landfill	On-Site Backfill TSDF	Treated soil would have concentrations below PRGs Excavated soil may require treatment prior to disposal to meet LDRs
		On-Site Backfill		
		TSDF		
Treatment	Immobilization	Solidification/ Stabilization	LTTS Soil Washing	Effectively removes PAHs Addresses inorganic compounds
	Thermal Treatment	Low Temperature Thermal Stripping (LTTS)		
	Physical/Chemical Treatment	Soil Washing		
		Solvent Extraction		

TABLE 3-3
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
No Action	No Action	Not Applicable	No Action	Retained. Used as baseline for comparison with other options as required by NCP.
Limited Action	Institutional Controls	Deed Restrictions/ Land Use Controls	Administrative action used to restrict future site activities on individual properties. Restrictions would prevent activities such as installation of new wells or use of groundwater.	Retained. Considered when no active remediation is required due to limited contamination. May also be considered in conjunction with active remedial alternatives.
	Groundwater Monitoring	Monitoring	Periodic monitoring events in the area where groundwater contamination exists.	Retained. Monitoring is viable for assessing the effectiveness of any remedial action taken.
Containment	Hydraulic Containment	Extraction Wells	Control of plume migration by a system to extract the contaminated groundwater.	Retained. Extraction wells placed on the downgradient edge may be used to prevent groundwater plume migration to Narragansett Bay.
	Subsurface Barriers	Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry to obstruct/divert the groundwater flow.	Eliminated. Large amount of coastline makes this impractical.
		Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes. Requires integration with confining layer to be effective.	Eliminated. Large amount of coastline makes this impractical.
		Sheet Piling	Driving interconnecting lengths of steel into the ground to form a thin, impermeable barrier. Requires integration with confining layer to be effective.	Eliminated. Large amount of coastline makes this impractical.
Removal	Extraction	Extraction Wells	Series of pumping wells to extract contaminated groundwater.	Retained. Collection wells are effective to address limited extent of contamination.

TABLE 3-3 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Removal (cont.)	Extraction (cont.)	Collection Trench	Perforated pipe in trenches backfilled with porous media to collect groundwater. May include sumps and gravity drains.	Retained. Collection trenches are effective to address limited extent of contamination in shallow aquifers.
Ex Situ Treatment (on site)	Bioremediation	Aerobic	Degradation of organics using microorganisms in an oxygen-enriched environment.	Eliminated. Time consuming process, not effective on metals.
	Physical Treatment	Dewatering	Removal of free water from water – sediment mix	Retained. Component of eathmoving operations
		Sedimentation	Removal of free water from water-sediment mix through gravity	Retained. Component of eathmoving operations
		Filtration	Removal of suspended solids by passing contaminated water through a filter media.	Retained. Component of eathmoving operations
		Air Stripping	Mixing large volumes of air with groundwater in a packed column or aerated basin to promote transfer of volatile organic compounds to air.	Retained. Component of thermal treatment
		Steam Stripping	Mixing large volumes of steam with groundwater in a packed column or aerated basin to promote transfer of volatile organic compounds to air.	Eliminated. Requires substantial energy and control.
		Adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column.	Retained. Component of most disposal or treatment operations

Eliminated process option (see screening comment)

TABLE 3-3 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR GROUNDWATER
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Ex Situ Treatment (on site) (cont'd)	Chemical Treatment	Ion Exchange	Ion exchange removes ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached. After the resin capacity has been exhausted, resins can be regenerated for re-use.	Retained.
		Chemical Oxidation	Chemical oxidation (increase in oxidation state) of chemicals into less toxic or soluble forms through the use of oxidizing agent(s). Includes ozone, peroxide, permanganate, and manganese oxidation.	Retained..
		UV Oxidation	Oxidation of chemicals into less toxic or soluble forms through the use of UV light.	Retained.
		Precipitation/ Flocculation	Conversion of heavy metals into insoluble solid forms through the addition of precipitating agents such as hydroxides and sulfides. Followed by use of chemicals to neutralize surface charges and promote particle size growth.	Retained.

Eliminated process option (see screening comment)

TABLE 3-3 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES
AND PROCESS OPTIONS FOR GROUNDWATER
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Ex Situ Treatment (on site) (cont'd)	Chemical Treatment (cont'd)	Fenton's Reagent	Solution of hydrogen peroxide and an iron catalyst that is used to oxidize contaminants in water: effecive on TCE and PCE.	Eliminated. Target compounds not generally affected.
In Situ Treatment	Bioremediation	Aerobic/ Oxygen Release Compound	Degradation of organics using microorganisms in an oxygen-enriched environment.	Retained.
		Anaerobic/ Hydrogen Release Compound	Degradation of organics using microorganisms in an oxygen-deficient environment.	Retained.
	Physical/ Chemical Treatment	Air Sparging	Injection of air below the water table. Rising bubbles volatilize dissolved and adsorbed phase contaminants and transport them to the vadose where they are removed by a method of collection such as vapor extraction or by in situ aerobic degradation. Furthermore, the carbon dioxide in air would decrease the pH in groundwater and thereby induce the precipitation/sorption of metals.	Eliminated. Target compounds not generally affected.
		Permeable Reactive Barriers (PRBs)	An in situ barrier composed of a permeable reactive material that reacts with the contaminants in the water, reducing their concentrations by physical and chemical processes.	Eliminated. Target compounds not generally affected.

Eliminated process option (see screening comment)

TABLE 3-3 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Disposal	Surface Discharge	Direct to Surface Water	Treated groundwater discharged to Narragansett Bay.	Eliminated. Sensitive habitats present.
		On Site Beneficial Reuse	Water is discharged to the ground for dust control or irrigation	Eliminated. No necessity forseen.
		Discharge to Local Treatment Facility	Treated groundwater discharged to local Publicly Owned Treatment Works (POTW).	Retained.
	Subsurface Discharge	Injection Wells	Series of injection wells to discharge collected/treated groundwater to subsurface. Requires regulatory approval.	Eliminated. Approval unlikely, other options available.
		Infiltration Gallery	Gravel-filled trench to discharge collected/treated groundwater to subsurface. Requires regulatory approval.	Retained

Eliminated process option (see screening comment)

TABLE 3-4
REPRESENTATIVE PROCESS OPTIONS FOR GROUNDWATER
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION (GRA)	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	REPRESENTATIVE PROCESS OPTION	RATIONALE
No Action	No Action	Not Applicable	No Action	Required
Limited Action	Groundwater Monitoring	Monitoring	Monitoring	Used for 5-year reviews to ensure remediation is complete.
Containment	Hydraulic Containment	Extraction Wells	Extraction Wells	Most effective means of containment.
Removal	Extraction	Extraction Wells	Extraction Wells	Most effective means of removal
Treatment	Physical Treatment	Adsorption	Adsorption Ion Exchange	Effectively removes organics. Addresses inorganic compounds.
	Chemical Treatment	Ion Exchange		
		Precipitation/ Flocculation		
Discharge	Surface Discharge	Direct to Surface Water	Discharge to POTW	Treated groundwater would have concentrations below PRGs.
		On-Site Beneficial Reuse		
		Discharge to POTW		

TABLE 3-5
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
No Action	None	Not Applicable	No activities conducted to address contamination.	Retained. Use for baseline comparison, as required by NCP.
Limited Action	Institutional Controls	Use Restrictions	Implementation of administrative action to restrict recreational use.	Retained for protection of human health. Not protective of ecological receptors.
	Access Restrictions	Fencing/Signs/ Buoys/Enforcement	Placement of fencing and buoys, and posting of warning signs to inform public of use restrictions and to deter access.	Retained for protection of human health. Not protective of ecological receptors.
	Long-Term Monitoring	Sediment Monitoring	Periodic sediment sampling and analysis to assess potential contaminant migration. Provides information to evaluate existing exposure risks.	Retained as potentially applicable. Can be combined with other GRAs for assessment of existing site conditions and exposure risks.
Containment	Permeable Cap	Natural Cap	Placement of natural materials (silts, fill, sand, gravel, and/or crushed stone) and stone/rock bedding over contaminated sediment to prevent direct contact and minimize erosion/contaminant migration.	Eliminated for affected areas because of concern that the permeable cap would not properly contain the contaminants present in the sediment.
		Multi-Media Cap	Placement of multi-media cap (natural materials, geotextile, and armament material) over contaminated sediment. Provides greater protection than does natural cap, especially in high energy areas.	Eliminated for affected areas because of concern that the permeable cap would not properly contain the contaminants present in the sediment.

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Containment (Cont'd)	Impermeable Cap	Natural (Clay) Cap	Placement of natural materials (clay) and stone/rock bedding over contaminated sediment to prevent direct contact and minimize erosion and contaminant migration.	Eliminated. Impermeable (low permeability and transmissivity) cap not appropriate for underwater application. Any water movement and gas formation under the cap could become trapped and stress the integrity of the cap. Placement of cap would cause excessive turbidity in water column because of low settleability of fine clay particles.
		Multi-Media Cap	Placement of multi-media cap (natural material, geomembrane, and bedding material) over contaminated sediment to prevent direct contact and minimize erosion and contaminant migration.	Eliminated. Impermeable (low permeability and transmissivity) cap not appropriate for underwater application. Any water movement and gas formation under the cap could become trapped and stress the integrity of the cap. Placement of the geomembrane would be difficult; it would tend to float on the water surface.
Removal	Excavation/Dredging	Mechanical Excavation/ Dredging	Use of mechanical force to dislodge contaminated sediment. Includes clamshell, dipper, bucket ladder, or dragline dredges or conventional earthmoving equipment. Also applicable for removal of debris.	Retained. Potentially applicable. Extensive erosion control measures required. Particularly useful in areas where large rocks or debris is present.

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Removal (Cont'd)	Excavation/Dredging (Cont'd)	Hydraulic Dredging	Use of centrifugal force to remove contaminated sediment in a slurry. Includes suction, cutterhead, and/or portable hydraulic dredges.	Retained. Potentially applicable. Less extensive erosion control measures required. Dewatering of slurry is required.
		Pneumatic Dredging	Use of compressed air and/or hydraulic pressure to remove contaminated sediment in a slurry. Includes Airlift, Pneuma, and Oozer dredges.	Eliminated. Not widely available in USA.
Disposal	On-Site/On-Base Disposal	Confined Aquatic Disposal	Disposal of dredged sediment in deep water disposal site.	Eliminated. Must be combined with containment to prevent marine biota exposure risks. No known disposal area available.
		Upland On-Site or On-Base Disposal	Disposal of dredged sediment at on-site location adjacent to McAllister Point Landfill cap or at other on-base location.	Eliminated. Sufficient space not available at on-base disposal locations.
	Off-Base Disposal	Off-Base Landfill or TSDF	Transport and disposal of dredged sediment at off-base landfill or TSDF licensed to accept the contaminant types detected.	Retained. Potentially applicable.
Treatment (In-Situ)	Chemical Treatment	Neutralization/ Precipitation/ Oxidation	Injection of treatment reagents into contaminated media to convert the contaminants to a less toxic form through chemical reactions. Reagents are typically chosen for treatment of specific contaminants. Toxic byproducts may form.	Eliminated. Containment of treated area and/or diversion of water required for the duration of the treatment. Difficult to ensure treatment reagents are thoroughly mixed with contaminated sediment. Reagents are not typically suited for treatment of all contaminants present.

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (In-Situ) (Cont'd)	Biological Treatment	Aerobic/Anaerobic Treatment	Biodegradation of contaminants by injection of nutrients and/or organisms into contaminated media. Effective for destruction of VOCs and SVOCs. Ineffective for inorganics.	Eliminated. Containment of treated area and/or diversion of water required. Difficult to ensure complete mixing of nutrients. Not effective in treating all site contaminants. Lack of nutrients and low temperature may impede degradation process.
		Phytoremediation	Use of plants to naturally remediate contaminants via three mechanisms: direct uptake and accumulation in plant tissue, release of enzymes that stimulate microbial activity and biochemical transformation, and enhancement of mineralization in plants' roots. Effective for destruction of some VOCs and SVOCs and effective for absorbing many inorganics.	Eliminated. Root systems of plants may not extend deep enough to remediate contaminants at depth. Wave action may impede adequate rooting of plants. Not effective in treating all site contaminants. Inorganics accumulate in plants, so plants would require harvesting and replanting.
	Physical Treatment	Solidification/ Stabilization	Immobilization of sediment and contaminants by treatment with reagents to solidify/fix them. Most suitable for treatment of inorganics in a controlled environment.	Eliminated. Not feasible in area where solidified mass cannot be tolerated.

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
Treatment (Ex-Situ; On-Site/On-Base)	Thermal Treatment	Thermal Desorption	Volatilization of organic contaminants by an externally-fired rotary dryer and removal as a condensed liquid. Proven for treatment of VOCs. Limited applicability to remove SVOCs and PAHs. Not applicable for inorganics or contaminants with low vapor pressures.	Eliminated. Does not address inorganic contaminants. Dredged sediment may require significant dewatering prior to treatment. Would require pilot testing.
		Infrared Incineration	Pyrolysis of organic contaminants using near infrared radiation. Not effective for treating inorganics. Most applicable to low BTU soils and homogeneous waste streams.	Eliminated. Does not address inorganic contaminants. Inefficient for material with high water content. Not cost effective; simpler processes available to treat contaminants.
		Vitrification	Contaminated sediment is melted into a glassy, crystalline monolith using electric current. Applicable to treatment of both inorganics and organics.	Eliminated. Inefficient for high water content material. Performance may be affected by high concentrations of organics.

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
	Chemical/Physical Treatment	Soil Washing	Particle-size separation process to reduce volume of materials requiring aggressive treatment. Fraction containing fines is separated from coarse by washing process; fines containing majority of contaminants require additional treatment. Contaminant removal using extractant solution. Solutions used include water, surfactants, acids, bases, and/or oxidizing or reducing agents. Can remove both organics and inorganics in multiple extraction process.	Eliminated. Only suitable for materials with low fines content. Would require numerous extraction processes to remove the various contaminants identified in site sediments. Residual solvents and surfactants may be difficult to remove from treated sediment. Not cost effective; simpler processes available to treat contaminants.
Treatment (Ex-Situ; On-Site/On-Base) (Cont'd)	Chemical/Physical Treatment (Cont'd)	Solvent Extraction	Preferential dissolution of contaminants from sediment into solvent. Most effective for organic contaminants. Can treat sediments in slurry form. Solvent requires further processing or disposal. Treated material requires dewatering prior to disposal.	Eliminated. Residual solvents may be difficult to remove from treated sediment. Requires bench-scale testing. Not cost effective; simpler processes available to treat contaminants.
		Wet Air Oxidation	Oxidation of organic and inorganic contaminants in an aqueous reactor using molecular oxygen at elevated temperatures/ pressures. Effectiveness proportional to sediment particle size; less effective on large grain sizes and heterogeneous waste streams.	Eliminated. Most effective on concentrated waste streams.
		Solidification/ Stabilization	Mixing of sediment with Portland cement, siliceous materials, lime, and/or proprietary agents, to form a chemically	Retained. Potentially applicable for treatment of inorganics and/or for use as a bulking agent. Space

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
			stable matrix of limited permeability. Most suitable for immobilizing inorganics. Not proven effective for many organic contaminants. May be used for bulking agents to reduce free liquids in dewatered sediment.	is available on site for treatment.
		Acid Extraction	Washing of sediment with acid, and processing of effluent through a membrane or ion exchange system. Most effective for inorganics. Not effective for organic wastes or waste materials.	Eliminated. Similar to solvent extraction, but for treatment of inorganics only. Better suited for material with low fines content. Requires bench-scale testing. Not cost effective; simpler processes available to treat contaminants.
Treatment (Ex-Situ; On-Site/On-Base) (Cont'd)	Chemical/Physical Treatment (Cont'd)	Dechlorination	Stripping of chlorine atoms from hazardous halogenated hydrocarbons using alkali metals or alkali metal/polyethylene glycol. Effective for destruction of chlorinated organics, dioxin, and PCBs. Ineffective for treatment of inorganics.	Eliminated. Not effective for treatment of PAHs, or metals.
	Biological Treatment	Slurry Phase Biodegradation	Preparation of dredged sediment into a pumpable slurry to which a nutrient-rich bacteria is added for degradation in a reactor system. Most effective for organic contaminants. Not effective for inorganics. Limited effectiveness for PAHs. Treated material requires dewatering prior to disposal.	Eliminated. Not effective in treating site contaminants.
		Landfarming	Aerobic biodegradation of contaminants	Eliminated. Not effective in

TABLE 3-5 (cont'd)
IDENTIFICATION AND PRELIMINARY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	DESCRIPTION OF PROCESS OPTION	SCREENING COMMENTS
			in sediment applied to the ground surface and amended with nutrients. Effective for destruction of VOCs. Ineffective for inorganics. Limited effectiveness for PAHs.	treating site contaminants.
Treatment (Ex-Situ; On-Site/On-Base) (Cont'd)	Biological Treatment (cont'd)	Phytoremediation	Use of plants to naturally remediate contaminants via three mechanisms: direct uptake and accumulation in plant tissue, release of enzymes that stimulate microbial activity and biochemical transformation, and enhancement of mineralization in plants' roots. Effective for destruction of some VOCs and SVOCs and effective for absorbing many inorganics.	Eliminated. Not effective in treating all site contaminants. Would require harvesting of plants and subsequent treatment/disposal and replanting.

Eliminated process option (see screening comment)

TABLE 3-6
REPRESENTATIVE PROCESS OPTIONS FOR SEDIMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA, NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

GENERAL RESPONSE ACTION (GRA)	REMEDIAL TECHNOLOGY TYPE	PROCESS OPTION	REPRESENTATIVE PROCESS OPTION	RATIONALE
No Action	No Action	Not Applicable	No Action	Required
Limited Action	Institutional Controls	Use Restrictions	Use Restrictions	Used to prevent exposure.
	Access Restrictions	Fencing/Signs/ Buoys/Enforcement		
	Long-Term Monitoring	Sediment Monitoring	Sediment Monitoring	Used for 5-year reviews
Removal	Excavation/ Dredging	Mechanical Excavation/ Dredging	Mechanical Excavation/ Dredging	Most effective means of removal
Disposal	Off-Base Disposal	Off-Base Landfill or TSDF	Off-Base Landfill or TSDF	Most effective means of disposal
Treatment (ex situ; on site)	Chemical/Physical Treatment	Solidification/ Stabilization	Solidification/Stabilization	Effectively immobilizes contaminants

TABLE 4-1
SUMMARY OF SOIL ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Alternative	Alternative Description
Alternative 1: No Action	• 5-year reviews
Alternative 2: Removal, Ex situ Treatment, Backfill	• Pre-design investigation • Excavation of the mounds and segregation of soil and debris • Excavation of site to remove debris and contaminated soil • Segregation and testing of debris and contaminated soil • Removal and replacement of the on-site storm drains as needed • Removal of inactive storm drains, sanitary piping, or other unused utilities • Confirmation sampling of excavated areas to ensure complete removal of contaminated soil • Temporary storage of contaminated and contaminant-free materials • On-site treatment of contaminated soil with LTTS and soil washing • Confirmation sampling of treated soil • Backfill with treated soil supplemented with clean fill material • Disposal of debris and treatment residues • Construction of a new revetment along the shoreline • Five-year review
Alternative 3: Removal, Disposal, Backfill	• Pre-design investigation • Excavation of the mounds and segregation of soil and debris • Excavation of site to remove debris and contaminated soil • Segregation and testing of debris and contaminated soil • Removal and replacement of the on-site storm drains as needed • Removal of inactive storm drains, sanitary piping, or other unused utilities • Confirmation sampling of excavated areas to ensure complete removal of contaminated soil • Temporary storage of contaminated and contaminant-free materials • Disposal of debris and non-hazardous soil at municipal landfill • Disposal of hazardous soil at a TSDF • Backfill with clean fill material • Construction of new revetment along the shoreline • Five-year review

TABLE 4-2
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR SOIL REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
THRESHOLD CRITERIA			
Overall Protection of Human Health and the Environment			
Does Alternative Protect Current and Future Users?	No	Yes	Yes
Are Environmental Risks Reduced by Alternative?	No	Yes	Yes
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)			
Compliance with Chemical-Specific ARARs	No	Yes	Yes
Compliance with Location-Specific ARARs	Not applicable	Yes	Yes
Compliance with Action-Specific ARARs	Not applicable	Yes	Yes
Compliance with Other Criteria	No	Yes	Yes
BALANCING CRITERIA			
Long-Term Effectiveness and Permanence			
Does Alternative Reduce Residual Risk?	No	Yes	Yes
Does Alternative Provide Adequate Remedial Controls?	No	Yes	Yes
Need a 5-Year Review?	Yes	No	No
Need for Long-Term Management?	Yes	No	No
Reduction of Toxicity, Mobility, or Volume through Treatment			
Treatment Process Used	None	Volatilization, liquid dissoluton	None
Soil Treated	No	Yes	Only if required (minimal volume)
Reduction in Toxicity, Mobility, or Volume	None	Toxicity, mobility, and volume – reduced	None
Type and Quantity of Residuals Remaining after Treatment	No treatment so no residuals	Solid and liquid residuals; low quantity	No residuals
Short-Term Effectiveness			
Risks to the Community during Remedial Action	No treatment so no construction risks	Minimal	Moderate, primarily due to truck traffic
Risk to Workers during Remedial Action	No treatment so no construction risks	Some risks; easily controlled	Some risks; easily controlled
Environmental Impacts	No treatment so no additional impacts	Minimal	Minimal
Time until Remedial Action Objectives Achieved	No remedial action; time >30 years.	Estimated 6 to 8 months	Estimated 4 to 6 months

TABLE 4-2 (cont'd)
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR SOIL REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
Implementability			
Constructable	No construction activities	Yes	Yes
Reliability of Technology	No technology implemented	Reliable	Reliable
Ease of Undertaking Additional Remedial Action, if Necessary	Easily implementable	High	High
Ability to Monitor Effectiveness of Remedy	Not applicable	Yes	Yes
Ability to Coordinate with Other Agencies	Easy	Moderately easy	Moderately easy
Availability of Off-Site Disposal Services	None required	Available	Available
Availability of Equipment and Specialists	None required	Available	Available
Availability of Prospective Technologies	None required	Available	Available
Cost[a,b]			
Capital Costs	$0	$11,897,000	$8,045,000
Total Annual Operations and Maintenance (O&M)	$0	$30,000	$30,000
5-Year Review Costs	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$11,957,000	$8,105,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded off to the nearest $1,000.

TABLE 4-3
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	Relevant and Appropriate	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards are relevant and appropriate and were used in developing soil PRGs. This alternative fails to meet this standard because soil exceeding PRGs is not addressed.

TABLE 4-4
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal location-specific ARARS.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state location-specific ARARs				

TABLE 4-5
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT,NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal action-specific ARARs.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state action-specific ARARs.				

TABLE 4-6
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 2: REMOVAL, EX SITU TREATMENT, BACKFILL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	Relevant and Appropriate	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards are relevant and appropriate and were used to develop soil PRGs. This alternative meets this standard because soil exceeding PRGs is treated to meet desired goals.

TABLE 4-7
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 2: REMOVAL, EX SITU TREATMENT, BACKFILL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state approved management programs.	The site is located next to a coastal zone management area, therefore, applicable coastal zone management requirements need to be addressed**.**
Executive Order 11988 RE: Floodplain Management	40 CFR Part 6, Appendix A	Applicable	The Order requires Federal agencies to evaluate the potential effects of actions it may take within a designated 100-year floodplain of a waterway to avoid adversely impacting floodplains wherever possible.	Excavation next to bay may impact floodplain. The potential for restoring and preserving floodplains so that their natural and beneficial values can be realized will be considered and incorporated into any plan or action wherever feasible. No long-term impact to the floodplain is anticipated.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**

TABLE 4-8
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 2: REMOVAL, EX SITU TREATMENT, BACKFILL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS)	42 USC 7411, 7412; 40 CFR Part 61	Applicable	NESHAPS are a set of emission standards for specific chemicals, including naphthalene, arsenic, cadmium, chromium, lead, mercury, nickel, PCBs, DDE, and hexachlorobenzene. Certain activities are regulated including site remediation.	Monitoring of air emissions from LTTS will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Resource Conservation and Recovery Act (RCRA), Subtitle C - Standards for Hazardous Waste Facilities	42 USC 6291 et seq.	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and soils will be tested to determine if they constitute hazardous waste. Any hazardous waste identified and treatment residues, filters etc will be tested for hazardous characteristics and will be handled and disposed according to these standards.
Clean Water Act (CWA), Section 402, National Pollutant Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR Parts 122-125, 131	Applicable	These standards govern discharge of water into surface waters. Regulated discharges must meet ambient water quality criteria.	Any water from temporary storage area will be treated as required to meet this ARAR before being discharged.

TABLE 4-9
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 3: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	Relevant and Appropriate	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards are relevant and appropriate and were used to develop soil PRGs. This alternative meets this standard because soil exceeding PRGs is excavated and disposed at TSDF.

TABLE 4-8 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 2: REMOVAL, EX SITU TREATMENT, BACKFILL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Hazardous Waste Management - Standards for Treatment, Storage, and Disposal Facilities	RIGL 23-19.1 *et seq.*; CRIR 12-030-003(10.00)	Applicable	Outlines specifications and standards for design, operation, closure, and monitoring of performance for hazardous waste storage, treatment, and disposal facilities. The standards of 40 CFR Part 264 are incorporated by reference.	Treated soil will be tested to meet all requirement before used as backfill. Any treatment filters or residues will be tested for hazardous characteristics and handled according to applicable standards.
Clean Air Act - Fugitive Dust Control	RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Removal, LTTS Treatment and processing, and temporary storage of debris and soil during the implementation of alternative would be implemented to prevent material from becoming airborne.
Clean Air Act - Emissions Detrimental to Persons or Property	RIGL 23-23 *et seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants which may be injurious to humans, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	Removal, LTTS Treatment and processing, and temporary storage of debris and soil during the implementation of alternative would be implemented to prevent material from becoming airborne. Monitoring of air emissions from the LTTS will be used to assess compliance with these standards if threshold levels are reached.

TABLE 4-8 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 2: REMOVAL, EX SITU TREATMENT, BACKFILL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (cont.)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Air Pollution Control	RIGL 23-23 *et seq.*; CRIR 12-31-09	Applicable	Establishes guidelines for the construction, installation, or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Site processing of soil through LTTS and treatment of off-gas will meet the substantive provisions of the standards if threshold levels are reached.
Clean Air Act - Air Toxics	RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels as set in the regulations	Monitoring of air emissions from the LTTS facility will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state. Also establishes criteria for discharge to a water body.	Any water from temporary storage area will be treated as required to meet this ARAR before being discharged.
Water Pollution Control - Pollution Discharge Elimination Systems	RIGL 42-16 *et seq.*; CRIR 12-190-003	Applicable	Contains applicable effluent monitoring requirements, and standards and special conditions for discharges.	The substantive provisions of these standards will be satisfied through on-site treatment of all discharges prior to being discharged.

TABLE 4-10
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 3: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state-approved management programs.	The site is located next to a coastal zone management area; therefore, applicable coastal zone management requirements need to be addressed**.**
Executive Order 11988 RE: Floodplain Management	40 CFR Part 6, Appendix A	Applicable	The Order requires Federal agencies to evaluate the potential effects of actions it may take within a designated 100-year floodplain of a waterway to avoid adversely impacting floodplains wherever possible.	Excavation next to bay may impact floodplain. The potential for restoring and preserving floodplains so that their natural and beneficial values can be realized will be considered and incorporated into any plan or action wherever feasible.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**

TABLE 4-11
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 3: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS)	42 USC 7411, 7412; 40 CFR Part 61	Applicable	NESHAPS are a set of emission standards for specific chemicals, including naphthalene, arsenic, cadmium, chromium, lead, mercury, nickel, PCBs, DDE, and hexachlorobenzene. Certain activities are regulated including site remediation.	Monitoring of air emissions during excavation will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Resource Conservation and Recovery Act (RCRA), Subtitle C - Standards for Hazardous Waste Facilities	42 USC 6291 et seq.	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and soils will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.
Clean Water Act (CWA), Section 402, National Pollutant Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR Parts 122-125, 131	Applicable	These standards govern discharge of water into surface waters. Regulated discharges must meet ambient water quality criteria.	Any water from temporary storage area will be treated as required to meet this ARAR before being discharged.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Fugitive Dust Control	RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Removal, and temporary storage of debris and soil during the implementation of alternative would be implemented to prevent material from becoming airborne.

TABLE 4-11 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 3: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (CONT'D)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Emissions Detrimental to Persons or Property	RIGL 23-23 *et seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants which may be injurious to humans, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	Removal and temporary storage of debris and soil during the implementation of alternative would be implemented to prevent material from becoming airborne. Monitoring of air emissions during removal will be used to assess compliance with these standards if threshold levels are reached.
Clean Air Act - Air Pollution Control	RIGL 23-23 *et seq.*; CRIR 12-31-09	Applicable	Establishes guidelines for the construction, installation, or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	No emissions are expected, however, removal action would be monitored and any if any control system is required it will meet the substantive provisions of the standards if threshold levels are reached.
Clean Air Act - Air Toxics	RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels as set in the regulations	Monitoring of air emissions during excavation will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.

TABLE 4-11 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SOIL ALTERNATIVE 3: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (CONT'D)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Hazardous Waste Management Standards for Treatment, Storage, and Disposal Facilities	RIGL 23-19.1 et seq.; CRIR 12-030-003	Applicable	Sets standards for handling, design, operation, and monitoring of hazardous waste. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and soils will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.

TABLE 4-12
SUMMARY OF COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
THRESHOLD CRITERIA			
Overall Protection of Human Health and the Environment			
Human Health Protection	No reduction in risk	Provides high level of protection. Exposure reduced by excavation and treatment. Treatment reduces exposure hazard from soil.	Provides high level of protection. Removal reduces future site exposure hazard from soil.
Environmental Protection	Allows continued exposure of contaminated soil.	Will prevent further exposure through removal and treatment.	Will provide protection at the site, however, future exposure from contaminants depends on treatment, storage, and disposal facility (TSDF).
Compliance with Applicable or Relevant and Appropriate Requirements			
Compliance with Chemical-Specific ARARs	No	Will meet PRGs within 1 year.	Will meet PRGs within 1 year.
Compliance with Location-Specific ARARs	Not applicable	Will be performed in accordance with floodplain, wetland, wildlife, and historic preservation regulations.	Will be performed in accordance with floodplain, wetland, wildlife, and historic preservation regulations.
Compliance with Action-Specific ARARs	Not applicable	Excavation and treatment systems will require dust suppression, silt fences, etc.	Excavation and treatment systems will require dust suppression, silt fences, etc.

TABLE 4-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
BALANCING CRITERIA			
Long-Term Effectiveness and Permanence			
Magnitude of Residual Risk	Will not meet either RIDEM or EPA risk target levels	Will be less than target cumulative cancer risk of 10^{-5} and HI of 1.0	Will be less than target cumulative cancer risk of 10^{-5} and HI of 1.0
Need for 5-Year Review	Required	Not Required	Not Required
Need for Long-Term Management	Not applicable	None	None
Adequacy and Reliability of Controls	Not applicable	Provides a good level of reliability of residual management. Controls are adequate and reliable.	No residuals requiring management will be generated.
Reduction of Toxicity, Mobility, or Volume through Treatment			
Amount Destroyed or Treated	None; only natural attenuation	Contaminant reduction of 99%	Removal (by excavation) efficiency of 99%. Small amount destroyed or treated.
Reduction in Toxicity, Mobility, and Volume	None; only natural attenuation	Mobility and volume reduced	None
Degree to which Treatment Is Irreversible	No active treatment	Low-Temperature Thermal Stripping (LTTS) and soil washing are considered permanent.	Removal is not considered permanent unless there is treatment at the TSDF.
Type and Quantity of Residuals Remaining after Treatment	No active treatment	LTTS and soil washing treatments will produce small quantity of liquids and activated carbon residuals.	Not applicable, no residuals

TABLE 4-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
BALANCING CRITERIA			
Short-Term Effectiveness			
Community Protection during Implementation	No active treatment; no risk to community	Dust and air emissions from excavation and treatment activities can be controlled.	Dust from excavation and removal activities can be controlled. Increased truck traffic in the community.
Worker Protection during Implementation	No active treatment; no risk to workers	PPE required against dermal contact, dust inhalation, and air emissions during construction and treatment.	PPE required against dermal contact and dust inhalation during excavation.
Environmental Impacts	No impact from alternative implementation	Impacts from dust and air emissions, soil erosion, etc., can be controlled.	Impacts from dust and soil erosion, etc., can be controlled.
Time until Remedial Action Objectives Achieved	> 30 years	Estimated 6-8 months.	Estimated 4-6 months
Implementability			
Ability to Construct and Operate the Technology	No construction activities	Implementable. Applicability depends on type of soil and pilot testing may be required.	Implementable. Contractors and equipment readily available.
Reliability of the Technology	No treatment	Average reliability. Requires considerable maintenance.	Better reliability. Properly maintained earthmoving equipment will have few failures.
Ease of Undertaking Additional Remedial Actions, if Necessary	Easily implementable	Additional soil removals can be easily implemented.	Additional soil removals can be easily implemented.
Ability to Monitor Effectiveness of Remedy	Not applicable	System efficiencies and failures can readily be monitored. System failure may allow uncontrolled air emissions and backfilling of contaminated soil.	Area and depth of removal can easily be monitored. Monitoring failure could allow contaminated soil to remain in place.

TABLE 4-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SOIL ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Removal, Ex situ Treatment, Backfill	Alternative 3 Removal and Disposal
BALANCING CRITERIA			
Administrative Requirements with Regulators	No active treatment	Need to comply with all ARAR standards. No on0site permits will be required.	Federal, state, and/or base permits may be required for transportation, off-site treatment and disposal. Need to comply with all ARAR standards. No on-site permits will be required. TSDF should have a permit.
Availability of Off-Site TSDF	None required	Available	Available
Availability of Necessary Equipment and Specialists	None required	Available	Available
Availability of Prospective Technologies	None required	Available	Available
Cost[a,b]			
Capital Costs	$0	$11,897,000	$8,045,000
Total Annual Operations and Maintenance (O&M)	$0	$30,000	$30,000
5-Year Reviews	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$11,957,000	$8,105,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded off to the nearest $1,000.

TABLE 5-1
SUMMARY OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Alternative	Alternative Description
Alternative 1: No Action	• Five-year reviews
Alternative 2: Limited Action	• Groundwater use restrictions • Long-term monitoring of use restrictions • Long-term monitoring of groundwater • Five-year reviews
Alternative 3: Extraction and Treatment	• Pre-design investigation • Installation of eight groundwater extraction wells • Installation of a groundwater treatment system (ion exchange and liquid-phase carbon adsorption) • Discharge of treated water to POTW • Long-term groundwater monitoring • Five-year reviews

TABLE 5-2
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR GROUNDWATER REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
THRESHOLD CRITERIA			
Overall Protection of Human Health and the Environment			
Does Alternative Protect Current and Future Users?	No	Yes	Yes
Are Environmental Risks Reduced by Alternative?	No	Yes, by natural processes	Yes
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)			
Compliance with Chemical-Specific ARARs	No	Yes	Yes
Compliance with Location-Specific ARARs	Not applicable	Yes	Yes
Compliance with Action-Specific ARARs	Not applicable	Yes	Yes
Compliance with Other Criteria	No	Yes	Yes
BALANCING CRITERIA			
Long-Term Effectiveness and Permanence			
Does Alternative Reduce Residual Risk?	No	No	Yes
Does Alternative Provide Adequate Remedial Controls?	No	Yes	Yes
Need a 5-Year Review?	Yes	Yes	Yes
Need for Long-Term Management?	Yes	Yes	Yes
Reduction of Toxicity, Mobility, or Volume through Treatment			
Treatment Process Used	None	None	Ion exchange, activated carbon adsorption
Groundwater Treated	No	No	Yes
Reduction in Toxicity, Mobility, or Volume	None	None	Toxicity, mobility, and volume – reduced
Type and Quantity of Residuals Remaining after Treatment	No treatment so no residuals	No treatment so no residuals	Spent exchange resins and activated carbon
Short-Term Effectiveness			
Risks to the Community during Remedial Action	No treatment so no construction risks	Minimal	Minimal
Risk to Workers during Remedial Action	No treatment so no construction risks	Minimal	Some risks; easily controlled
Environmental Impacts	No treatment so no additional impacts	Minimal	Minimal
Time until Remedial Action Objectives Achieved	No remedial action; time >30 years.	>30 years	>30 years

TABLE 5-2 (cont'd)
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR GROUNDWATER REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
Implementability			
Constructable	No construction activities	No construction activities	Yes
Reliability of Technology	No technology implemented	Reliable	Reliable
Ease of Undertaking Additional Remedial Action, if Necessary	Easily implementable	High	High
Ability to Monitor Effectiveness of Remedy	Not applicable	Yes	Yes
Ability to Coordinate with Other Agencies	Easy	Easy	Moderately easy
Availability of Off-Site Disposal Services	None required	None Required	Available
Availability of Equipment and Specialists	None required	Available	Available
Availability of Prospective Technologies	None required	Available	Available
Cost[a,b]			
Capital Costs	$0	$53,000	$586,000
Total Annual Operations and Maintenance (O&M)	$0	$44,000 (years 1-5) $11,000 (others)	$158,000 (years 1-5) $59,000 (other years)
5-Year Review Costs	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$543,000	$2,128,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded off to the nearest $1,000.

TABLE 5-3
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	To Be Considered	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards were considered in the development of groundwater PRGs based on the implausible use of the groundwater as a water supply.

TABLE 5-4
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal location-specific ARARS.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state location-specific ARARs				

TABLE 5-5
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal action-specific ARARs.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state action-specific ARARs.				

TABLE 5-6
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	To Be Considered	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards were considered in the development of groundwater PRGs based on the implausible use of the groundwater as a water supply.

TABLE 5-7
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state approved management programs.	The site is located next to a coastal zone management area, therefore, applicable coastal zone management requirements need to be addressed**.**

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**

TABLE 5-8
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Safe Drinking Water Act Maximum Contaminant Levels (MCLs)	40 CFR 141.11-141.16	To Be Considered	These standards are for protection of drinking water sources. MCLs consider health factors as well as economic and technical feasibility of removing a contaminant.	MCLs were considered in development of PRGs, based on an implausible use of the groundwater for a drinking water supply.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state.	Groundwater concentrations will be compared against these criteria during the long-term monitoring events.

TABLE 5-9
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 3: EXTRACTION AND TREATMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Safe Drinking Water Act Maximum Contaminant Levels (MCLs)	40 CFR 141.11-141.16	To Be Considered	These standards are for protection of drinking water sources. MCLs consider health factors as well as economic and technical feasibility of removing a contaminant.	MCLs were considered in development of PRGs, based on an implausible use of the groundwater for a drinking water supply.
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
State of Rhode Island Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Short Title: Remediation Regulations)	CRIR 12-180-001, Section 8; DEM-DSR-01-93, as amended August 1996	Relevant and Appropriate	These regulations set remediation standards for contaminated media at non-NPL sites in Rhode Island. These standards may also be determined to be relevant and appropriate for NPL sites when they are more stringent than federal standards.	These standards are relevant and appropriate and were used to develop groundwater PRGs.

TABLE 5-10
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 3: EXTRACTION AND TREATMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state-approved management programs.	The site is located next to a coastal zone management area; therefore, applicable coastal zone management requirements need to be addressed**.**

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**

TABLE 5-11
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
GROUNDWATER ALTERNATIVE 3: EXTRACTION AND TREATMENT
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Water Act (CWA), Section 402, National Pollutant Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR Parts 122-125, 131	Applicable	These standards govern discharge of water into surface waters. Regulated discharges must meet ambient water quality criteria.	Any extracted groundwater will be treated as required to meet this ARAR before being discharged.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state. Also establishes criteria for discharge to a water body.	Any extracted groundwater will be treated as required to meet this ARAR before being discharged.
Water Pollution Control - Pollution Discharge Elimination Systems	RIGL 42-16 *et seq.*; CRIR 12-190-003	Applicable	Contains applicable effluent monitoring requirements, and standards and special conditions for discharges.	The substantive provisions of these standards will be satisfied through on-site treatment of all effluent prior to being discharged.

TABLE 5-12
SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
THRESHOLD CRITERIA			
Overall Protection of Human Health and the Environment			
Human Health Protection	No reduction in risk	Prevents exposure through groundwater use controls.	Exposure reduced by extraction and treatment.
Environmental Protection	Allows continued potential migration of contaminated groundwater.	Allows continued potential migration of contaminated groundwater. Monitoring will indicate any changes over time.	Will prevent migration of contaminated groundwater through extraction and treatment.
Compliance with Applicable or Relevant and Appropriate Requirements			
Compliance with Chemical-Specific ARARs	No	Prevents exposure to water exceeding PRGs through use restrictions. Will meet PRGs over time with natural flushing.	Will meet PRGs over time with extraction and treatment.
Compliance with Location-Specific ARARs	Not applicable	Will be performed in accordance with floodplain, wildlife, and historic preservation regulations.	Will be performed in accordance with floodplain, wildlife, and historic preservation regulations.
Compliance with Action-Specific ARARs	Not applicable	MCLs and will be used to compare against for groundwater monitoring.	Extraction, treatment, and discharge will be performed in accordance with water quality regulations and NPDES.

TABLE 5-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
BALANCING CRITERIA			
Long-Term Effectiveness and Permanence			
Magnitude of Residual Risk	Residual risk remains	Residual risk remains but exposure pathway is eliminated through use restrictions	Treatment eliminates residual risk
Need for 5-Year Review	Required	Required	Required
Need for Long-Term Management	Not applicable	Yes, use restrictions and groundwater monitoring	Yes, groundwater monitoring
Adequacy and Reliability of Controls	Not applicable	Controls are adequate and reliable.	Controls are adequate and reliable.
Reduction of Toxicity, Mobility, or Volume through Treatment			
Amount Destroyed or Treated	None; only natural attenuation	None; only natural attenuation	Treatment efficiency of ion exchange and GAC is high.
Reduction in Toxicity, Mobility, and Volume	None; only natural attenuation	None; only natural attenuation	Toxicity, Mobility, and Volume reduced.
Degree to which Treatment Is Irreversible	No active treatment	No active treatment	Ion exchange and GAC permanently remove contaminants from the extracted groundwater.
Type and Quantity of Residuals Remaining after Treatment	No active treatment	No active treatment	Spent ion exchange resins and GAC.

TABLE 5-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
BALANCING CRITERIA			
Short-Term Effectiveness			
Community Protection during Implementation	No active treatment; no risk to community	No active treatment; no risk to community	Minimal dust disturbance and increased truck traffic in the community during construction activities can be controlled.
Worker Protection during Implementation	No active treatment; no risk to workers	PPE required during monitoring events.	PPE required during installation, maintenance, and monitoring events.
Environmental Impacts	No impact from alternative implementation	No impact from alternative implementation	Impacts from construction can be controlled.
Time until Remedial Action Objectives Achieved	> 30 years	>30 years	>30 years
Implementability			
Ability to Construct and Operate the Technology	No construction activities	No construction activities	Implementable. Contractors and equipment available.
Reliability of the Technology	No treatment	No treatment	Good reliability. Properly maintained system equipment will have few failures.
Ease of Undertaking Additional Remedial Actions, if Necessary	Easily implementable	Additional remedial actions can be easily implemented.	Additional remedial actions can be easily implemented.
Ability to Monitor Effectiveness of Remedy	Not applicable	Monitoring of use restrictions and groundwater will indicate effectiveness.	Treatment system effectiveness will be indicated by sampling.

TABLE 5-12 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF GROUNDWATER ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Extraction and Treatment
BALANCING CRITERIA			
Administrative Requirements with Regulators	None required	Reporting of use restrictions and groundwater monitoring is required.	Federal, state, and/or base permits may be required for transportation and NPDES disposal. Reporting of groundwater monitoring is required.
Availability of Off-Site TSDF	None required	None required	Available
Availability of Necessary Equipment and Specialists	None required	Available	Available
Availability of Prospective Technologies	None required	Available	Available
Cost[a,b]			
Capital Costs	$0	$53,000	$586,000
Total Annual Operations and Maintenance (O&M)	$0	$44,000 (years 1-5) $11,000 (others)	$158,000 (years 1-5) $59,000 (others)
5-Year Reviews	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$543,000	$2,128,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded off to the nearest $1,000.

TABLE 6-1
SUMMARY OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Alternative	Alternative Description
Alternative 1: No Action	• Five-year reviews
Alternative 2: Limited Action	• Access restrictions • Long-term O&M of access restrictions • Long-term monitoring to determine if COC concentrations are reduced by source removal • Five-year reviews
Alternative 3: Limited Removal (Beach Area)	• Pre-design investigation • Engineering controls to minimize erosion and sediment migration during construction • Removal of 5,716 cy of contaminated sediment from the beach • Confirmation sampling of excavated areas to ensure complete removal • Sediment dewatering • Treatment of dewatering fluids and discharge to bay • Disposal of sediment at TSDF • Backfill with natural fill • Long-term monitoring a)of offshore areas remaining that exceed ecological standards and b) of excavated areas to measure possible recontamination • Five-year reviews
Alternative 4: Removal and Disposal Option A	• Pre-design investigation • Engineering controls to minimize erosion and sediment migration during construction • Removal of 5,716 cy of contaminated sediment from the beach • Removal of 214 cy of contaminated sediment from the offshore areas exceeding ecological standards except for areas containing eelgrass • Use of portadams and a temporary excavator causeway to facilitate removal • Confirmation sampling of excavated areas to ensure complete removal of contaminated sediment • Sediment dewatering • Treatment of dewatering fluids and discharge to bay • Disposal of sediment at TSDF • Backfill with natural fill • Long-term monitoring a)of offshore areas remaining that exceed ecological standards and b) of excavated areas to measure possible recontamination • Five-year reviews
Alternative 5: Removal and Disposal Option B	• Pre-design investigation • Engineering controls to minimize erosion and sediment migration during construction • Removal of 5,716 cy of contaminated sediment from the beach • Removal of 290 cy of contaminated sediment from the offshore areas exceeding ecological standards including areas containing eelgrass • Use of portadams and a temporary excavator causeway to facilitate removal • Confirmation sampling of excavated areas to ensure complete removal of contaminated sediment • Sediment dewatering • Treatment of dewatering fluids and discharge to bay • Disposal of sediment at TSDF • Backfill with natural fill • Natural restoration of eelgrass beds (0.05 acre) • Long-term monitoring of excavated areas to measure possible recontamination

TABLE 6-2
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR SEDIMENT REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Limited Removal, Disposal	Alternative 4 Removal, Disposal Option A	Alternative 5 Removal, Disposal Option B
THRESHOLD CRITERIA					
Overall Protection of Human Health and the Environment					
Does Alternative Protect Current and Future Users?	No	Yes	Yes	Yes	Yes
Are Environmental Risks Reduced by Alternative?	No	If source removal results in a decrease of sediment COC concentrations	If source removal results in a decrease of sediment COC concentrations	If source removal results in a decrease of sediment COC concentrations	Yes
Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)					
Compliance with Chemical-Specific ARARs	No	No	Yes, over time	Yes, over time	Yes
Compliance with Location-Specific ARARs	Not applicable	No	Yes	Yes	Yes
Compliance with Action-Specific ARARs	Not applicable	Yes	Yes	Yes	Yes
Compliance with Other Criteria	No	No	Yes	Yes	Yes
BALANCING CRITERIA					
Long-Term Effectiveness and Permanence					
Does Alternative Reduce Residual Risk?	No	Yes, except for the subtidal sediment and eelgrass beds	Yes, except for the subtidal sediment and eelgrass beds	Yes, except for the eelgrass beds	Yes
Does Alternative Provide Adequate Remedial Controls?	No	To some extent	No controls in place	No controls in place	No controls in place
Need 5-Year Reviews?	Yes	Yes	Yes	Yes	No
Need for Long-Term Management?	Yes	No	Yes	Yes	No
Reduction of Toxicity, Mobility, or Volume through Treatment					
Treatment Process Used	None	None	Sediment may be stabilized prior to disposal and may be treated at TSDF to meet LDRs	Sediment may be stabilized prior to disposal and may be treated at TSDF to meet LDRs	Sediment may be stabilized prior to disposal and may be treated at TSDF to meet LDRs
Sediment Treated	No	No	Only if required	Only if required	Only if required
Reduction in Toxicity, Mobility, or Volume	None	None	Toxicity (if treated) and Mobility reduced	Toxicity (if treated) and Mobility reduced	Toxicity (if treated) and Mobility reduced
Type and Quantity of Residuals Remaining after Treatment	No treatment so no residuals	No treatment so no residuals	Residual water from dewatering-small quantity Lime based residuals if treated – small quantity	Residual water from dewatering-small quantity Lime based residuals if treated – small quantity	Residual water from dewatering-small quantity Lime based residuals if treated – small quantity

TABLE 6-2 (cont'd)
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR SEDIMENT REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Limited Removal, Disposal	Alternative 4 Removal, Disposal Option A	Alternative 5 Removal, Disposal Option B
Short-Term Effectiveness					
Risks to the Community during Remedial Action	No treatment so no construction risks	No risks	No risks	No risks	No risks
Risk to Workers during Remedial Action	No treatment so no construction risks	Some risks; easily controlled	Exposure risks during excavation require PPE	Exposure risks during excavation require PPE	Exposure risks during excavation require PPE
Environmental Impacts	No treatment so no additional impacts	Minimal. Sediment resuspension	Excavation disturbs sediment and requires control measures Intertidal and subtidal habitat interrupted	Excavation disturbs sediment and requires control measures. Intertidal and subtidal habitat interrupted	Excavation disturbs sediment and requires control measures. Intertidal and subtidal habitat interrupted Eelgrass beds will be destroyed.
Time until Remedial Action Objectives Achieved	No remedial action; time >30 years.	Estimated 1 to 2 months	Estimated 3 to 4 months	Estimated 6 to 8 months	Estimated 6 to 8 months
Implementability					
Constructable	No construction activities	Yes	Yes	Yes	Yes
Reliability of Technology	No technology implemented	No technology implemented	Excavation is reliable	Excavation is reliable	Excavation is reliable
Ease of Undertaking Additional Remedial Action, if Necessary	Easily implementable	High	High	Moderate	Moderate
Ability to Monitor Effectiveness of Remedy	Not applicable	Moderate	High	High	High
Ability to Coordinate with Other Agencies	Easy	Moderately easy	Moderately easy	Moderately easy	Moderately easy
Availability of Off-Site Disposal Services	None required	None required	Available	Available	Available
Availability of Equipment and Specialists	None required	Available	Available	Available	Available
Availability of Prospective Technologies	None required	None required	Available	Available	Available

TABLE 6-2 (cont'd)
SUMMARY OF DETAILED ANALYSES OF ALTERNATIVES FOR SEDIMENT REMEDIATION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Criteria	Alternative 1 No Action	Alternative 2 Limited Action	Alternative 3 Limited Removal, Disposal	Alternative 4 Removal, Disposal Option A	Alternative 5 Removal, Disposal Option B
Cost[a,b]					
Capital Costs	$0	$10,000	$3,032,000	$3,496,000	$3,775,000
Total Annual Operations and Maintenance (O&M)	$0	$70,000	$73,000	$52,000	$44,000
5-Year Reviews	$22,000	$22,000	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$653,000	$3,605,000	$3,922,000	$4,095,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded off to the nearest $1,000.

TABLE 6-3
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.
Clean Water Act, Section 304	40 USC 1314; 40 CFR 122.44	Relevant and Appropriate	Establish Ambient Water Quality Criteria (AWQC): Guidelines established for the protection of human health and/or the aquatic organisms.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet this standard because sediments exceeding PRGs are not adequately addressed.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control	RIGL 46-12 *et seq.*; ENVM 112-88.97-1	Relevant and Appropriate	Establishes water use classification and water quality criteria for waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet this standard because sediments exceeding PRGs are not adequately addressed.

TABLE 6-4
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal location-specific ARARS.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state location-specific ARARs				

TABLE 6-5
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 1: NO ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no federal action-specific ARARs.				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
There are no state action-specific ARARs.				

TABLE 6-6
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.
Clean Water Act, Section 304	40 USC 1314; 40 CFR 122.44	Relevant and Appropriate	Establish Ambient Water Quality Criteria (AWQC): Guidelines established for the protection of human health and/or the aquatic organisms.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet this standard because sediments exceeding PRGs are not adequately addressed.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control	RIGL 46-12 *et seq.*; ENVM 112-88.97-1	Relevant and Appropriate	Establishes water use classification and water quality criteria for waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet this standard because sediments exceeding PRGs are not adequately addressed.

TABLE 6-7
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Executive Order 11990 RE: Protection of Wetlands	40 CFR Part 6, Appendix A	Applicable	This Order requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order.	Fails to comply with this standard because the action to be taken does not address the risk to the wetland environment posed by the contamination. Installation of fencing and buoys would be conducted to minimize damage of the wetlands.
Executive Order 11988 RE: Floodplain Management	40 CFR Part 6, Appendix A	Applicable	The Order requires Federal agencies to evaluate the potential effects of actions it may take within a designated 100-year floodplain of a waterway to avoid adversely impacting floodplains wherever possible.	Fails to comply with this standard because the action to be taken does not address the risk to the floodplain environment posed by the contamination.
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*; 40 CFR 122.49	Applicable	This statute requires consultation with appropriate agencies to protect fish and wildlife when federal actions result in control or structural modification of a body of water or to critical habitat upon which endangered or threatened species depends.	Appropriate agencies will be consulted to find ways to minimize adverse effects to fish and wildlife from installation of fencing and buoys.

TABLE 6-7 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Endangered Species Act	16 USC 1531 *et seq.*, 50 CFR Part 200, 50 CFR Part 402	Applicable	If a location contains a federal endangered or threatened species or its critical habitat, and an action may impact the species or its habitat, the U.S. Fish & Wildlife Service or the National Marine Fisheries Service must be consulted.	The federally endangered loggerhead turtle (*Caretta caretta*) and federally threatened Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species and its habitat from installation of fencing and buoys.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state approved management programs.	The entire site is located in a coastal zone management area, therefore, applicable coastal zone management requirements need to be addressed**.**
National Historic Preservation Act	16 USC 470 *et seq.*, 26 CFR Part 800	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks	Historic vessels may be sunken in the area. Monitoring and installation of fencing and buoys will be carried out to minimize potential harm to historic sites.

TABLE 6-7 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire Site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**
Endangered Species Act	RIGL 20-37-1 *et seq.*	Applicable	Regulates activities affecting state-listed endangered or threatened species or their critical habitat.	The state listed loggerhead turtle (*Caretta caretta*) and Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species and its habitat from installation of fencing and buoys.

TABLE 6-8
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 2: LIMITED ACTION
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
None				

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state.	Monitoring and installation of access restrictions will not cause degradation of surface water quality in Narragansett Bay.

TABLE 6-9
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.
Clean Water Act, Section 304	40 USC 1314; 40 CFR 122.44	Relevant and Appropriate	Establish Ambient Water Quality Criteria (AWQC): Guidelines for the protection of human health and/or the aquatic organisms.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet the standard, unless the COCs in sediment left in place will reach the PRGs within an acceptable time frame.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control	RIGL 46-12 *et seq.*; ENVM 112-88.97-1	Relevant and Appropriate	Establishes water use classification and water quality criteria for waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. Sediments exceeding PRGs must be adequately addressed to meet these standards.

TABLE 6-10
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Executive Order 11990 RE: Protection of Wetlands	40 CFR Part 6, Appendix A	Applicable	This Order requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order.	Restoration and preservation of the wetlands altered by the removal action will be conducted so that the wetlands' natural and beneficial values can be realized. Implementation of the Order will be considered and incorporated into any plan or action, wherever feasible.
Clean Water Act, Section 404	33 USC 1344; 40 CFR Part 230 and 33 CFR Parts 320-323	Applicable	This statute regulates the discharge of dredge and fill materials into Waters of the United States, including special aquatic sites - such as wetlands, intertidal habitats, and vegetated shallows. Such discharges are not allowed if practicable alternatives are available.	Refilling of the excavated/dredged intertidal habitats will only satisfy this requirement if no practicable alternative that has less effect is available. Impacts to aquatic habitats would be mitigated as part of this alternative.
Rivers and Harbors Act, Section 10	33 USC 403; 33 CFR Parts 320-323	Applicable	Sets forth criteria for obstructions or alterations of navigable waters.	Excavation, dredging, and habitat restoration will comply with the Act's environmental standards.

TABLE 6-10 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Executive Order 11988 RE: Floodplain Management	40 CFR Part 6, Appendix A	Applicable	The Order requires Federal agencies to evaluate the potential effects of actions it may take within a designated 100-year floodplain of a waterway to avoid adversely impacting floodplains wherever possible.	The potential for restoring and preserving floodplains so that their natural and beneficial values can be realized will be considered and incorporated into any plan or action wherever feasible.
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*; 40 CFR 122.49	Applicable	This statute requires consultation with appropriate agencies to protect fish and wildlife when federal actions result in control or structural modification of a body of water or to critical habitat upon which endangered or threatened species depends.	The appropriate agencies will be consulted to find ways to minimize adverse effects to fish and wildlife from the implementation of the proposed removal, containment, and restoration remedy.
Endangered Species Act	16 USC 1531 *et seq.*, 50 CFR Part 200, 50 CFR Part 402	Applicable	If a location contains a federal endangered or threatened species or its critical habitat, and an action may impact the species or its habitat, the U.S. Fish & Wildlife Service or the National Marine Fisheries Service must be consulted.	The federally endangered loggerhead turtle (*Caretta caretta*) and federally threatened Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species from the removal, containment, and restoration remedy.

TABLE 6-10 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state approved management programs.	The entire site is located in a coastal zone management area; therefore, applicable coastal zone management requirements need to be addressed**.**
National Historic Preservation Act	16 USC 470 *et seq.*, 26 CFR Part 800	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks	Historic vessels may be sunken in the area. Excavation/dredging, containment, and restoration activities will be carried out to minimize potential harm to historic sites.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area; therefore, applicable coastal resource management requirements need to be addressed**.**
Endangered Species Act	RIGL 20-37-1 *et seq.*	Applicable	Regulates activities affecting state-listed endangered or threatened species or their critical habitat.	The state listed loggerhead turtle (*Caretta caretta*) and Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate state agencies will be consulted to find ways to minimize adverse effects to the listed species from the implementation of the removal and restoration remedy.

TABLE 6-11
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Water Act (CWA), Section 402, National Pollutant Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122-125, 131	Applicable	These standards govern discharge of water into surface waters. Regulated discharges must meet ambient water quality criteria (AWQC).	Any drainage from the temporary debris/sediment storage area and any dewatering discharge will be treated by as necessary to meet this requirement and discharged into Narragansett Bay.
Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS)	42 USC 7411, 7412; 40 CFR Part 61	Applicable	NESHAPS are a set of emission standards for specific chemicals, including naphthalene, arsenic, cadmium, chromium, lead, mercury, nickel, PCBs, DDE, and hexachlorobenzene. Certain activities are regulated including site remediation.	Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Resource Conservation and Recovery Act (RCRA), Subtitle C - Standards for Hazardous Waste Facilities	42 USC 6291 et seq.	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and sediment will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.

TABLE 6-11 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Fugitive Dust Control	RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Removal, processing, and temporary storage of debris and sediments during dewatering and before shipment would be implemented to prevent material from becoming airborne.
Clean Air Act - Emissions Detrimental to Persons or Property	RIGL 23-23 *et seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants which may be injurious to humans, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	Removal, processing, and temporary storage of debris and sediments during dewatering and before shipment would be implemented to prevent emissions of contaminants. Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached.
Clean Air Act - Air Pollution Control	RIGL 23-23 *et seq.*; CRIR 12-31-09	Applicable	Establishes guidelines for the construction, installation, or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Site processing of debris and sediment and treatment of dewatering liquid will meet the substantive provisions of the standards if threshold levels are reached.

TABLE 6-11 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Air Toxics	RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels as set in the regulations	Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state. Also establishes criteria for discharge to a water body.	Monitoring operations must not cause degradation of surface water quality in the bay. Any drainage off the temporary debris/sediment storage area and any dewatering discharge will be treated as necessary to meet these requirements and discharged.
Water Pollution Control - Pollution Discharge Elimination Systems	RIGL 42-16 *et seq.*; CRIR 12-190-003	Applicable	Contains applicable effluent monitoring requirements, and standards and special conditions for discharges.	The substantive provisions of these standards will be satisfied through on-site treatment of all discharges prior to being discharged.
Hazardous Waste Management Standards for Treatment, Storage, and Disposal Facilities	RIGL 23-19.1 et seq.; CRIR 12-030-003	Applicable	Sets standards for handling, design, operation, and monitoring of hazardous waste. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of sediments will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.

TABLE 6-12
ASSESSMENT OF CHEMICAL-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
EPA Human Health Assessment Cancer Slope Factors (CSFs).		To Be Considered	These are guidance values used to evaluate the potential carcinogenic hazard caused by exposure to contaminants.	Used to compute the individual incremental cancer risk resulting from exposure to carcinogenic contaminants in site media.
EPA Risk Reference Doses (RfDs)		To Be Considered	Toxicity values for evaluating non-carcinogenic hazards from exposures to contamination.	Used to characterize human health risks due to non-carcinogens in site media.
Clean Water Act, Section 304	40 USC 1314; 40 CFR 122.44	Relevant and Appropriate	Establish Ambient Water Quality Criteria (AWQC): Guidelines for the protection of human health and/or the aquatic organisms.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet the standard unless COC concentrations decrease to below PRGs within a acceptable time frame.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control	RIGL 46-12 *et seq.*; ENVM 112-88.97-1	Relevant and Appropriate	Establishes water use classification and water quality criteria for waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	These standards are relevant and appropriate for sediment PRGs derived using these water quality criteria. This alternative fails to meet the standard unless COC concentrations decrease to below PRGs within a acceptable time frame.

TABLE 6-13
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Executive Order 11990 RE: Protection of Wetlands	40 CFR Part 6, Appendix A	Applicable	This Order requires Federal agencies to take action to avoid adversely impacting wetlands wherever possible, to minimize wetlands destruction and to preserve the values of wetlands, and to prescribe procedures to implement the policies and procedures of this Executive Order.	Restoration and preservation of the intertidal wetlands altered by the remedial action will be conducted so that the wetlands' natural and beneficial values can be realized. Implementation of the Order will be considered and incorporated into any plan or action, wherever feasible.
Clean Water Act, Section 404	33 USC 1344; 40 CFR Part 230 and 33 CFR Parts 320-323	Applicable	This statute regulates the discharge of dredge and fill materials into Waters of the United States, including special aquatic sites - such as wetlands, intertidal habitats, and vegetated shallows. Such discharges are not allowed if practicable alternatives are available.	Refilling of the excavated/dredged aquatic habitats will only satisfy this requirement if no practicable alternative that has less effect is available. Impacts to aquatic habitats would be mitigated as part of this alternative.
Rivers and Harbors Act, Section 10	33 USC 403; 33 CFR Parts 320-323	Applicable	Sets forth criteria for obstructions or alterations of navigable waters.	Excavation/dredging and habitat restoration will comply with the Act's environmental standards.

TABLE 6-13 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Executive Order 11988 RE: Floodplain Management	40 CFR Part 6, Appendix A	Applicable	The Order requires Federal agencies to evaluate the potential effects of actions it may take within a designated 100-year floodplain of a waterway to avoid adversely impacting floodplains wherever possible.	The potential for restoring and preserving floodplains so that their natural and beneficial values can be realized will be considered and incorporated into any plan or action wherever feasible.
Fish and Wildlife Coordination Act	16 USC Part 661 *et. seq.*; 40 CFR 122.49	Applicable	This statute requires consultation with appropriate agencies to protect fish and wildlife when federal actions result in control or structural modification of a body of water or to critical habitat upon which endangered or threatened species depends.	The appropriate agencies will be consulted to find ways to minimize adverse effects to fish and wildlife from the implementation of the proposed removal and restoration remedy.

TABLE 6-13 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS (Cont'd)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Endangered Species Act	16 USC 1531 *et seq.*, 50 CFR Part 200, 50 CFR Part 402	Applicable	If a location contains a federal endangered or threatened species or its critical habitat, and an action may impact the species or its habitat, the U.S. Fish & Wildlife Service or the National Marine Fisheries Service must be consulted.	The federally endangered loggerhead turtle (*Caretta caretta*) and federally threatened Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate agencies will be consulted to find ways to minimize adverse effects to the listed species from the removal and restoration remedy.
Coastal Zone Management Act	16 USC Parts 1451 *et. seq*.	Applicable	Requires that any actions must be conducted in a manner consistent with state approved management programs.	The entire site is located in a coastal zone management area, therefore, applicable coastal zone management requirements need to be addressed**.**
National Historic Preservation Act	16 USC 470 *et seq.*, 26 CFR Part 800	Applicable	Requires action to take into account effects on properties included on or eligible for the National Register of Historic Places and minimizes harm to National Historic Landmarks	Historic vessels may be sunken in the area. Excavation/dredging, and restoration activities will be carried out to minimize potential harm to historic sites.

TABLE 6-13 (cont'd)
ASSESSMENT OF LOCATION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Coastal Resources Management	RIGL 46-23-1 *et seq.*	Applicable	Sets standards for management and protection of coastal resources.	The entire site is located in a coastal resource management area, therefore, applicable coastal resource management requirements need to be addressed**.**
Endangered Species Act	RIGL 20-37-1 *et seq.*	Applicable	Regulates activities affecting state-listed endangered or threatened species or their critical habitat.	The state listed loggerhead turtle (*Caretta caretta*) and Kemp's ridley turtle (*Lepidochelys kempii*) occur in the waters of Narragansett Bay. Appropriate state agencies will be consulted to find ways to minimize adverse effects to the listed species from the implementation of the removal and restoration remedy.

TABLE 6-14
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

FEDERAL REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Water Act (CWA), Section 402, National Pollutant Discharge Elimination System (NPDES)	33 USC 1342; 40 CFR 122-125, 131	Applicable	These standards govern discharge of water into surface waters. Regulated discharges must meet ambient water quality criteria (WQC).	Any drainage off the temporary debris/sediment storage area and any dewatering discharge will be treated by an on-site treatment plant and discharged into Narragansett Bay.
Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAPS)	42 USC 7411, 7412; 40 CFR Part 61	Applicable	NESHAPS are a set of emission standards for specific chemicals, including naphthalene, arsenic, cadmium, chromium, lead, mercury, nickel, PCBs, DDE, and hexachlorobenzene. Certain activities are regulated including site remediation.	Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.
Resource Conservation and Recovery Act (RCRA), Subtitle C - Standards for Hazardous Waste Facilities	42 USC 6291 et seq.	Applicable	Rhode Island is delegated to administer the federal RCRA statute through its state regulations. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and sediment will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.

STATE OF RHODE ISLAND REQUIREMENTS

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Fugitive Dust Control	RIGL 23-23 *et seq.*; CRIR 12-31-05	Applicable	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	Removal, processing, and temporary storage of debris and sediments during dewatering and before shipment would be implemented to prevent material from becoming airborne.

TABLE 6-14 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (CONT'D)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Clean Air Act - Emissions Detrimental to Persons or Property	RIGL 23-23 *et seq.*; CRIR 12-31-07	Applicable	Prohibits emissions of contaminants which may be injurious to humans, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	Removal, processing, and temporary storage of debris and sediments during dewatering and before shipment would be implemented to prevent emissions of contaminants. Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached.
Clean Air Act - Air Pollution Control	RIGL 23-23 *et seq.*; CRIR 12-31-09	Applicable	Establishes guidelines for the construction, installation, or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Site processing of debris and sediment and treatment of dewatering liquid will meet the substantive provisions of the standards if threshold levels are reached.
Clean Air Act - Air Toxics	RIGL 23-23 *et seq.*; CRIR 12-31-22	Applicable	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels as set in the regulations	Monitoring of air emissions from the dewatering facility will be used to assess compliance with these standards if threshold levels are reached. Operation and maintenance activities will be carried out in a manner which will minimize potential air releases.

TABLE 6-14 (cont'd)
ASSESSMENT OF ACTION-SPECIFIC ARARs AND TBCs
SEDIMENT ALTERNATIVES 4 AND 5: REMOVAL AND DISPOSAL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

STATE OF RHODE ISLAND REQUIREMENTS (CONT'D)

Requirement	Citation	Status	Synopsis of Requirement	Action to Be Taken to Attain ARAR
Water Pollution Control - Water Quality	RIGL 42-16 *et seq.*; CRIR 12-190-001	Applicable	Establishes water use classification and water quality criteria for waters of the state. Also establishes criteria for discharge to a water body.	Any drainage from the temporary debris/sediment storage area and any dewatering discharge will be treated as required to meet this ARAR and discharged.
Water Pollution Control - Pollution Discharge Elimination Systems	RIGL 42-16 *et seq.*; CRIR 12-190-003	Applicable	Contains applicable effluent monitoring requirements, and standards and special conditions for discharges.	The substantive provisions of these standards will be satisfied through on-site treatment of all discharges prior to being discharged.
Hazardous Waste Management Standards for Treatment, Storage, and Disposal Facilities	RIGL 23-19.1 et seq.; CRIR 12-030-003	Applicable	Sets standards for handling, design, operation, and monitoring of hazardous waste. The standards of 40 CFR Part 264 are incorporated by reference.	Areas of debris and sediments will be tested to determine if they constitute hazardous waste. Any hazardous waste identified will be handled and disposed according to these standards.

TABLE 6-15
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Overall Protection of Human Health and the Environment:					
Human Health	No reduction in risk is anticipated. Risks associated with shoreline access would remain. RAOs for protection of human health would not be achieved.	Risk reduction would be provided by deterring recreational use. RAOs for protection of human health would be addressed by the installation of fencing, signs and buoys.	Would provide protection by removal of beach sediment exceeding PRGs. RAOs for protection of human health would be achieved.	Would provide protection by removal of beach sediment exceeding PRGs. RAOs for protection of human health would be achieved.	Would provide protection by removal and disposal of beach sediment. RAOs for protection of human health would be achieved.
Environment	No reduction in risk is anticipated. Low to high probability of risk to marine biota would remain. PAHs and metals contaminants would continue to migrate. RAOs for protection of the environment would not be achieved.	Risk reduction would occur if source removal results in a decrease of sediment contaminant concentrations to below PRGs	Possible short-term impacts from sediment resuspension during excavation and no long-term impacts from filling. Remaining subtidal sediments would show risk reduction if the source and beach removal actions result in a decrease of COC concentrations below PRGs. RAOs for protection of the environment would be partially achieved.	Short-term impacts from sediment resuspension during excavation and no long-term impacts from filling. Remaining subtidal sediments in eelgrass area would show risk reduction if the source and beach removal actions result in a decrease of COC concentrations below PRGs. RAOs for protection of the environment would be partially achieved.	Short-term impacts from sediment resuspension during excavation. Total removal of contaminated sediment would ensure long-term protection. Eelgrass beds may not be restored completely. RAOs for protection of the environment would be achieved.

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Compliance with ARARs/TBCs:					
Chemical-Specific	Fails to meet sediment PRGs that were derived from federal and state water quality standards.	May not meet sediment PRGs that were derived from federal and state water quality standards. Will leave contaminated sediment in place and would not completely address the standards unless source removal results in reduction in COC concentrations to below PRGs.	Would meet chemical-specific ARARs only in the excavated areas. Will leave some contaminated sediment in place and would not completely address the standards unless source removal results in reduction in COC concentrations to below PRGs.	Would meet chemical-specific ARARs only in the excavated areas. Will leave some contaminated sediment in place and would not completely address the standards unless source removal results in reduction in COC concentrations to below PRGs.	Would meet chemical-specific ARARs because sediments exceeding the PRGs derived from state and federal water quality criteria would be removed.
Location-Specific	No Location-Specific ARARs/TBCs	Fails to meet wetland and floodplain standards since it will leave contaminated waste in place and would not address the risk to the wetland and floodplain environments posed by the contamination unless source removal results in reduction in COC concentrations to below PRGs.	Fails to meet wetland and floodplain standards since it will leave some contaminated waste in place and would not address all risk to the wetland and floodplain environments posed by the contamination. Temporary and permanent habitat losses may need to be mitigated to meet CWA requirements. Would be conducted in accordance with all other identified ARARs/TBCs.	Fails to meet wetland and floodplain standards since it will leave some contaminated waste in place and would not address all risk to the wetland and floodplain environments posed by the contamination. Temporary and permanent habitat losses may need to be mitigated to meet CWA requirements. Would be conducted in accordance with all other identified ARARs/TBCs.	Temporary and permanent habitat losses may need to be mitigated to meet CWA requirements. Would be conducted in accordance with all other identified ARARs/TBCs.
Action-Specific	No Action-Specific ARARs/TBCs.	Would be conducted in accordance with identified ARARs/TBCs.	Would be conducted in accordance with identified ARARs/TBCs.	Would be conducted in accordance with identified ARARs/TBCs.	Would be conducted in accordance with identified ARARs/TBCs.

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Long-Term Effectiveness and Permanence:					
Magnitude of Residual Risk	All existing risks to human health and the environment would remain.	Use and access restrictions would discourage/deter continued human health risk, while enforcement would be required to prevent risk. No reduction in risk to ecological receptors would occur unless source removal results in a decrease of sediment COC concentrations to below PRGs	Some contaminated marine sediment would remain on site. Removal of large volume of sediment will reduce long-term risks.	Some contaminated marine sediment would remain on site. Removal of large volume of sediment will reduce long-term risks.	Contaminants would be removed. No residual risks would remain on site. Permanent solution.
Adequacy and Reliability of Controls	Not applicable.	Would require enforcement of use and access restrictions. Long-term adequate enforcement of access restrictions to intertidal area may be difficult to ensure.	No control would be in place for contaminated sediment remaining in-place.	No control would be in place for contaminated sediment remaining in-place.	No on-site controls needed to ensure reliability because all sediment exceeding PRGs would be disposed off site.

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: LIMITED REMOVAL AND DISPOSAL (BEACH AND NEARSHORE)	ALTERNATIVE 5: REMOVAL AND DISPOSAL
Reduction of Toxicity, Mobility, or Volume Through Treatment:					
Need for 5-Year Review	Review would be required since contaminants would remain on site.	Review would be required since contaminants would remain on site.	Review would be required since contaminants would remain on site.	Review would be required since contaminants would remain on site.	All contaminants exceeding PRGs would be removed. Assumed 1 review would be conducted in year 5 to assess the remediation.
Treatment Process Used and Materials Treated	None.	None.	TSDF may have treatment to meet LDRs	TSDF may have treatment to meet LDRs	TSDF may have treatment to meet LDRs
Amount of Hazardous Materials Destroyed or Treated	None.	None.	None. TSDF may treat sediment to meet LDRs	None. TSDF may treat sediment to meet LDRs	None. TSDF may treat sediment to meet LDRs
Degree of Expected Reductions in Toxicity, Mobility, or Volume Through Treatment	No reduction is anticipated.	No reduction is anticipated.	Would provide reduction in toxicity and mobility through treatment at off site. May result in increase in volume associated with solidification/ stabilization of the treated portion.	Would provide reduction in toxicity and mobility through treatment at off site. May result in increase in volume associated with solidification/ stabilization of the treated portion.	Would provide reduction in toxicity and mobility through treatment at off site. May result in increase in volume associated with solidification/ stabilization of the treated portion.

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Degree to Which Treatment is Irreversible	Not applicable.	Not applicable.	Irreversible for sediment receiving treatment.	Irreversible for sediment receiving treatment.	Irreversible for sediment receiving treatment.
Type and Quantity of Residuals Remaining after Treatment	Not applicable.	Not applicable.	Residuals from treatment would depend on process(es) used. Residuals would be handled by TSDF or landfill. Residual water from sediment dewatering would require treatment prior to discharge; volume depends on sediment removal technique.	Residuals from treatment would depend on process(es) used. Residuals would be handled by TSDF or landfill. Residual water from sediment dewatering would require treatment prior to discharge; volume depends on sediment removal technique.	Residuals from treatment would depend on process(es) used. Residuals would be handled by TSDF or landfill. Residual water from sediment dewatering would require treatment prior to discharge; volume depends on sediment removal technique.
Statutory Preference for Treatment	Not achieved.	Not achieved.	Achieved for that portion of excavated sediment receiving treatment at TSDF.	Achieved for that portion of excavated sediment receiving treatment at TSDF.	Achieved for that portion of excavated sediment receiving treatment at TSDF.

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Short-Term Effectiveness:					
Community Protection	No short-term risks are anticipated.	Same as Alternative1.	Minor risks associated with transportation of dredge spoils over the road	Minor risks associated with transportation of dredge spoils over the road	Minor risks associated with transportation of dredge spoils over the road
Worker Protection	No short-term risks are anticipated.	Exposure risks (direct contact) associated with monitoring activities and installation of fencing and buoy system in intertidal zone would be minimized by use of PPE.	Exposure risks associated with excavation and monitoring would be minimized by use of PPE.	Exposure risks associated with excavation and monitoring would be minimized by use of PPE.	Exposure risks associated with excavation and monitoring would be minimized by use of PPE.
Environmental Impacts	Not applicable.	Minimal impacts (sediment resuspension) associated with installation of fencing and buoy system in intertidal zone would be minimized by use of silt curtains, silt fences, etc.	Short-term risks (sediment resuspension) associated with site preparation and excavation would be minimized by use of silt curtains, silt fences, etc.	Short-term risks (sediment resuspension) associated with site preparation and excavation would be minimized by use of silt curtains, silt fences, etc.	Short-term risks (sediment resuspension) associated with site preparation and excavation would be minimized by use of silt curtains, silt fences, etc. Eelgrass beds may not be fully restored.
Time Until RAOs are Achieved	Not achieved.	One month to meet human health RAOs only. RAOs for protection of the environment would not be achieved	3-4 months (assuming no interruption of alternative implementation).	6-8 months (assuming no interruption of alternative implementation).	6-8 months (assuming no interruption of alternative implementation).

TABLE 6-15 (cont'd)
SUMMARY OF COMPARATIVE ANALYSIS OF SEDIMENT ALTERNATIVES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

CRITERIA	ALTERNATIVE 1: NO ACTION	ALTERNATIVE 2: LIMITED ACTION	ALTERNATIVE 3: LIMITED REMOVAL AND DISPOSAL (BEACH AREA)	ALTERNATIVE 4: REMOVAL AND DISPOSAL OPTION A	ALTERNATIVE 5: REMOVAL AND DISPOSAL OPTION B
Cost[a, b]					
Capital Costs	$0	$10,000	$3,022,000	$3,496,000	$3,775,000
Total Annual Operations and Maintenance (O&M)	$0	$70,000	$73,000	$52,000	$44,000
5-Year Reviews	$22,000	$22,000	$22,000	$22,000	$22,000
Total Present Worth Project Costs	$70,000	$653,000	$3,605,000	$3,922,000	$4,095,000

[a]Detailed cost estimates are presented in Appendix F.
[b]These costs have been rounded to the nearest $1,000.

FIGURES

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

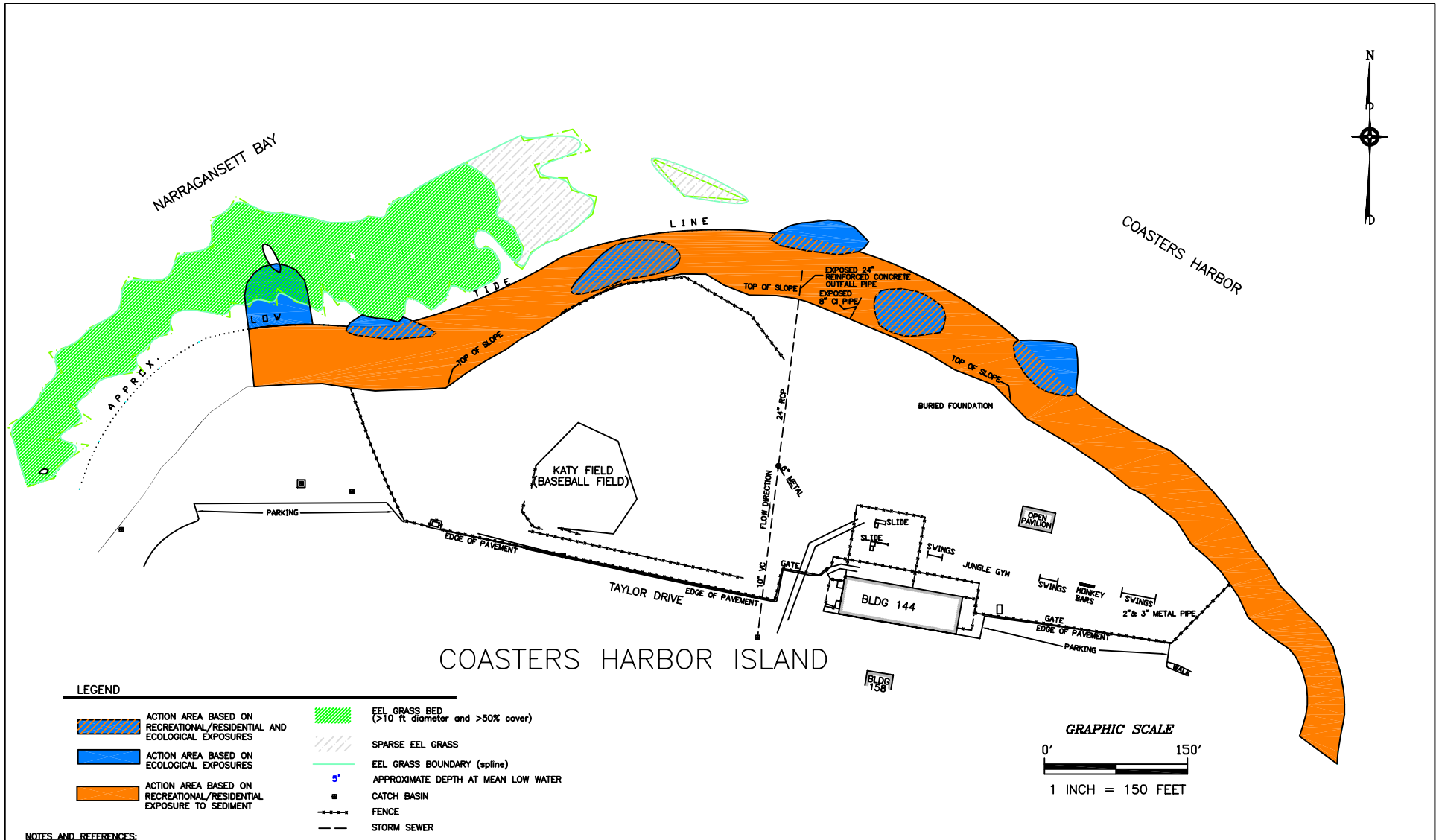
2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

5. DEPTHS OF EXCAVATION ASSUME THAT THE THREE MOUNDS WILL HAVE BEEN REMOVED AND LEVELED WITH THE SURROUNDING GRADE.

APPROXIMATE DEPTHS OF SOIL CONTAMINANTS			FIGURE E-1
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.: 0	
CHECKED BY:	S. PARKER	DATE: JUNE 24, 2002	
SCALE:	1" = 130'	FILE NO.: DWG\4152\0441\FIG_E-1.DWG	



LEGEND

- ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL AND ECOLOGICAL EXPOSURES
- ACTION AREA BASED ON ECOLOGICAL EXPOSURES
- ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- CATCH BASIN
- FENCE
- STORM SEWER

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

SEDIMENT ALTERNATIVES 2,3,4 AND 5 ACTION AREAS

OLD FIRE FIGHTING TRAINING AREA

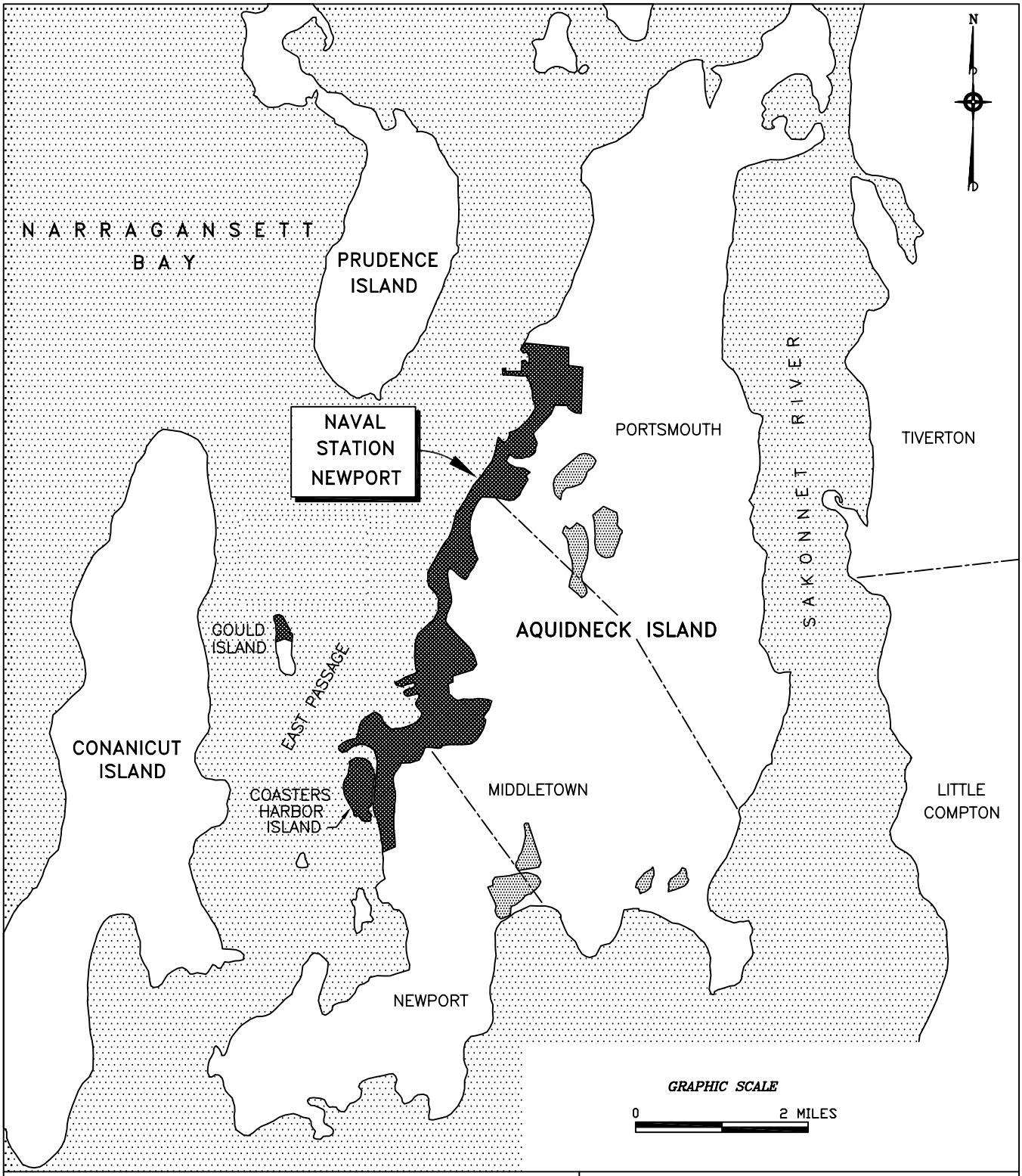
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND

DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	JUNE 24, 2002
SCALE:	1" = 150'	FILE NO.:	DWG\4152\0441\FIG_E-2.DWG

FIGURE E-2

TETRA TECH NUS, INC.

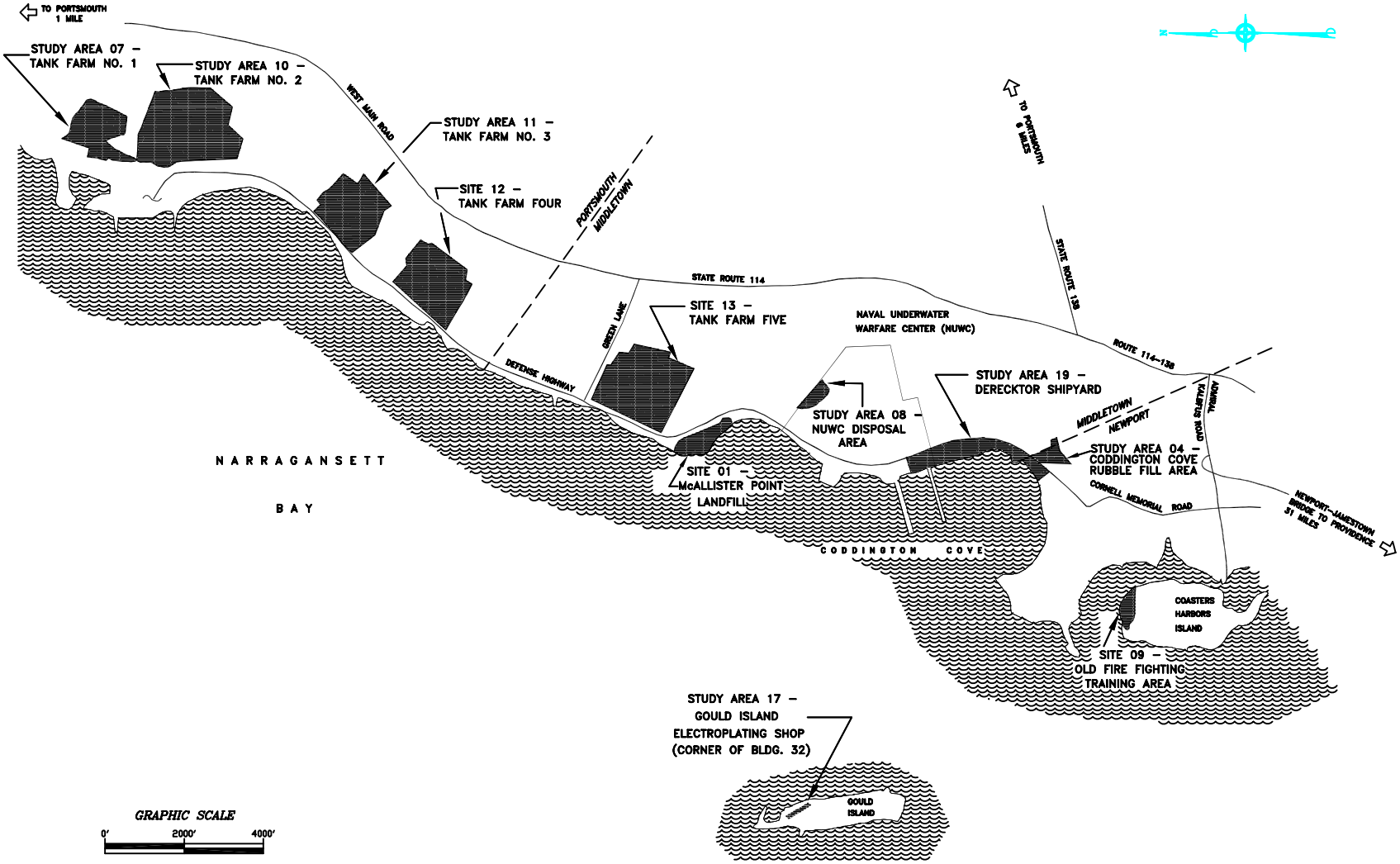
55 Jonspin Road Wilmington, MA 01887
(978)658-7899



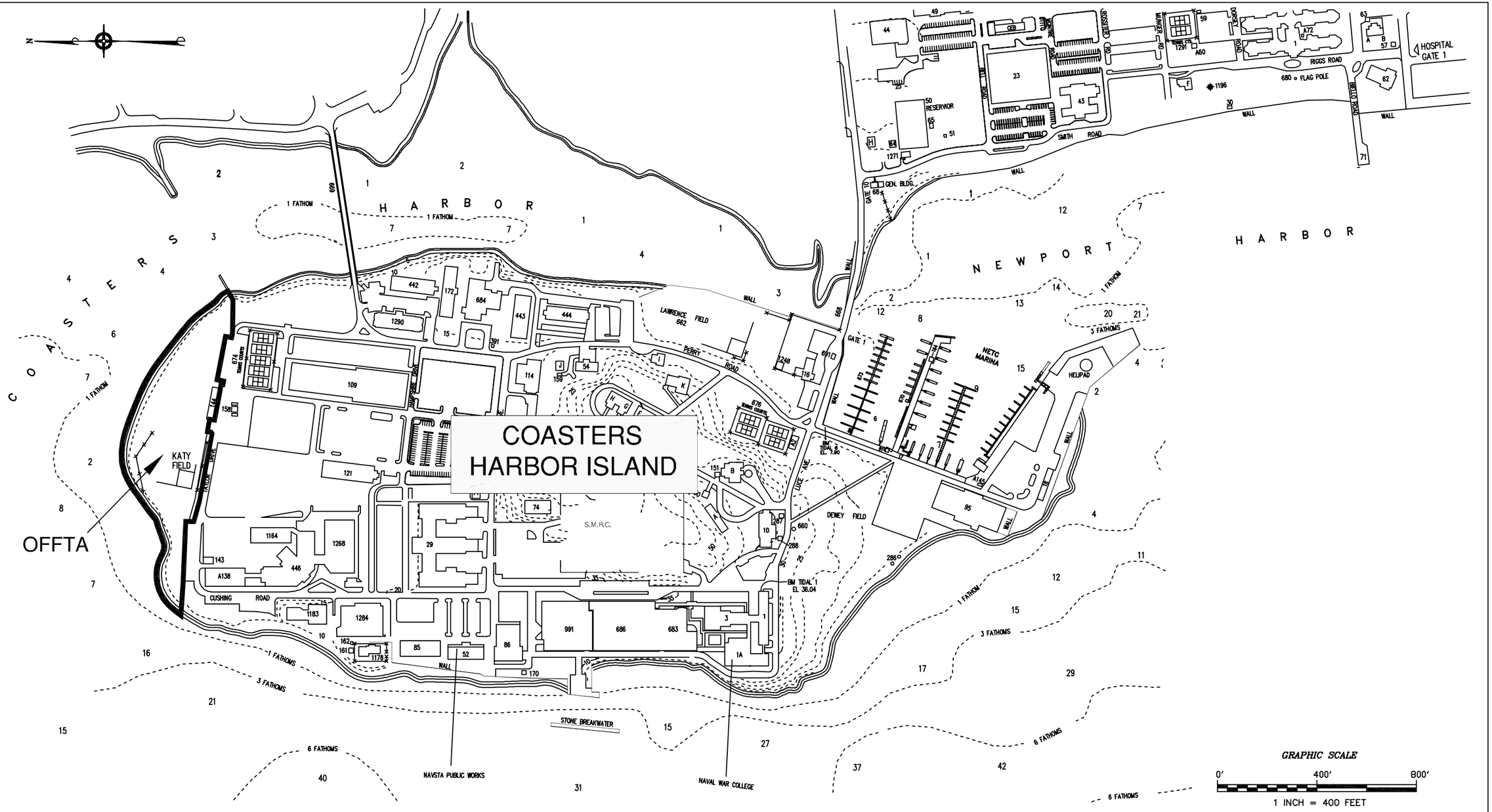
SITE LOCUS		FIGURE 1–1	
SURFACE WARFARE OFFICERS SCHOOL			
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	L. SEYDEWITZ	DATE:	MARCH 8, 2004
SCALE:	AS NOTED	ACAD NAME:	DWG\5152\0441\FIG_1–1.DWG

TETRA TECH NUS, INC.

55 Jonspin Road Wilmington, MA 01887
(978)658–7899



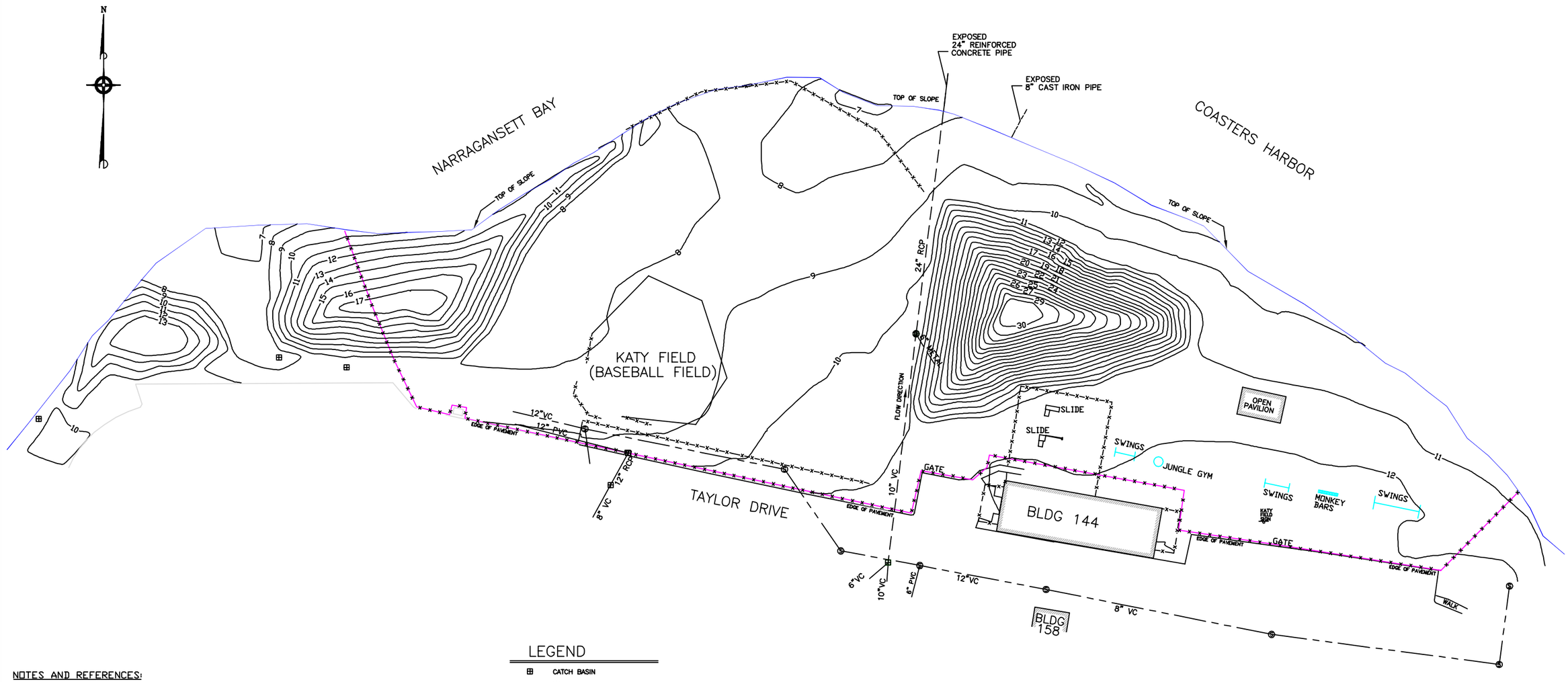
NAVSTA NEWPORT SITES AND STUDY AREAS			FIGURE 1–2
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658–7899
DRAWN BY:	D.W. MACDOUGALL	REV.: 0	
CHECKED BY:	D. McKENNA	DATE: SEPTEMBER 20, 2000	
SCALE:	AS NOTED	FILE NO.: DWG\5278\0531\FIG_1–2.DWG	



NOTES:

BASE MAP FROM PLAN BY DEPT. OF NAVY, "COASTERS HARBOR ISLAND AND NAVAL HOSPITAL EXISTING CONDITIONS MAP", DATED: 9/98, NETC DWG NO.: 31058-307, CODE ID NO.: 80091, SCALE: 1"=200'.

OFFTA LOCATION MAP			FIGURE 1-3
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	D. BAXTER	DATE:	OCTOBER 9, 2000
SCALE:	1" = 400'	FILE NO.:	DWG\5278\0531\FIG_1-3.DWG



NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVAL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

LEGEND

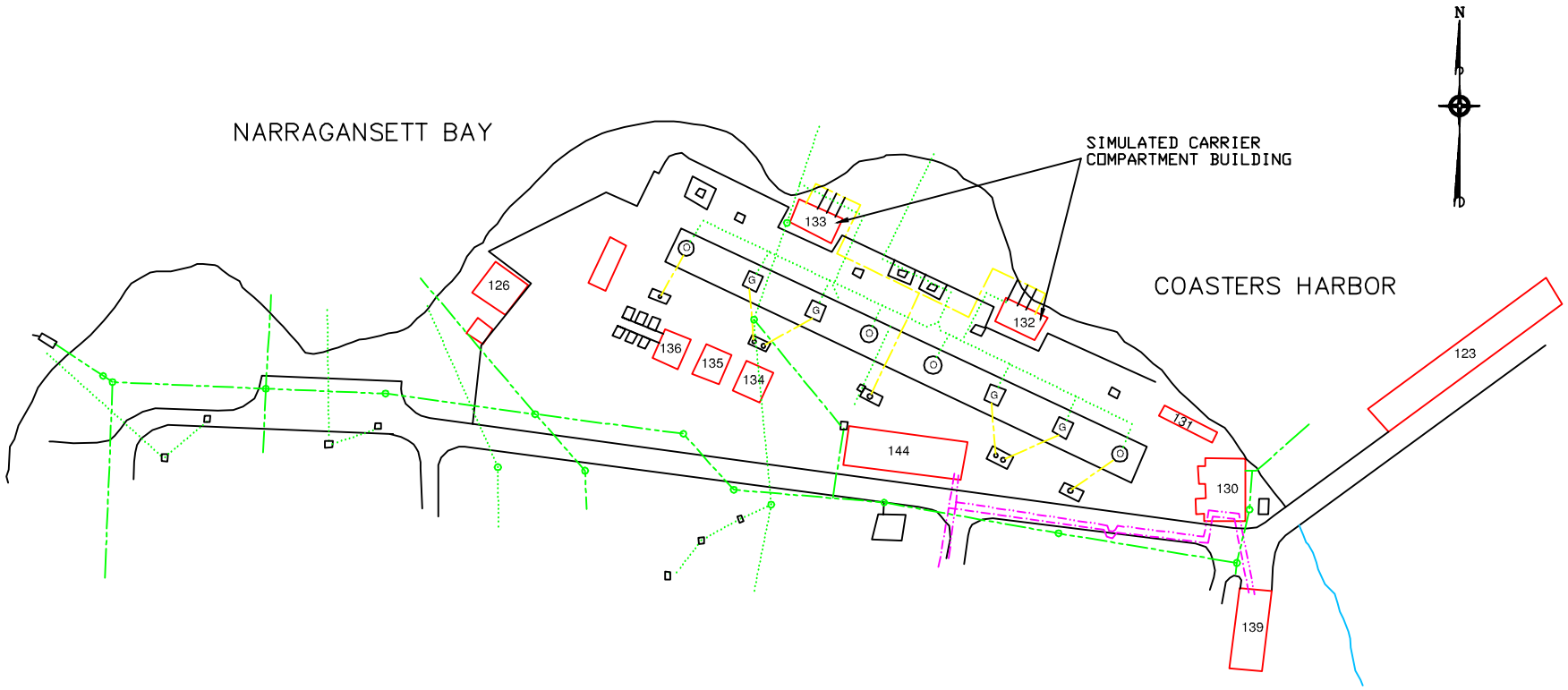
- CATCH BASIN
- SIGN
- FENCE
- EXISTING CONTOUR
- SANITARY SEWER MANHOLE
- SANITARY SEWER
- STORM SEWER MANHOLE
- STORM SEWER MANHOLE

GRAPHIC SCALE

0' 80' 160'

1 INCH = 80 FEET

SITE PLAN		FIGURE 1-4
OLD FIRE FIGHTING TRAINING AREA		
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND		TETRA TECH NUS, INC.
DRAWN BY: D.W. MACDOUGALL	REV.: 0	55 Jonspin Road Wilmington, MA 01887 (978)658-7899
CHECKED BY: D. BAXTER	DATE: OCTOBER 17, 2000	
SCALE: 1" = 80'	FILE NO.: DWG\5278\0531\FIG_1-4.DWG	



LEGEND

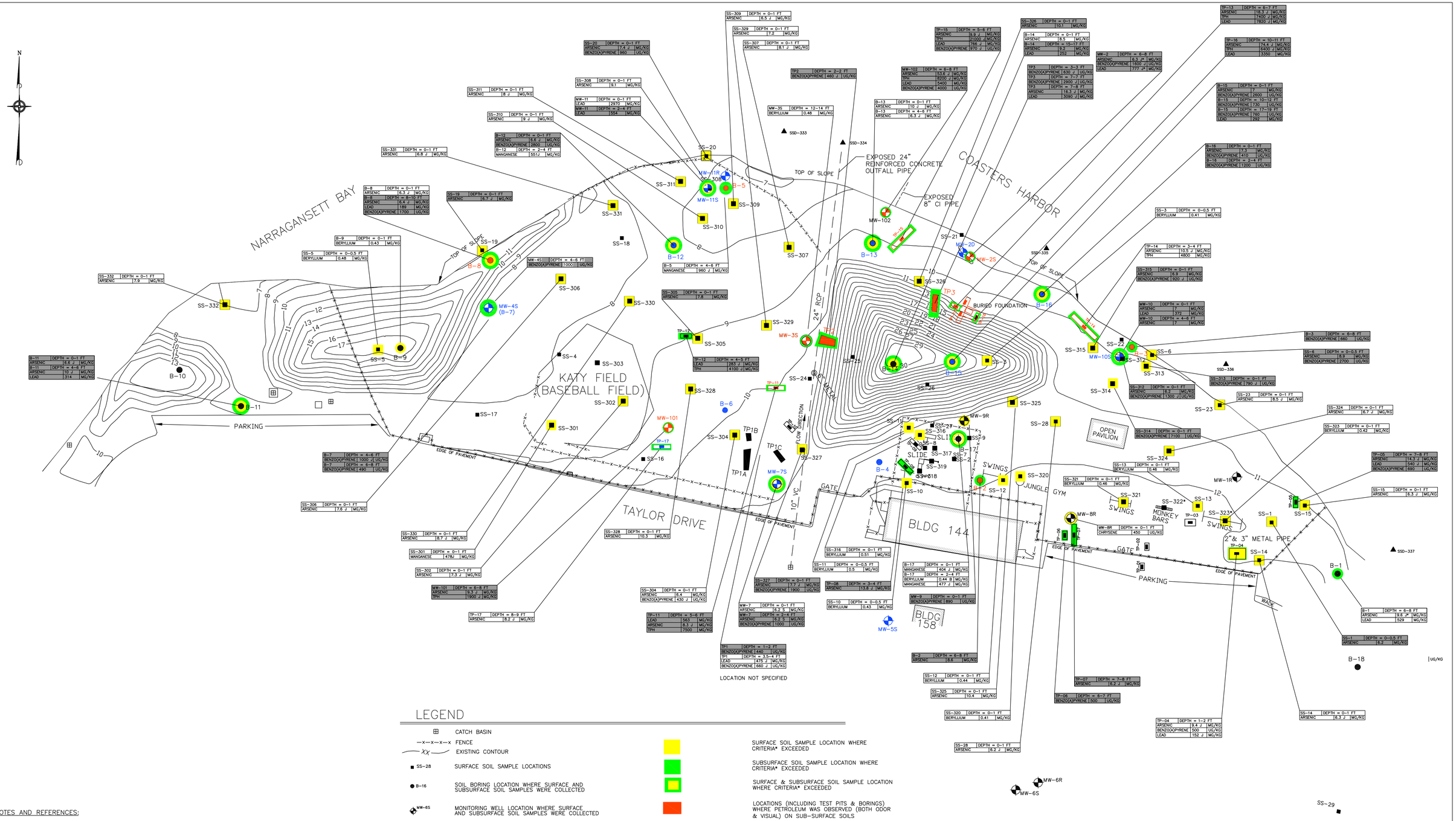
- 135 BUILDING AND BUILDING ID
- STEAM LINE RETURN
- STEAM LINE SUPPLY
- STORM SEWER LINE
- SANITARY SEWER LINE
- OIL LINE
- OIL TANKS
- GAS TANKS

SOURCE: MASTER SHORE STATION DEVELOPMENT PLANS, US NAVAL STATION NEWPORT, R. I., 1953

1953 FACILITY DESIGN MAP			FIGURE 1-5
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	D. McKENNA	DATE:	SEPTEMBER 29, 2000
SCALE:	NOT TO SCALE	FILE NO.:	DWG\5278\0531\FIG_1-5.DWG

SOURCE: OFFICIAL PHOTOGRAPH; US NAVAL AIR STATION; QUONSET POINT, RHODE ISLAND; NEG NO. 5979; DATE - MAY 1, 1944.

1944 AERIAL PHOTO – COASTERS HARBOR ISLAND			FIGURE 1–6
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658–7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	D. BAXTER	DATE:	AUGUST 28, 2000
SCALE:	NOT TO SCALE	FILE NO.:	DWG\5278\0531\FIG_1–6.DWG



LEGEND

- ⊞ CATCH BASIN
- —x—x—x—x FENCE
- —xx— EXISTING CONTOUR
- ■ SS-28 SURFACE SOIL SAMPLE LOCATIONS
- ● B-16 SOIL BORING LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- MW-6S MONITORING WELL LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- ▲ SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- —— —— STORM SEWER
- TP-10 TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (B&RE, 6/97)
- TP1C TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (TRC, 1/94)

- SURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SURFACE & SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- LOCATIONS (INCLUDING TEST PITS & BORINGS) WHERE PETROLEUM WAS OBSERVED (BOTH ODOR & VISUAL) ON SUB-SURFACE SOILS
- LOCATIONS (INCLUDING TEST PITS & BORINGS) WHERE PETROLEUM ODORS WERE NOTED IN SUB-SURFACE SOILS

* RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA EXCEPT FOR ARSENIC (PROPOSED 6.2 MG/KG BACKGROUND LEVEL WAS USED)

SELECT CONTAMINANTS INCLUDE ARSENIC, LEAD, BENZO(A)PYRENE, AND TPH
SEE TABLES 2-11 AND 2-12 FOR A COMPLETE LIST OF CONTAMINANTS EXCEEDING CRITERIA.

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

DEPTH OF SAMPLING
TEST SAMPLE LOCATION IDENTIFIER
B-3 DEPTH 12-14 FT
ARSENIC 13.5 J* MG/KG
CONTAMINANT TESTED
SAMPLE RESULTS

TYPICAL CONTAMINANT LEVEL BOX
J INDICATES THAT QUANTITATION IS APPROXIMATE
U INDICATES CONTAMINANT NOT DETECTED AT DETECTION LEVEL SPECIFIED

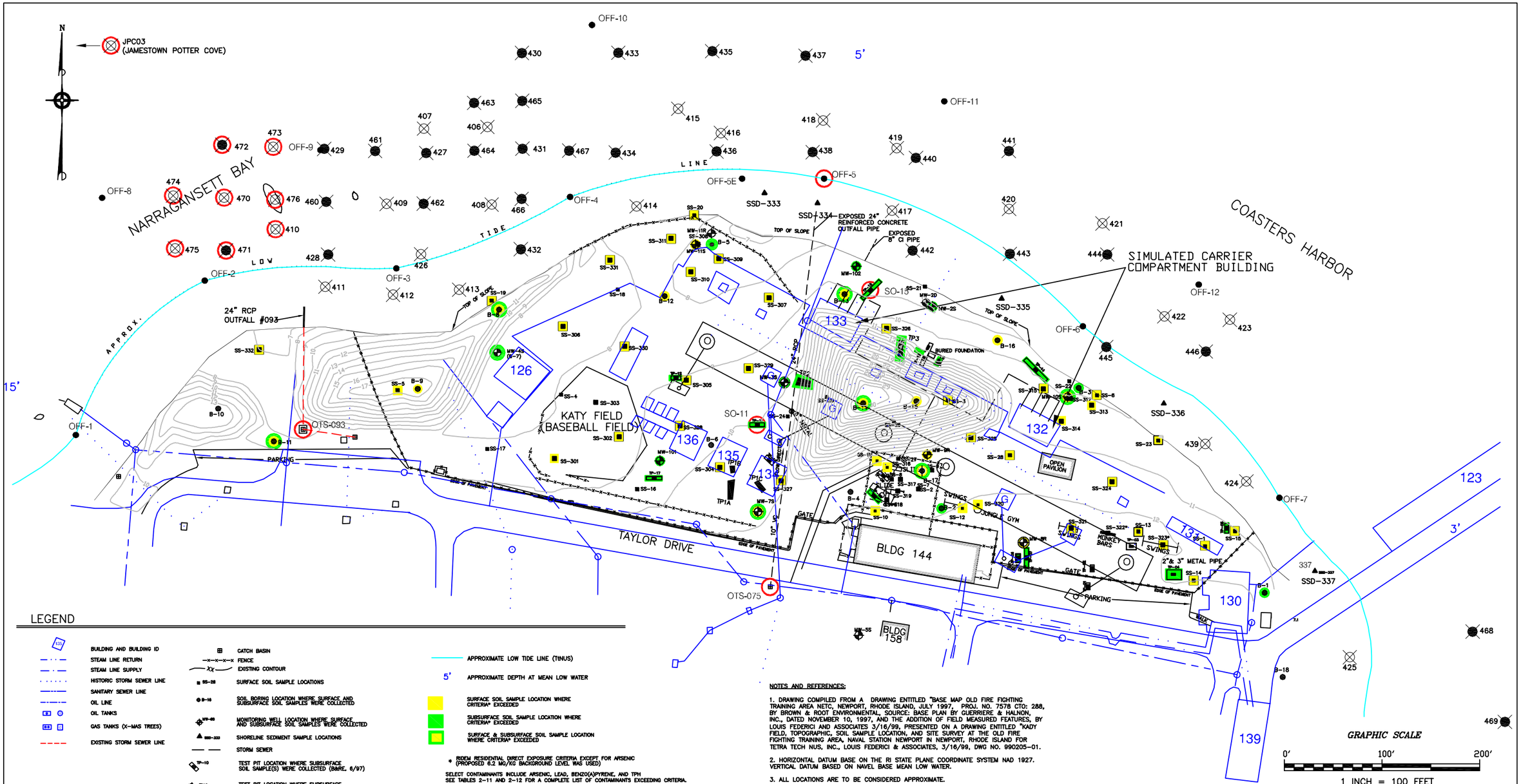
TAGS WITH GRAY BACKGROUNDS HAVE OTHER CONTAMINANTS THAT EXCEED THE CRITERIA.

TAGS WITH WHITE BACKGROUNDS LIST ALL CONTAMINANTS THAT EXCEED THE CRITERIA.

GRAPHIC SCALE
40' 0' 40' 80'
1 INCH = 40 FEET

DRAWN BY: D.W. MACDOUGALL	TITLE: SOIL AREAS EXCEEDING PRGs OLD FIRE FIGHTING TRAINING AREA NAVAL STATION NEWPORT, RHODE ISLAND
PREPARED BY: C. WOODS	
CHECKED BY: J. DAVIS	
	SOURCE: BASE PLAN BY SEE NOTES.
	SCALE: 1" = 40' / DATE: JULY 5, 2002 / PROJ. NO: 5278
PROJECT MANAGER: J. FORRELLI	DRAWING NO: FIGURE 2-1 / ACFILE NAME: DWG\4152\1120\FIG_2-1.DWG / REV: 0
PROGRAM MANAGER: J. TREPANOWSKI	

TETRA TECH NUS, INC.
55 JONSPIN ROAD
WILMINGTON, MASSACHUSETTS 01887
(978)658-7899



LEGEND

- BUILDING AND BUILDING ID
- STEAM LINE RETURN
- STEAM LINE SUPPLY
- HISTORIC STORM SEWER LINE
- SANITARY SEWER LINE
- OIL LINE
- OIL TANKS
- GAS TANKS (X-MAS TREES)
- EXISTING STORM SEWER LINE
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- SS-28 SURFACE SOIL SAMPLE LOCATIONS
- B-16 SOIL BORING LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- MW-8S MONITORING WELL LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- TP-10 TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (B&RE, 6/97)
- TP1C TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (TRC, 1/94)
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION
- OFF-3 SEDIMENT SAMPLE LOCATION
- APPROXIMATE LOW TIDE LINE (TINUS)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- SURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SURFACE & SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED

* RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA EXCEPT FOR ARSENIC (PROPOSED 6.2 MG/KG BACKGROUND LEVEL WAS USED)

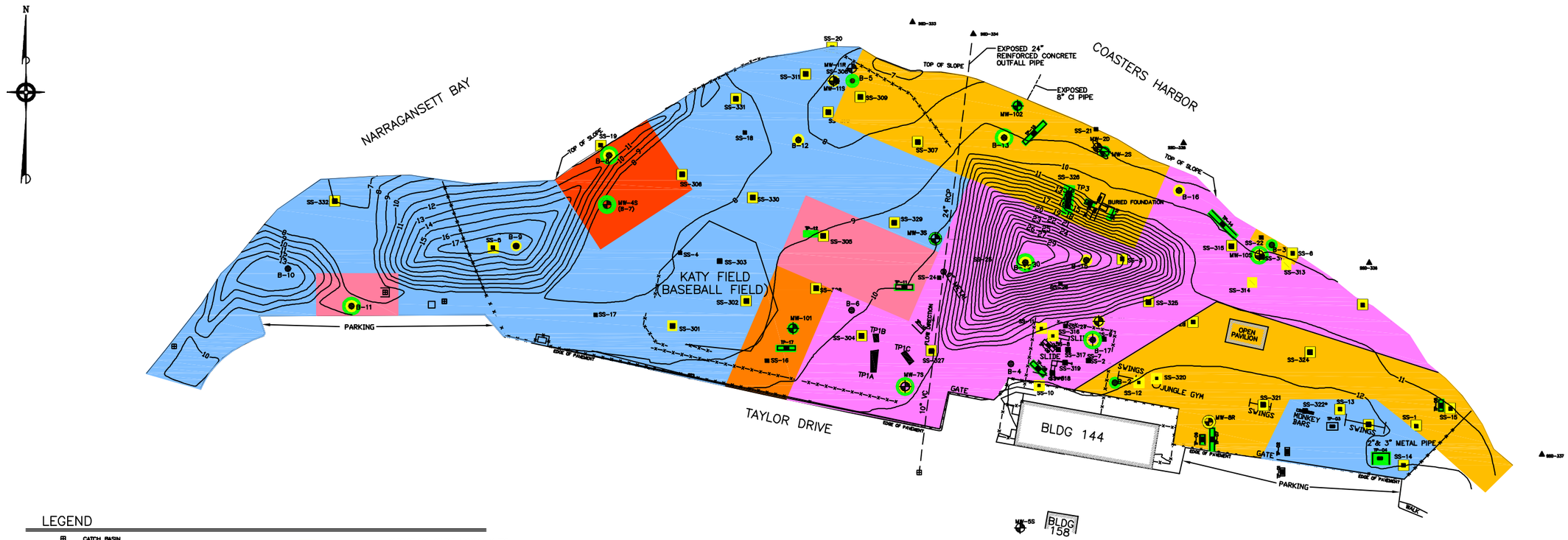
SELECT CONTAMINANTS INCLUDE ARSENIC, LEAD, BENZO(A)PYRENE, AND TPH
SEE TABLES 2-11 AND 2-12 FOR A COMPLETE LIST OF CONTAMINANTS EXCEEDING CRITERIA.

- PHASE 2 PLANNED PREDESIGN SAMPLE STATION

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.
2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.
3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.
4. PLAN NOT TO BE USED FOR DESIGN.

HISTORICAL FEATURES			FIGURE 2-2
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVAL STATION NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	JULY 3, 2002
SCALE:	1" = 100'	FILE NO.:	DWG\4152\1120\FIG_2-2.DWG



LEGEND

- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- SS-28 SURFACE SOIL SAMPLE LOCATIONS
- B-18 SOIL BORING LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- MW-6S MONITORING WELL LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- SED-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- TP-10 TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (B&RE, 6/97)
- TP1C TEST PIT LOCATION WHERE SUBSURFACE SOIL SAMPLE(S) WERE COLLECTED (TRC, 1/94)

- SURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED
- SURFACE & SUBSURFACE SOIL SAMPLE LOCATION WHERE CRITERIA* EXCEEDED

* RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA EXCEPT FOR ARSENIC (PROPOSED 6.2 MG/KG BACKGROUND LEVEL WAS USED)

SELECT CONTAMINANTS INCLUDE ARSENIC, LEAD, BENZO(A)PYRENE, AND TPH

SEE TABLES 2-11 AND 2-12 FOR A COMPLETE LIST OF CONTAMINANTS EXCEEDING CRITERIA.

- ESTIMATED DEPTH OF CONTAMINANTS TO 10 FT. BELOW GROUND SURFACE
- ESTIMATED DEPTH OF CONTAMINANTS TO 9 FT. BELOW GROUND SURFACE
- ESTIMATED DEPTH OF CONTAMINANTS TO 8 FT. BELOW GROUND SURFACE
- ESTIMATED DEPTH OF CONTAMINANTS TO 6 FT. BELOW GROUND SURFACE
- ESTIMATED DEPTH OF CONTAMINANTS TO 4 FT. BELOW GROUND SURFACE
- ESTIMATED DEPTH OF CONTAMINANTS TO 2 FT. BELOW GROUND SURFACE

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

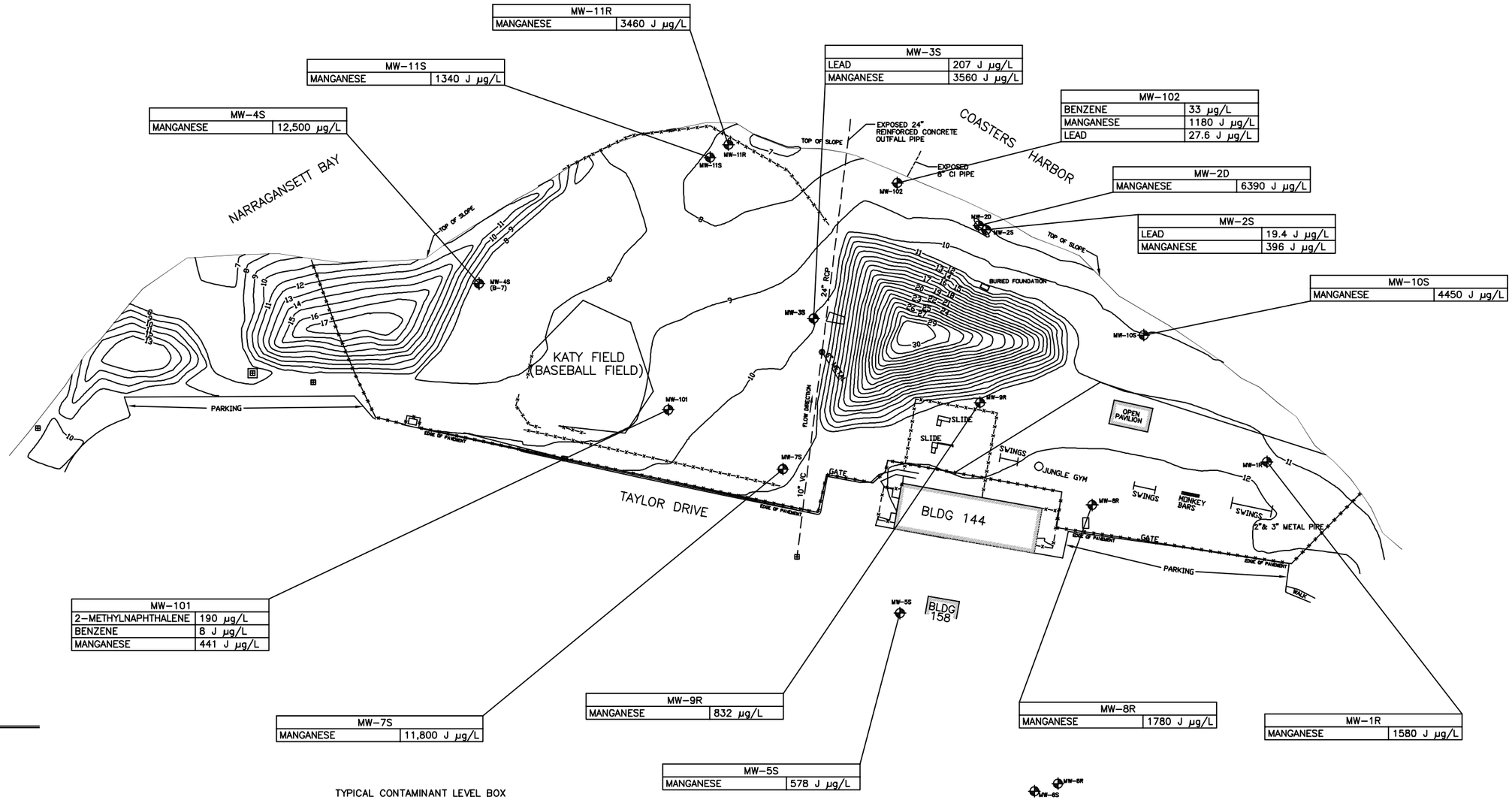
5. DEPTHS OF EXCAVATION ASSUME THAT THE THREE MOUNDS WILL HAVE BEEN REMOVED AND LEVELED WITH THE SURROUNDING GRADE.

GRAPHIC SCALE

0′ 100′ 200′

1 INCH = 100 FEET

APPROXIMATE DEPTHS OF SOIL CONTAMINANTS			FIGURE 2-3
OLD FIRE FIGHTING TRAINING AREA			
NAVAL STATION NEWPORT, RHODE ISLAND			TETRA TECH NUS, INC.
DRAWN BY:	R.G. DEWSNAP	REV.: 0	55 Jonspin Road Wilmington, MA 01887 (978)658-7899
CHECKED BY:	J. DAVIS	DATE: APRIL 5, 2001	
SCALE:	1" = 100′	FILE NO.: DWG\5278\0445\CONTAM_DEPTH.DWG	



LEGEND

- ⊞ CATCH BASIN
- —x—x—x— FENCE
- EXISTING CONTOUR
- MW-6S MONITORING WELL LOCATION WHERE SURFACE AND SUBSURFACE SOIL SAMPLES WERE COLLECTED
- STORM SEWER

TYPICAL CONTAMINANT LEVEL BOX

TEST SAMPLE LOCATION IDENTIFIER

MW-7S	
MANGANESE	11,800 J µg/L

CONTAMINANT TESTED

SAMPLE RESULTS

J INDICATES THAT QUANTITATION IS APPROXIMATE

GRAPHIC SCALE

0′ 100′ 200′

1 INCH = 100 FEET

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY QUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

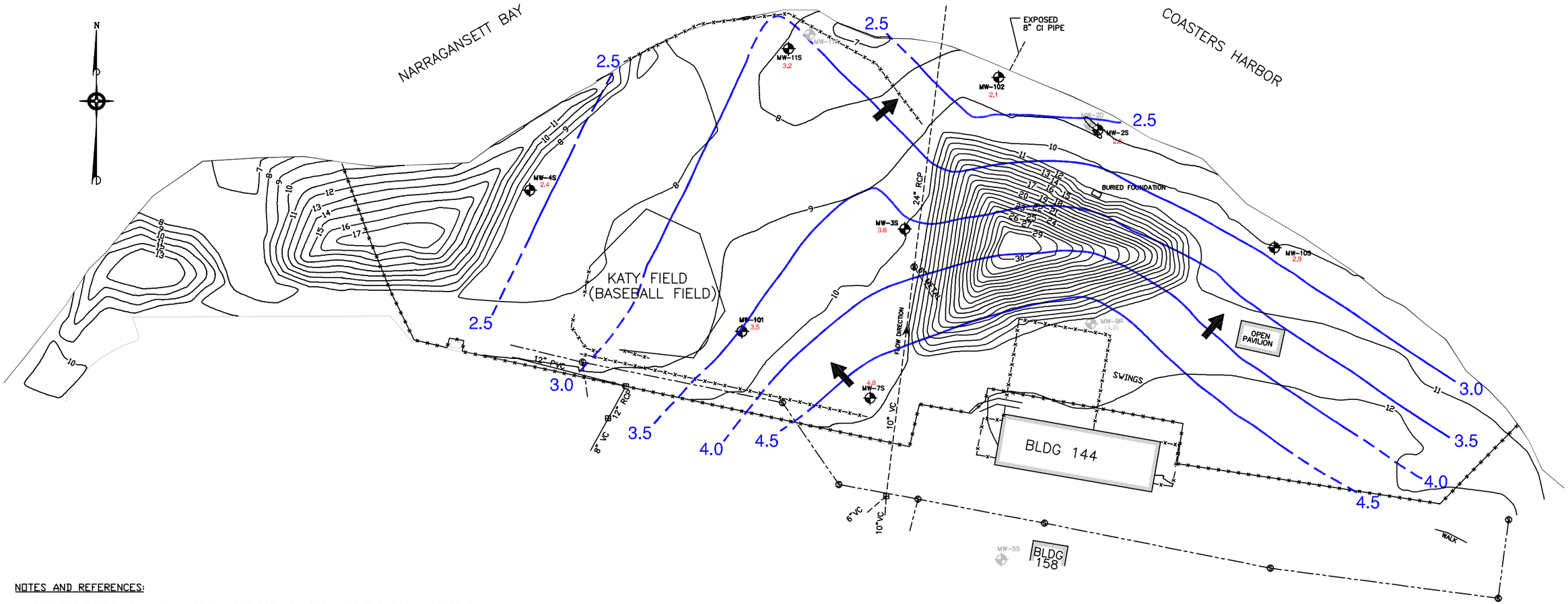
2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

5. DEPTHS OF EXCAVATION ASSUME THAT THE THREE MOUNDS WILL HAVE BEEN REMOVED AND LEVELED WITH THE SURROUNDING GRADE.

GROUNDWATER SAMPLES EXCEEDING PRGs			FIGURE 2-4
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVAL STATION NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.: 0	
CHECKED BY:	J. DAVIS	DATE: JULY 16, 2002	
SCALE:	1" = 100'	FILE NO.: DWG\4152\1120\FIG_2-4.DWG	



NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVAL BASE MEAN LOW WATER.

3. GROUNDWATER FLOW IN OVERBURDEN WELLS DURING A RISING TIDE ON 7/11/97.

4. MW-101 INSTALLED ON 7/9/97. MW-102 INSTALLED ON 7/8/97.

5. OMITTED WATER LEVEL DATA FOR MW-5S FROM PLOT. IT IS INCONSISTENT WITH HISTORICAL DATA. MEASUREMENT MAY HAVE BEEN ERRONEOUS.

6. LOW TIDE AT 6:00 A.M. ON 7/11/97. WATER LEVELS COLLECTED BETWEEN 0720 AND 0846.

7. MW-10S AND MW-5S CONSIDERED OVERBURDEN WELLS, HOWEVER, SCREENED INTERVALS IN EACH CROSSES THE OVERBURDEN/BEDROCK INTERFACE. THE MAJORITY OF THE SCREEN IS IN THE OVERBURDEN.

8. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

9. PLAN NOT TO BE USED FOR DESIGN.

LEGEND

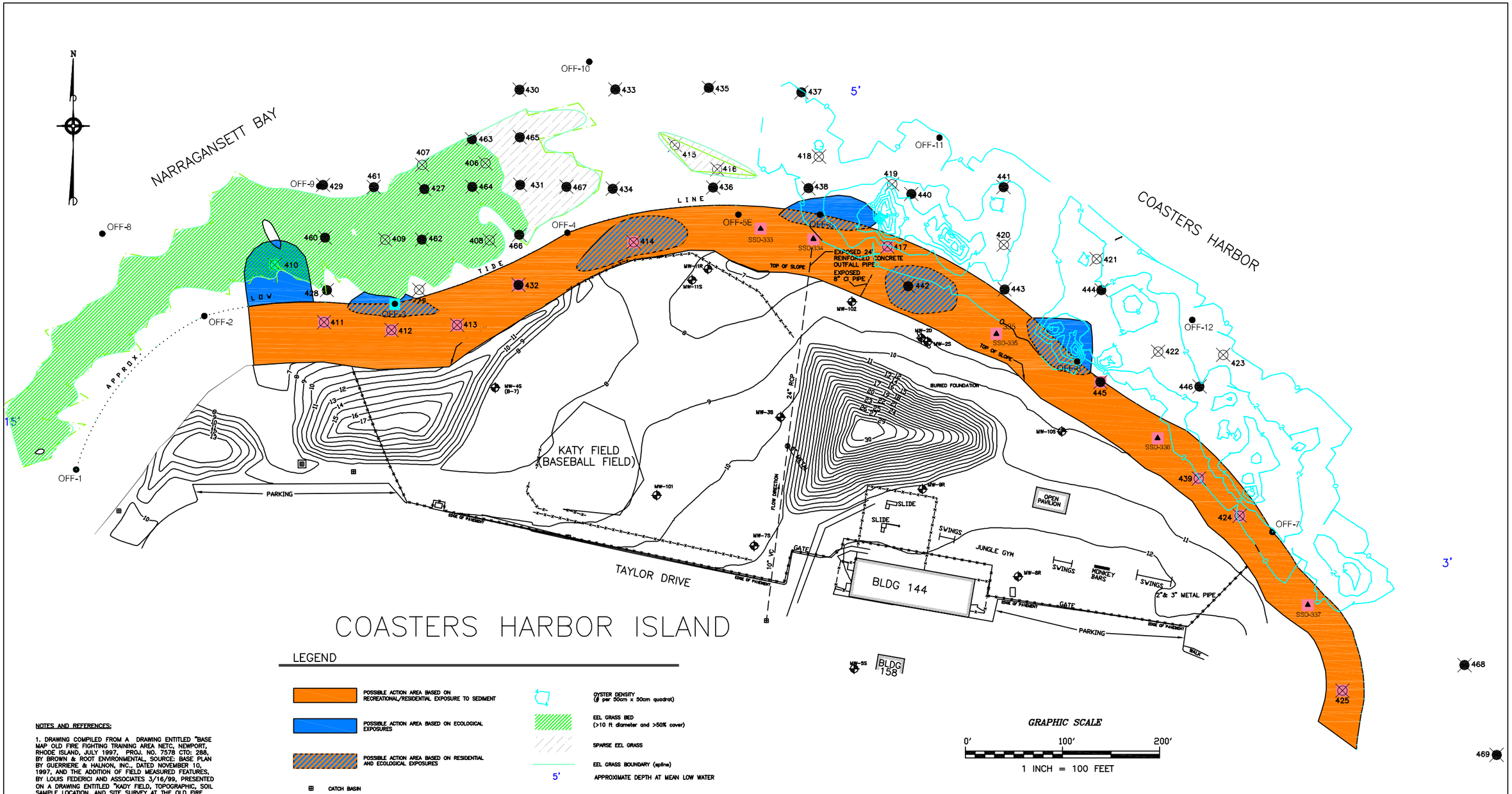
- 4 — OVERBURDEN GROUNDWATER CONTOUR WITH ELEVATION
- OVERBURDEN GROUNDWATER CONTOUR (ESTIMATED)
- MW-101 3.5 — MONITORING WELL WITH GROUNDWATER ELEVATION
- GROUNDWATER FLOW DIRECTION
- SANITARY SEWER MANHOLE
- SANITARY SEWER
- STORM SEWER MANHOLE
- STORM SEWER MANHOLE
- CATCH BASIN

GRAPHIC SCALE

0' 80' 160'

1 INCH = 80 FEET

WATER TABLE CONTOURS (07/11/97)			FIGURE 2-5
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	J. DAVIS	DATE:	JULY 16, 2002
SCALE:	1" = 80'	FILE NO.:	DWG\4152\1120\FIG_2-5.DWG



COASTERS HARBOR ISLAND

LEGEND

- POSSIBLE ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT
- POSSIBLE ACTION AREA BASED ON ECOLOGICAL EXPOSURES
- POSSIBLE ACTION AREA BASED ON RESIDENTIAL AND ECOLOGICAL EXPOSURES
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- MW-8S MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- OYSTER DENSITY (# per 50cm x 50cm quadrat)
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

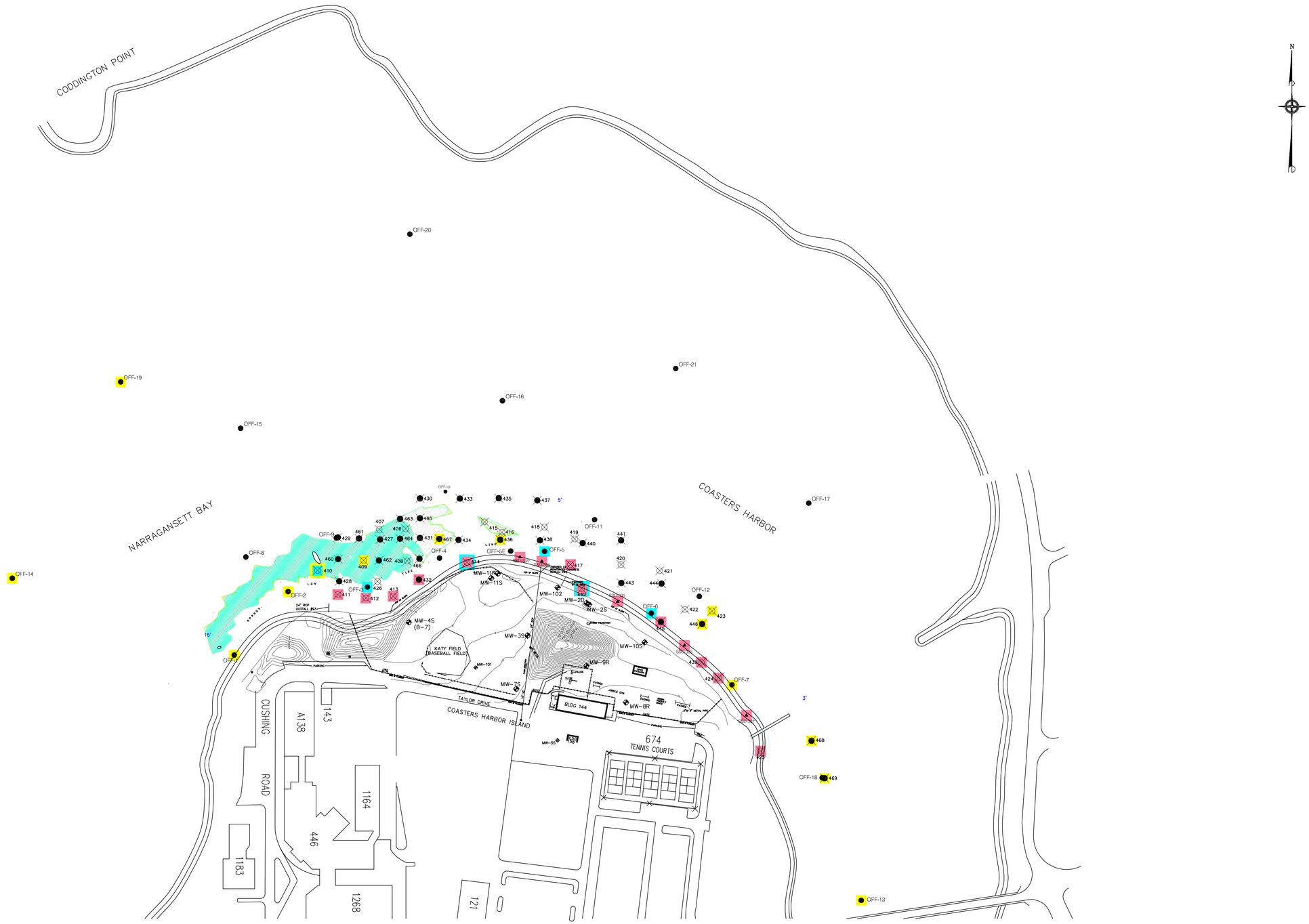
GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

SEDIMENT AREAS EXCEEDING PRGs			FIGURE 2-6
OLD FIRE FIGHTING TRAINING AREA			
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	JULY 16, 2002
SCALE:	1" = 100'	FILE NO.:	DWG\4152\1120\FIG_2-6.DWG

TETRA TECH NUS, INC.
55 Jonspin Road Wilmington, MA 01887
(978)658-7899



NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO. 255, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

LEGEND

- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION
- MW-1R MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- SHORELINE SEDIMENT SAMPLE WHERE HUMAN HEALTH DIRECT EXPOSURE PRG EXCEEDED
- MARINE SEDIMENT SAMPLE WHERE ECOLOGICAL PRG EXCEEDED
- MARINE SEDIMENT SAMPLE WHERE SHELLFISH INGESTION PRG EXCEEDED

* RIDEM RESIDENTIAL DIRECT EXPOSURE CRITERIA EXCEPT FOR ARSENIC (PROPOSED 8.2 MG/KG BACKGROUND LEVEL WAS USED)

SELECT CONTAMINANTS INCLUDE ARSENIC, LEAD, BENZO(A)PYRENE, AND TPH

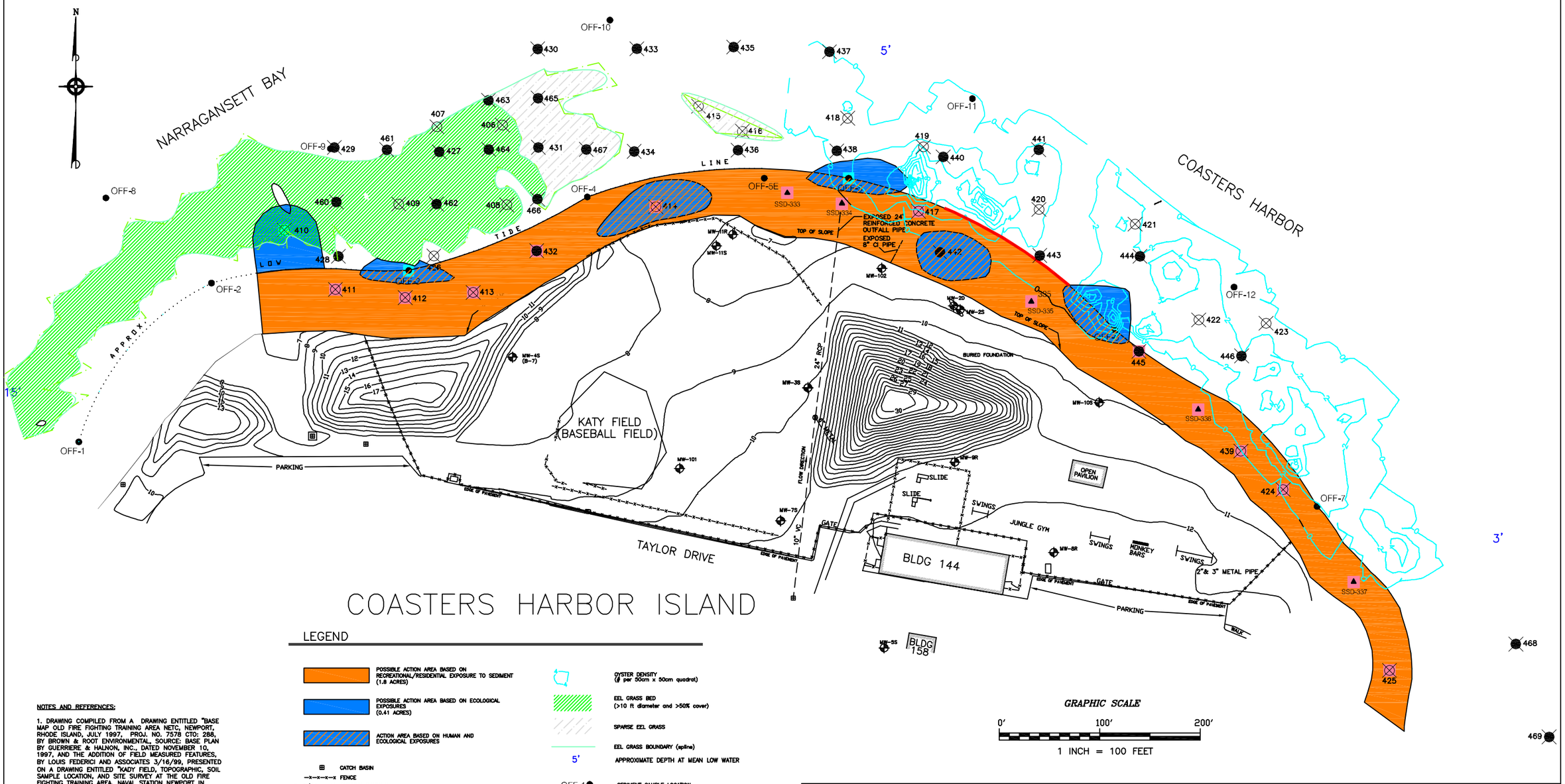
GRAPHIC SCALE

120' 0' 120' 240'

1 INCH = 120 FEET

DRAWN BY: D.W. MACDOUGALL	TITLE: SAMPLE STATIONS EXCEEDING PRGs OLD FIRE FIGHTING TRAINING AREA SITE, PRG DEVELOPMENT NAVAL STATION NEWPORT, RHODE ISLAND		
PREPARED BY: S. PARKER			
CHECKED BY: S. PARKER			
	SOURCE: SEE NOTE 1		
	SCALE: 1" = 120'	DATE: JULY 5, 2002	PROJ. NO: 4152
PROJECT MANAGER: S. PARKER	DRAWING NO: FIGURE 4-1	ACFILE NAME: DWG\4152\1120\FIG_4-1.DWG	REV: 0
PROGRAM MANAGER: J. TREPANOWSKI			

TETRA TECH NUS, INC.
55 JONSPIN ROAD
WILMINGTON, MASSACHUSETTS 01887
(978)658-7899



COASTERS HARBOR ISLAND

LEGEND

- POSSIBLE ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT (1.8 ACRES)
- POSSIBLE ACTION AREA BASED ON ECOLOGICAL EXPOSURES (0.41 ACRES)
- ACTION AREA BASED ON HUMAN AND ECOLOGICAL EXPOSURES
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- MW-8S MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- OYSTER DENSITY (# per 50cm x 50cm quadrat)
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

NOTES AND REFERENCES:

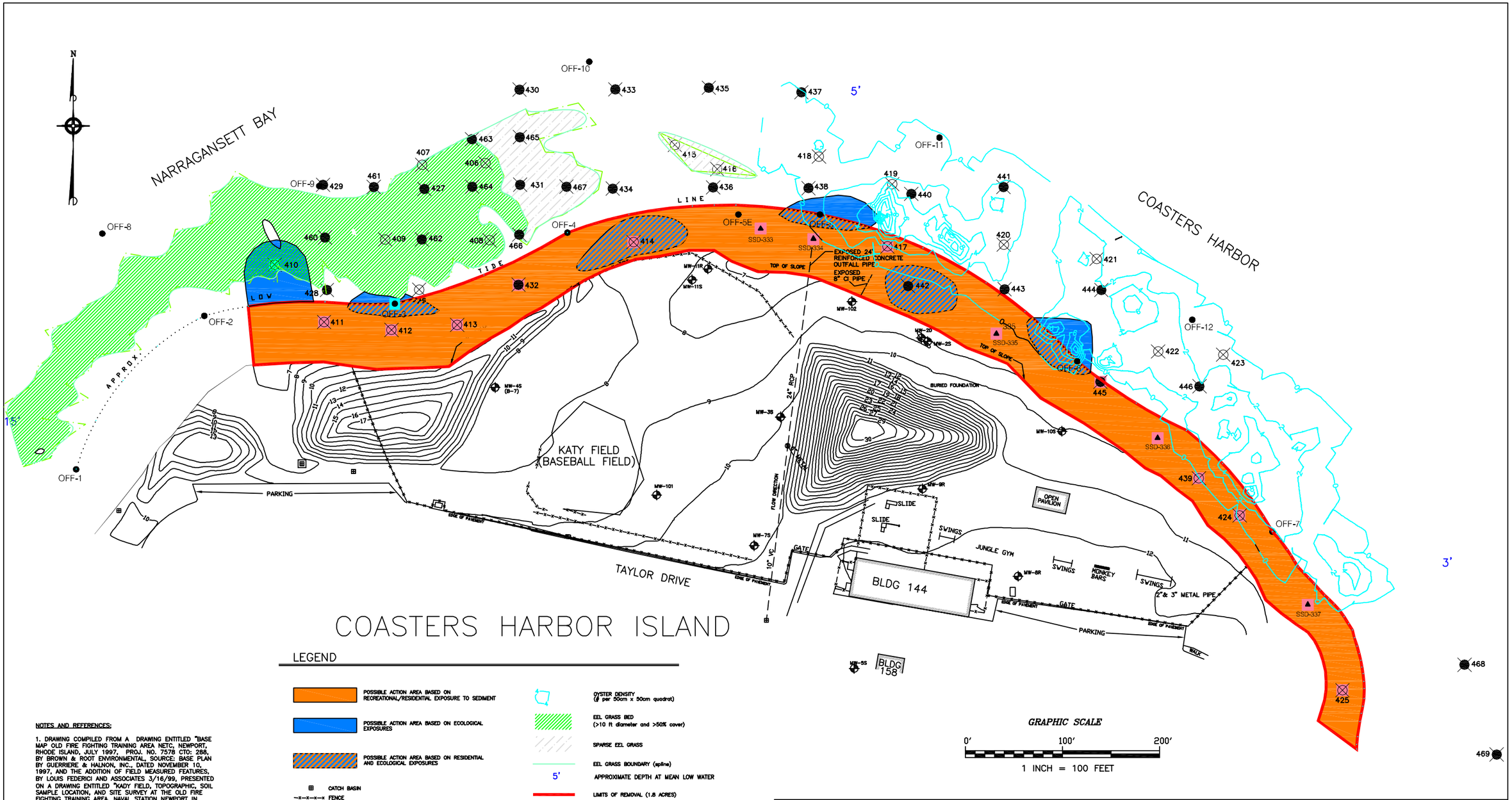
1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HAINON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

AREAS EXCEEDING PRGs		FIGURE 4-2
OLD FIRE FIGHTING TRAINING AREA		
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND		
DRAWN BY: D.W. MACDOUGALL	REV.: 0	TETRA TECH NUS, INC.
CHECKED BY: S. PARKER	DATE: AUGUST 30, 2002	55 Jonspin Road Wilmington, MA 01887 (978)658-7899
SCALE: 1" = 100'	FILE NO.: DWG\4152\1120\FIG_4-2.DWG	



COASTERS HARBOR ISLAND

LEGEND

- POSSIBLE ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT
- POSSIBLE ACTION AREA BASED ON ECOLOGICAL EXPOSURES
- POSSIBLE ACTION AREA BASED ON RESIDENTIAL AND ECOLOGICAL EXPOSURES
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- MW-9S MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- OYSTER DENSITY (# per 50cm x 50cm quadrat)
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- LIMITS OF REMOVAL (1.8 ACRES)
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

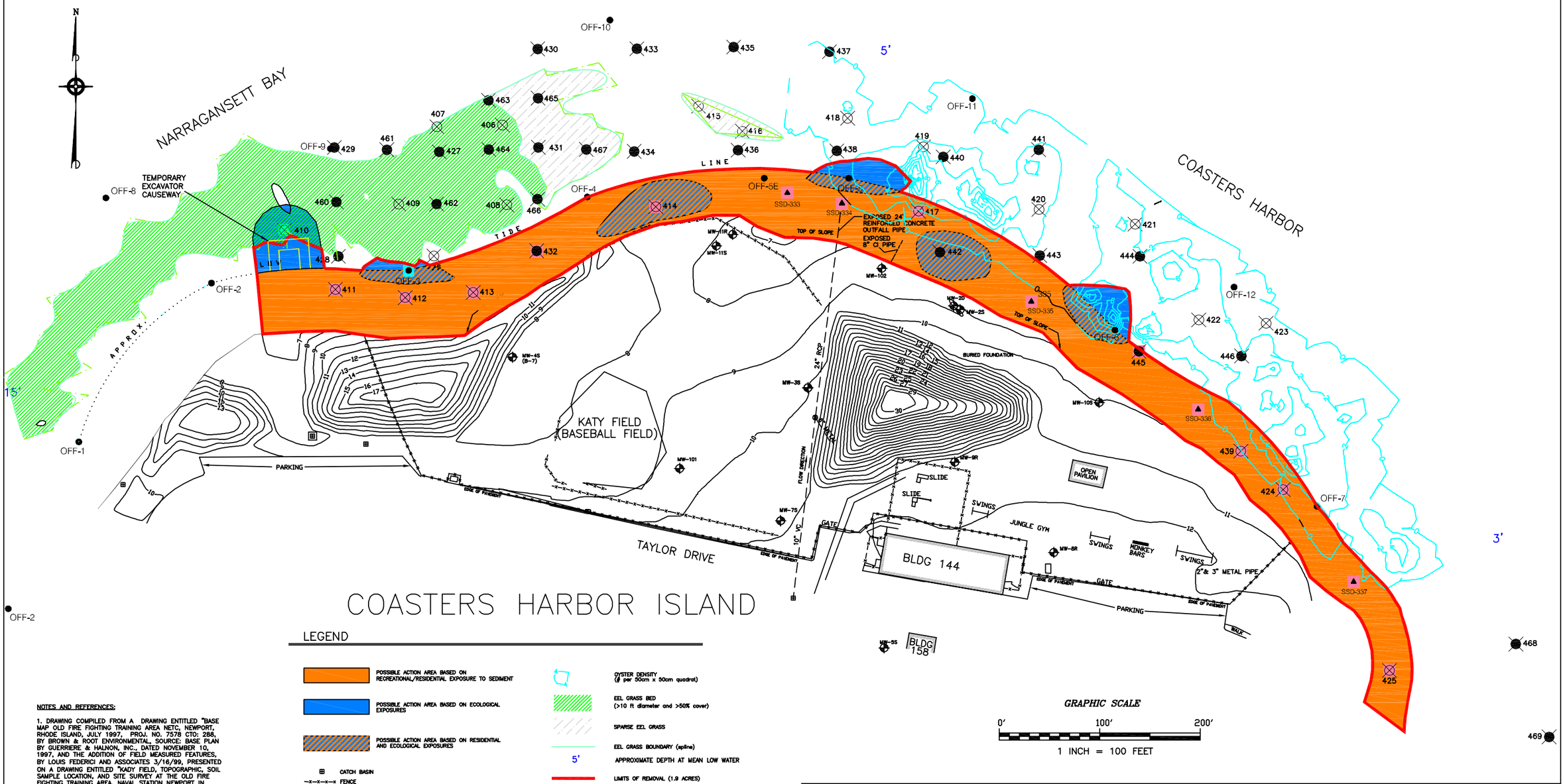
4. PLAN NOT TO BE USED FOR DESIGN.

GRAPHIC SCALE

0' 100' 200'

1 INCH = 100 FEET

SEDIMENT ALTERNATIVE 3 – AREA OF REMOVAL	FIGURE 6–1
OLD FIRE FIGHTING TRAINING AREA	
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND	
DRAWN BY: D.W. MACDOUGALL / REV.: 0	TETRA TECH NUS, INC.
CHECKED BY: S. PARKER / DATE: JULY 5, 2002	55 Jonspin Road Wilmington, MA 01887 (978)658-7899
SCALE: 1" = 100' / FILE NO.: DWG\4152\1120\FIG_6-1.DWG	



LEGEND

- POSSIBLE ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT
- POSSIBLE ACTION AREA BASED ON ECOLOGICAL EXPOSURES
- POSSIBLE ACTION AREA BASED ON RESIDENTIAL AND ECOLOGICAL EXPOSURES
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- MW-9S MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- OYSTER DENSITY (# per 50cm x 50cm quadrat)
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- LIMITS OF REMOVAL (1.9 ACRES)
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION

NOTES AND REFERENCES:

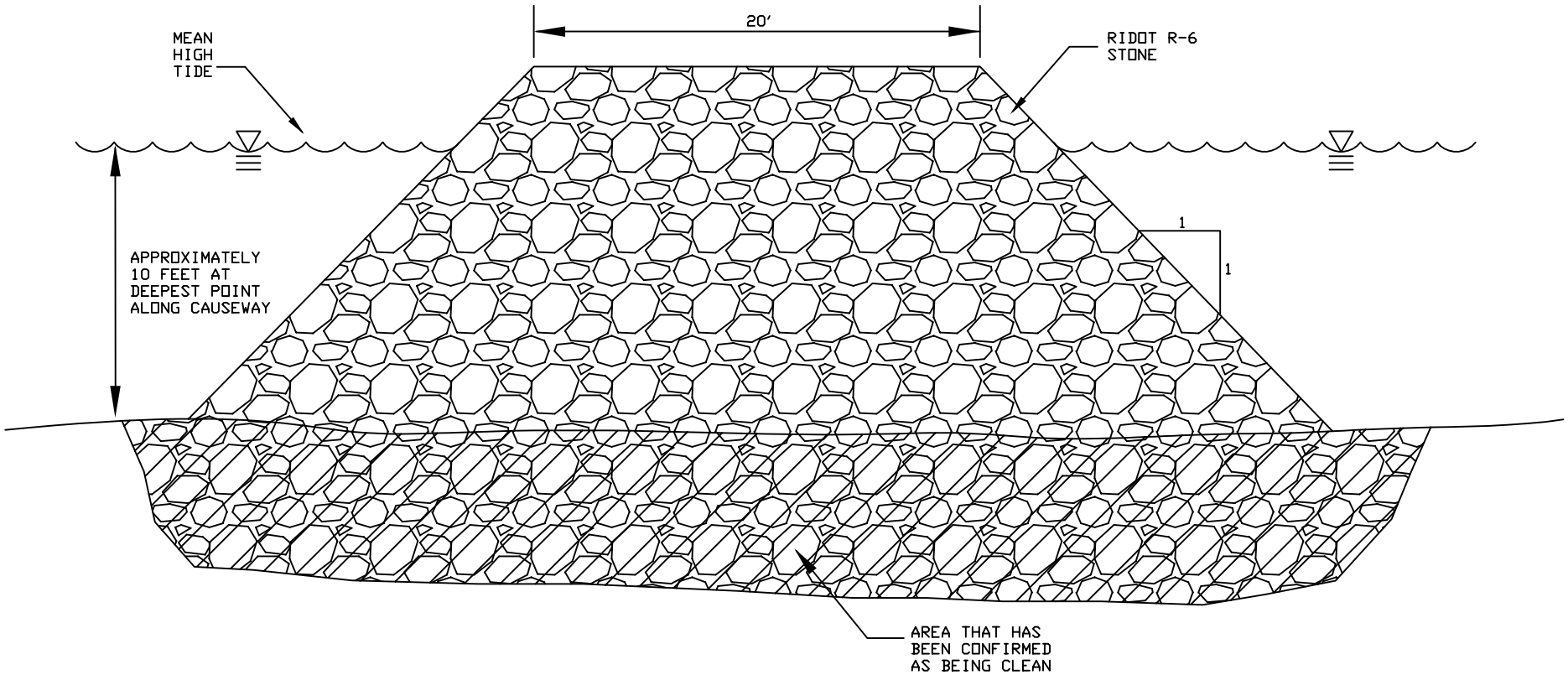
1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HAINON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.
2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.
3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.
4. PLAN NOT TO BE USED FOR DESIGN.

GRAPHIC SCALE

0' 100' 200'

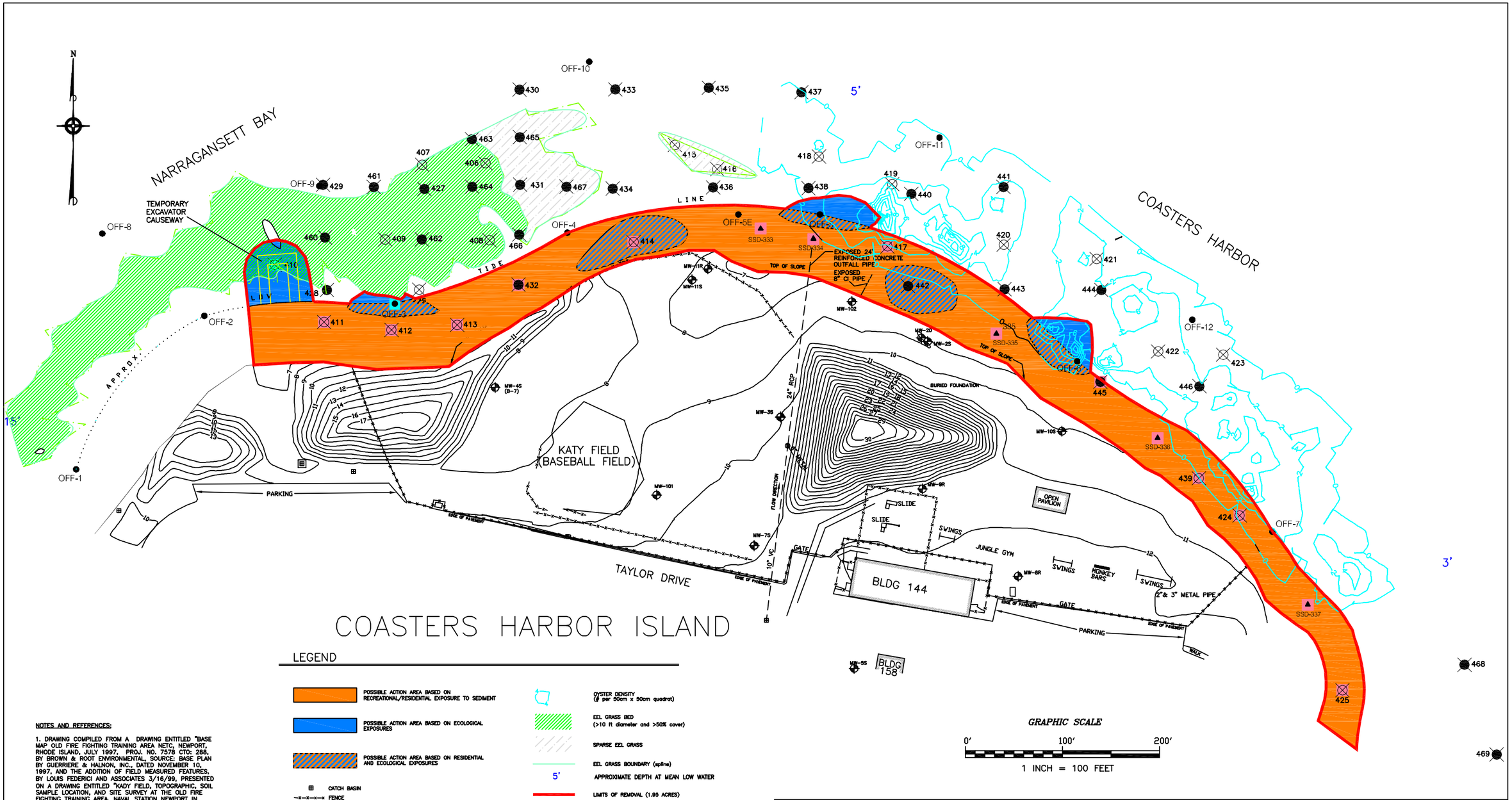
1 INCH = 100 FEET

SEDIMENT ALTERNATIVE 4 – AREA OF REMOVAL			FIGURE 6–2
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658–7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	S. PARKER	DATE:	JULY 5, 2002
SCALE:	1" = 100'	FILE NO.:	DWG\4152\1120\FIG_6–2.DWG



NOTES:

TEMPORARY EXCAVATOR CAUSEWAY			FIGURE 6-3
OLD FIRE FIGHTING TRAINING AREA			TETRA TECH NUS, INC.
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			55 Jonspin Road Wilmington, MA 01887 (978)658-7899
DRAWN BY:	D.W. MACDOUGALL	REV.:	0
CHECKED BY:	J. DAVIS	DATE:	JULY 16, 2002
SCALE:	NOT TO SCALE	FILE NO.:	DWG\4152\1120\FIG_6-3.DWG



COASTERS HARBOR ISLAND

LEGEND

- POSSIBLE ACTION AREA BASED ON RECREATIONAL/RESIDENTIAL EXPOSURE TO SEDIMENT
- POSSIBLE ACTION AREA BASED ON ECOLOGICAL EXPOSURES
- POSSIBLE ACTION AREA BASED ON RESIDENTIAL AND ECOLOGICAL EXPOSURES
- CATCH BASIN
- FENCE
- EXISTING CONTOUR
- MW-9S MONITORING WELL LOCATION WHERE SURFACE SOIL SAMPLE WAS COLLECTED
- SSD-333 SHORELINE SEDIMENT SAMPLE LOCATIONS
- STORM SEWER
- OYSTER DENSITY (# per 50cm x 50cm quadrat)
- EEL GRASS BED (>10 ft diameter and >50% cover)
- SPARSE EEL GRASS
- EEL GRASS BOUNDARY (spline)
- 5' APPROXIMATE DEPTH AT MEAN LOW WATER
- LIMITS OF REMOVAL (1.95 ACRES)
- OFF-1 SEDIMENT SAMPLE LOCATION
- 464 SEDIMENT SAMPLE LOCATION
- 426 SEDIMENT SAMPLE LOCATION

NOTES AND REFERENCES:

1. DRAWING COMPILED FROM A DRAWING ENTITLED "BASE MAP OLD FIRE FIGHTING TRAINING AREA NETC, NEWPORT, RHODE ISLAND, JULY 1997, PROJ. NO. 7578 CTO: 288, BY BROWN & ROOT ENVIRONMENTAL, SOURCE: BASE PLAN BY GUERRIERE & HALNON, INC., DATED NOVEMBER 10, 1997, AND THE ADDITION OF FIELD MEASURED FEATURES, BY LOUIS FEDERICI AND ASSOCIATES 3/16/99, PRESENTED ON A DRAWING ENTITLED "KADY FIELD, TOPOGRAPHIC, SOIL SAMPLE LOCATION, AND SITE SURVEY AT THE OLD FIRE FIGHTING TRAINING AREA, NAVAL STATION NEWPORT IN NEWPORT, RHODE ISLAND FOR TETRA TECH NUS, INC., LOUIS FEDERICI & ASSOCIATES, 3/16/99, DWG NO. 990205-01.

2. HORIZONTAL DATUM BASE ON THE RI STATE PLANE COORDINATE SYSTEM NAD 1927. VERTICAL DATUM BASED ON NAVEL BASE MEAN LOW WATER.

3. ALL LOCATIONS ARE TO BE CONSIDERED APPROXIMATE.

4. PLAN NOT TO BE USED FOR DESIGN.

SEDIMENT ALTERNATIVE 5 – AREA OF REMOVAL			FIGURE 6–4
OLD FIRE FIGHTING TRAINING AREA			
NAVSTA NEWPORT – NEWPORT, RHODE ISLAND			TETRA TECH NUS, INC.
DRAWN BY:	D.W. MACDOUGALL	REV.: 0	55 Jonspin Road Wilmington, MA 01887 (978)658-7899
CHECKED BY:	S. PARKER	DATE: JULY 5, 2002	
SCALE:	1" = 100'	FILE NO.: DWG\4152\1120\FIG_6-4.DWG	

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REFERENCES

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APPENDIX A

EVALUATION OF THE GROUNDWATER TO SEDIMENT PATHWAY

APPENDIX A
EVALUATION OF THE GROUNDWATER TO SEDIMENT PATHWAY
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

This appendix provides an evaluation of potential migration from OFFTA groundwater to marine sediment.

Activities associated with the operation and demolition of the OFFTA site have resulted in the presence of VOCs, SVOCs, pesticides, PCBs, dioxins, furans, and metals in site soils. The occurrence of several of these chemicals in groundwater and adjacent marine sediments suggests they have migrated from the soil to other environmental media. The purpose of this analysis is to evaluate the extent to which groundwater transfers site-related contaminants to the shoreline and marine sediments.

The shallow groundwater beneath the OFFTA site flows radially away from the south-central portion of the site toward the shoreline at the northern end of Coasters Harbor Island (TtNUS, 2001). Water levels in overburden and shallow bedrock wells near the shoreline are influenced by ocean tides (TtNUS, 2001). In addition, groundwater near the shoreline is contaminated by seawater. The direction of shallow groundwater flow, the presence of tidally-induced water-level fluctuations in the shoreline groundwater, and geochemical evidence for sea water intrusion indicate groundwater and seawater pass through the nearshore marine sediments along the northern edge of the OFFTA site.

Several VOCs, SVOCs, and metals are present in the groundwater beneath the OFFTA site. Most of the contaminants occur at very low concentrations, and many were detected in only a few samples. Table A-1 lists all of the VOCs, SVOCs, and EPA Priority Pollutant metals found in the OFFTA groundwater in 1997 when the wells were sampled using a low flow/low stress approach. Table A-1 also provides sediment data for these contaminants, and Table A-2 provides soil data.

The only VOCs detected in the groundwater in 1997 were benzene and ethylbenzene. Low concentrations of benzene were found in two of the 13 groundwater samples (8 μg/l and 33 μg/l), and a small amount of ethylbenzene was detected in one of these samples (38 μg/l). Benzene and ethylbenzene, together with toluene and xylene comprise the more volatile, water soluble, and therefore mobile components of petroleum fuels. These four VOCs were not detected in most of the soil, groundwater, and sediment samples collected during the various phases of investigation at the OFFTA site (TtNUS, 2001). In fact, the only BTEX compound found in any of the sediment samples was benzene, and it was only found one sample at a concentration of 1 μg/kg. The scarcity and low

concentrations of BTEX compounds in the soils, groundwater, and sediments of this petroleum-affected system indicate the bulk of the soluble and volatile petroleum hydrocarbons have already partitioned to the vapor phase or dissolved phase, and have been degraded or transported out of the system. Therefore, OFFTA groundwater does not appear to represent a present or future threat to sediment quality with respect to significant VOC contamination.

Six of the eight SVOCs found in the groundwater in 1997 were petroleum-related, and five of these were polycyclic aromatic hydrocarbons, or PAHs. Petroleum-related PAHs are generally much less volatile and soluble than BTEX compounds; as a result, these contaminants are still present at relatively high concentrations in many of the soil samples collected at the OFFTA site. Measures of total PAH concentrations in subsurface soil samples were as high as 21,100 μg/kg (TtNUS, 2001). By contrast, PAHs were detected in only two of the 1997 groundwater samples, and both of these samples were collected from wells installed within petroleum-stained soils. The total PAH concentration in MW-101 was 368 μg/l. This well is situated near the southern (landward) boundary of the OFFTA site. The total PAH concentration in MW-102, which is located near the shoreline, was 26 μg/l. Naphthalene and 2-Methylnaphthalene — by far the most soluble PAHs found in the 1997 groundwater samples — comprised the bulk of the PAHs in both samples. The low concentrations and infrequent occurrences of PAHs in groundwater are likely due to the low solubilities of these compounds and their strong affinities to sorb to soil particles. The PAHs associated with the OFFTA soils will continue to leach into the groundwater, but the solubility and adsorptive characteristics of these contaminants should act to keep groundwater PAH concentrations low.

Apart from the naphthalenes, the concentrations of PAHs in the marine sediments are much higher than would be expected from groundwater discharge alone. (Although phenanthrene was the only PAH detected in the shoreline sediment samples, the detection limits for the other PAHs ranged from 1800 μg/kg to 4000 μg/kg. Therefore, the shoreline sediments may also contain much higher concentrations of PAHs than the groundwater.) It is possible the groundwater transported higher concentrations of PAHs in the past when the site was being used for fire fighting training activities, but presently, the groundwater appears to play a negligible role in non-naphthalene PAH transport. The PAHs associated with OFFTA shoreline and marine sediments were probably derived not only from groundwater, but also from direct contact with site-related fuels and combustion byproducts, wind and water erosion of PAH-coated soil particles, weathering of asphalt fragments present in the intertidal zone, and other off-site sources such as fuel leaks and spills from boating activities in the harbor and bay.

The other three SVOCs in the 1997 groundwater samples were phenols, carbazole, and dibenzofuran. These three contaminants were present in only three of the 13 groundwater samples. Groundwater

concentrations of each these constituents were always less than 9 μg/l, and none of them were detected in the sediment samples.

EPA Priority Pollutant metals were detected more frequently in the OFFTA groundwater (see Table A-1). Each of the 13 groundwater samples collected in 1997 contained at least one of the following metals: arsenic, cadmium, chromium, copper, lead, mercury, silver, or zinc. However, concentrations of these inorganics in groundwater were two to five orders of magnitude lower than their concentrations in sediments, and only arsenic and lead were found at concentrations exceeding MCLs in one or more groundwater samples.

The maximum arsenic concentration detected in groundwater (0.0498 mg/l) was similar to its background value (0.0165 mg/l). Likewise, the maximum arsenic concentrations in surface and subsurface soils were similar to their respective background values (see Table A-2). Since onsite arsenic concentrations were comparable to those detected in background samples, all of the arsenic present in the site's soil and groundwater may be naturally occurring. The slightly higher than background concentrations of arsenic in groundwater are probably due to reducing conditions enhancing the mobility of arsenic (TtNUS, 2001).

Arsenic concentrations in the shoreline and marine sediments were slightly less than those found in the site's soils. Moreover, arsenic concentrations in the groundwater are two orders of magnitude less than those found in the sediments. As a result, groundwater appears to contribute a relatively small amount of arsenic to these sediments, and nearly all of the arsenic in the sediments may be naturally occurring.

Unlike arsenic, lead concentrations in the OFFTA soil samples were much higher than those in the background soil samples, indicating the presence of lead contamination at the site. Lead is relatively immobile in near neutral pH environments, and the pH in the 1997 groundwater samples generally ranged from 6.5 to 7.5. As a result, lead concentrations exceeded the 0.015 mg/l action level in only three samples, and two of these samples contained less than 0.030 mg/l. Despite the high concentrations of lead in the OFFTA soils (up to 7,820 mg/kg), only traces are dissolved in groundwater due to the low solubility of lead minerals and its strong affinity for soil particles in nonacidic environments.

Lead concentrations in both the shoreline and marine sediments are much lower than those in the OFFTA soils, but they are still well above soil background levels. Since groundwater concentrations of lead are as many as five orders of magnitude less than those in the sediments, groundwater appears to contribute a relatively insignificant amount of lead to the shoreline and marine sediments. Potentially more significant sources of sediment contamination include wind and water erosion of lead-rich soil particles, and off-site sources such as offshore leaded gasoline spills and leaks and the deposition of leaded gasoline combustion products.

TABLE A-1
VOCs, SVOCs, AND EPA PRIORITY POLLUTANT METALS
FOUND IN 1997 GROUNDWATER SAMPLES AND SEDIMENT SAMPLES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Fraction	1997 Unfiltered Groundwater						Sediment Shoreline					Sediment Marine				
		Units	Detects	Count	MinOfDetects	MaxOfDetects	Background	Units	Detects	Count	MinOfDetects	MaxOfDetects	Units	Detects	Count	MinOfDetects	MaxOfDetects
ARSENIC	M	MG/L	2	13	0.0445	0.0498	0.0165	MG/KG	5	5	4.2	7.1	MG/KG	35	35	2.70	8.5
CADMIUM	M	MG/L	3	13	0.0024	0.0034	0.0007	MG/KG	0	5	ND	ND	MG/KG	35	35	0.06	1.3
CHROMIUM	M	MG/L	12	13	0.0032	0.0399	0.1130	MG/KG	5	5	10.9	15.8	MG/KG	35	35	17.60	232.0
COPPER	M	MG/L	4	13	0.0136	0.1660	0.1200	MG/KG	5	5	16.2	61.4	MG/KG	35	35	2.50	84.9
LEAD	M	MG/L	10	13	0.0016	0.2070	0.0590	MG/KG	5	5	39.4	168.0	MG/KG	35	35	11.60	294.0
MERCURY	M	MG/L	3	13	0.00002	0.0002	ND	MG/KG	0	5	ND	ND	MG/KG	26	35	0.05	1.9
SILVER	M	MG/L	2	13	0.0008	0.0019	0.0006	MG/KG	4	5	5.7	11.3	MG/KG	18	35	0.16	1.2
ZINC	M	MG/L	5	13	0.0080	1.5700	0.3800	MG/KG	5	5	78.3	228.0	MG/KG	16	35	106.00	315.0
2-METHYLNAPHTHALENE	OS	UG/L	2	13	3	190	NA	UG/KG	0	5	ND	ND	UG/KG	31	35	2.6	330
ACENAPHTHENE	OS	UG/L	2	13	3	9	NA	UG/KG	0	5	ND	ND	UG/KG	32	35	0.9	966
CARBAZOLE	OS	UG/L	2	13	1	2	NA	UG/KG	0	5	ND	ND	UG/KG	NA	NA	--	--
DIBENZOFURAN	OS	UG/L	2	13	2	8	NA	UG/KG	0	5	ND	ND	UG/KG	NA	NA	--	--
FLUORENE	OS	UG/L	2	13	3	9	NA	UG/KG	0	5	ND	ND	UG/KG	33	35	0.3	1360
NAPHTHALENE	OS	UG/L	2	13	11	150	NA	UG/KG	0	5	ND	ND	UG/KG	31	35	2.7	258
PHENANTHRENE	OS	UG/L	2	13	3	7	NA	UG/KG	4	5	810	2300	UG/KG	32	35	16.2	14600
PHENOLS	OS	UG/L	2	13	2	5	NA	UG/KG	0	5	ND	ND	UG/KG	NA	NA	--	--
BENZENE	OV	UG/L	2	13	8	33	NA	UG/KG	1	5	1	1	UG/KG	NA	NA	--	--
ETHYLBENZENE	OV	UG/L	1	13	38	38	NA	UG/KG	0	5	ND	ND	UG/KG	NA	NA	--	--

NA = Not Analyzed
ND = Not Detected

TABLE A-2
VOCs, SVOCs, AND EPA PRIORITY POLLUTANT METALS FOUND IN SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Parameter	Fraction	Surface Soil						Subsurface Soil					
		Units	Detects	Count	MinOfDetects	MaxOfDetects	Background	Units	Detects	Count	MinOfDetects	MaxOfDetects	Background
ARSENIC	M	MG/KG	76	76	1.50	10.4	5.5	MG/KG	50	50	1.30	74.4	42.8
CADMIUM	M	MG/KG	3	76	0.72	0.9	0.7	MG/KG	11	38	0.25	8.1	ND
CHROMIUM	M	MG/KG	76	76	1.70	37.9	20.2	MG/KG	50	50	5.40	61.9	24.1
COPPER	M	MG/KG	75	76	2.40	220.0	23.8	MG/KG	49	50	6.10	2310.0	30.9
LEAD	M	MG/KG	75	76	2.90	2970.0	48.8	MG/KG	49	49	2.20	7820.0	15.4
MERCURY	M	MG/KG	32	76	0.05	0.6	0.2	MG/KG	26	37	0.06	2.2	ND
SILVER	M	MG/KG	22	76	0.68	26.5	ND	MG/KG	0	35	ND	ND	12.7
ZINC	M	MG/KG	75	76	13.40	1910.0	225.0	MG/KG	47	50	23.60	4240.0	175.0
2-METHYLNAPHTHALENE	OS	UG/KG	9	71	41	660	NA	UG/KG	13	35	77	11000	NA
ACENAPHTHENE	OS	UG/KG	12	71	46	940	NA	UG/KG	14	37	100	4900	NA
CARBAZOLE	OS	UG/KG	9	65	40	930	NA	UG/KG	1	21	170	170	NA
DIBENZOFURAN	OS	UG/KG	8	71	39	650	NA	UG/KG	11	34	86	4000	NA
FLUORENE	OS	UG/KG	13	71	49	1200	NA	UG/KG	17	36	120	3400	NA
NAPHTHALENE	OS	UG/KG	7	71	39	740	NA	UG/KG	10	34	41	4000	NA
PHENANTHRENE	OS	UG/KG	45	71	43	9700	NA	UG/KG	43	47	38	14000	NA
PHENOLS	OS	UG/KG	1	71	60	60	NA	UG/KG	3	22	250	490	NA
BENZENE	OV	UG/KG	0	67	ND	ND	NA	UG/KG	0	35	ND	ND	NA
ETHYLBENZENE	OV	UG/KG	0	67	ND	ND	NA	UG/KG	3	37	89	630	NA

NA = Not Analyzed
ND = Not Detected

APPENDIX B

GROUNDWATER RISK EVALUATION

W5201257DF

Groundwater Risk Evaluation

for

Old Fire Fighting Training Area
Naval Station Newport
Newport, Rhode Island

Engineering Field Activity Northeast
Naval Facilities Engineering Command

Contract Number N62472-90-D-1298
Contract Task Order 0282

March 2002

W5201257DF

GROUNDWATER RISK EVALUATION

FOR

OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT
NEWPORT, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
U.S Naval Facility Engineering Command
Engineering Field Activity Northeast
Environmental Contracts Branch
10 Industrial Highway, Mail Stop # 82
Lester, Pennsylvania 19113-2090

Submitted by:
Tetra Tech NUS, Inc.
600 Clark Avenue, Suite 3
King of Prussia, Pennsylvania 19406-1433

Contract Number N62472-90-D-1298
Contract Task Order 0282

March 2002

PREPARED UNDER DIRECTION OF:

JAMES FORELLI, P.E.
PROJECT MANAGER
TETRA TECH NUS, INC.
WILMINGTON, MASSACHUSETTS

APPROVED BY:

JOHN J. TREPANOWSKI, P.E.
PROGRAM MANAGER
TETRA TECH NUS, INC.
KING OF PRUSSIA, PENNSYLVANIA

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ACRONYMS

COPC	Chemical of Potential Concern
CTE	Central Tendency Exposure
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
FS	Feasibility Study
HI	Hazard Index
HQ	Hazard Quotient
ICR	Integrated Cancer Risk
IEUBK	Integrated Exposure and Uptake Biokinetic Model
MCL	Maximum Contaminant Level
PRG	preliminary remediation goal
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Dose
RI	Remedial Investigation
RIDEM	Rhode Island Department of Environmental Management
RME	Reasonable Maximum Exposure
SF	Slope Factor
ug/L	micrograms per liter

EXECUTIVE SUMMARY

The groundwater risk evaluation for OFFTA Site considered potential exposures to residents, assuming residential tap water ingestion and household bathing/showering. This standard residential scenario is unrealistic for the Site based on the groundwater classification, the high salinity of groundwater at the site, and the availability of nearby alternative potable water supplies. Under unrestricted future residential use conditions, other secondary types of residential contact with groundwater are conceivable - for example, contact with groundwater associated with lawn or garden sprinklers, car washing, swimming pools, etc. The standard residential scenario was applied to this evaluation to be protective of all potential uses of groundwater at the site.

Non-cancer risks were evaluated using both reasonable maximum (RME) and central tendency (CTE) conditions for both children and adults. Non-cancer hazard indices for both children and adults exceed the acceptable level of 1.0 for at least one target organ under each exposure. The target organs likely to be most affected are the CNS, skin and vascular system, kidney, weight loss, and blood. The principal contaminants contributing to these unacceptable non-cancer hazard indices are manganese, arsenic, barium, cadmium, chromium, dibenzofuran, naphthalene, 2-methylnaphthalene, benzene, and zinc. Drinking water ingestion contributed the majority of non-cancer risk.

Cancer risks were evaluated using both RME and CTE conditions for lifetime residents exposed to groundwater at OFFTA Site. Under RME conditions, cancer risks exceed EPA's target risk range (1×10^{-4} to 1×10^{-6}). Under CTE conditions, cancer risks are within EPA's target risk range (1×10^{-4} to 1×10^{-6}), but exceed the 1×10^{-5} RIDEM criterion. The primary contributors to unacceptable cancer risks are arsenic via ingestion and benzene via inhalation and ingestion.

Blood-lead levels resulting from groundwater exposure in residential children (age 1 - 6) were estimated using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA (EPA, 1994a) assuming that site groundwater is the primary drinking water source. The estimated percentage of children exposed to groundwater and site soil that are predicted to exhibit a blood lead level above 10 µg/dL is greater than EPA's protective level cutoff of 5 percent. This indicates that adverse effects from exposure to lead by residential children under these conditions cannot be ruled out.

The estimated risks described above (non-cancer, cancer, and blood lead levels) are based on the unrealistic scenario of unrestricted residential groundwater use as the primary drinking water source for future on-site residents. The resulting risks overestimate the probable risks associated with secondary residential exposure pathways. Since these risks result primarily from ingestion and inhalation pathways; predicted risks from the more likely secondary residential groundwater, which involve predominantly dermal

exposures with less frequent exposures, are likely to be significantly lower and may be less than EPA benchmarks.

1.0 INTRODUCTION

This report presents the Groundwater Risk Evaluation for the Old Fire Fighting Training Area (OFFTA) site (Site 09), located at Naval Station Newport (NAVSTA Newport) in Newport, Rhode Island (formerly the Naval Education and Training Center [NETC]). The Groundwater Risk Evaluation is submitted in partial fulfillment of the Remedial Investigation/Feasibility Study (RI/FS) for the site. The RI/FS was initiated by TRC Environmental Corporation (TRC) on behalf of the United States Navy (Navy) under contract N62472-86-C-1282 for the Engineering Field Activity Northeast Naval Facilities Engineering Command (EFA Northeast). The RI/FS is being completed by Tetra Tech NUS, Inc. (TtNUS), formerly Brown and Root Environmental (B&RE), on behalf of the Navy under Contract Number N62472-90-D-1298 for EFA Northeast.

The Final OFFTA RI Report was submitted to the United States Environmental Protection Agency, Region I (EPA) and the Rhode Island Department of Environmental Management (RIDEM) in July 2001. In October 2001 the Draft FS Report addressing contaminated soil and sediment at the site was submitted to the EPA and RIDEM. Based on the comments received, it was determined that the FS report could not be finalized until an evaluation of groundwater risks was completed and the results integrated into a revised Draft Final FS Report.

1.1 OBJECTIVE

The general objectives of the risk evaluation were to estimate the potential risks to human health resulting from the presence of contamination in groundwater and to provide the basis for determining appropriate remedial measures, if any, for this medium as part of the Feasibility Study.

The specific objectives of the risk evaluation were as follows:

- To estimate the potential future risks to human health resulting from the presence of contamination in groundwater, considering unrestricted use of groundwater for residential activities.

- To provide a basis for establishing concentrations that are protective of potential human receptors under a residential exposure scenario.

- To determine the need for remedial actions, if any, consistent with the unrestricted use of the site. Note that groundwater within the study area has been classified by RIDEM as GB. A groundwater classification of GB indicates that groundwater has been designated as unsuitable

for public or private drinking water use. The groundwater in the study area occurs under urbanized/developed land and is affected by seawater. Nearby potable water supply lines are available; therefore, it would be considered impractical to treat saline groundwater for the purpose of generating a usable drinking water supply. Although use restrictions may not be necessary to prevent consumption of groundwater as residential tap water under the current classification, institutional controls might be advisable to prevent other types of contact with groundwater - for example, lawn or garden sprinklers, car washing, swimming pools, etc.

Three major aspects of chemical contamination must be considered when assessing public health risks: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; (2) potential exposure points must exist either at the source or via migration pathways if exposure occurs at a remote location other than the source; and (3) human or environmental receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure; without any one of the three factors listed above, there is no risk.

1.2 BACKGROUND

The OFFTA RI report (TtNUS July 2001) provides a summary of background information about NAVSTA Newport and the Old Fire Fighting Training Area. It includes summaries of the scope and findings of the Phase I RI, Phase II RI, Source Removal Evaluation, Phase III RI, Background Soils Investigation, and the offshore ecological risk investigations. The RI provides a comprehensive site contamination assessment. This document also includes a human health risk assessment (HHRA) for soil and sediment exposure and the findings of the marine ERA.

1.3 REPORT ORGANIZATION

This risk evaluation is divided into Data Evaluation, Exposure Assessment, Toxicity Assessment, Risk Characterization, Uncertainty Analysis, and Summary/Conclusions. Each section is briefly discussed below.

Data Evaluation (Section 2.0) is primarily concerned with data quality assessment, identification of chemicals of potential concern (COPCs), distributional analysis of the data, and calculation of exposure point concentrations. The data are analyzed and COPCs are selected that are representative of the type expected for potential human health exposure. Distributional analysis of the data allows an evaluation of the variation in exposure point concentrations, which can be used to assess the uncertainty related to use of the maximum groundwater concentration of each COPC as the input exposure point concentration for risk evaluation.

Exposure Assessment (Section 3.0) identifies potential human health exposure, including a characterization of the site setting, description of potential receptors, selection of exposure routes, derivation of exposure estimates for each pathway, and a special explanation of the blood-lead modeling. This section identifies potential pathways of COPC migration, selected potential receptors, and the estimated intakes of COPCs for the identified receptors.

Toxicity Assessment (Section 4.0) presents available reference doses, cancer slope factors, EPA weight of evidence, and adjustment of the dose-response parameters. Quantitative toxicity indices, where available, are presented in this section, including any applicable regulatory standards and criteria.

Risk Characterization (Section 5.0) presents the approaches for determining carcinogenic risks, noncarcinogenic risks, and lead risks. The risk characterization evaluates the potential for adverse health effects from exposure to COPC concentrations in environmental media by integrating information developed during the toxicity and exposure assessments.

Uncertainty Analysis (Section 6.0) is a discussion of the general and site-specific uncertainties associated with the groundwater risk evaluation.

Summary (Section 7.0) presents major conclusions of the groundwater risk evaluation.

2.0 DATA EVALUATION

This section presents the approaches for data quality assessment, identification of COPCs, distributional analysis of the data, and exposure point concentrations.

2.1 DATA USED FOR THE RISK EVALUATION

The available database considered for use in this risk evaluation includes background and site-associated sample results from recent (1997) groundwater investigations. Data utilized in this risk evaluation were comprised of validated analytical results of known or sufficient quality for use in quantitative risk calculations. The data were collected by Tetra Tech NUS (Phase III - 1997). Only the 1997 groundwater data were considered for use in this risk evaluation because these samples were collected using low-flow sampling pumps to minimize the generation of suspended solids during sampling, unlike the earlier samples collected by TRC (Phase I - 1990, Phase Ia - 1991, and Phase II - 1993), which were obtained using conventional bailers. Only unfiltered results were used. Background groundwater samples were collected from two upgradient monitoring wells.

2.2 IDENTIFICATION OF COPCS

The selection of COPCs was based on chemical-specific concentrations, occurrence, distribution, and toxicity. COPCs were selected to represent site contamination and to provide the framework for the quantitative groundwater risk evaluation. COPCs include only those chemicals with positive detections within the area of interest (i.e., detected in on-site wells).

A chemical was selected as a COPC if the maximum detected concentration was greater than the associated risk-based concentration (RBC) based on a target cancer risk of 1×10^{-6} or a noncancer hazard quotient (HQ) of 0.1. RBCs were obtained from the latest EPA Region IX Preliminary Remediation Goals (PRGs) listing for residential groundwater use (EPA, 2000a). All exposures to groundwater for all receptors were conservatively screened using the residential exposure assumptions in the PRG table. PRGs that were based on noncancer effects were adjusted from a HQ of 1.0 to a HQ of 0.1 to protect against the possibility of additive toxic effects from multiple chemicals.

COPCs for metals were not eliminated from consideration based on comparison to the levels found in upgradient wells. Statistical background comparison tests could not be performed because of lack of a sufficient number of background sample locations (data were collected from only two upgradient wells). However, a qualitative comparison of site and background samples for groundwater is presented within the risk evaluation uncertainty discussion.

Essential nutrients were not considered as COPCs, including calcium, chloride, magnesium, potassium, and sodium. Several other common minerals (aluminum, cobalt, copper, and iron) have only provisional toxicity criteria, based on risk assessment guidance from EPA Region I (EPA, 1999). Of the detected common minerals that did not have published toxicity criteria from accepted references (EPA, IRIS, or HEAST), all were retained as COPCs for illustration to document cases in which a current lack of knowledge regarding toxicity adds uncertainty to the risk evaluation.

EPA has not developed PRGs for 2-methylnaphthalene and phenanthrene. RBCs for these contaminants were developed using surrogate PAHs, naphthalene and fluoranthene, respectively.

The PRG for hexavalent chromium was used for COPC selection because speciation data (i.e., trivalent versus hexavalent) were not available for groundwater samples collected at OFFTA. Similarly, the PRG for methyl mercury was used for COPC selection because the form of mercury at the site is unknown and methyl mercury is considered the most toxic form of mercury.

The COPC selections and the rationale for inclusion or exclusion of chemicals are documented in Table 2-1 (RAGs D Table 2). In this table, chemicals with a "Y" listed in the COPC selection column were retained as COPCs for all quantitative risk calculations.

2.3 COMPARISON TO MAXIMUM CONTAMINANT LEVELS (MCLS)

In addition to comparing maximum detected concentrations to RBCs, Table 2-1 presents a comparison of maximum detected concentrations to MCLs. Only two contaminants exceeded their respective MCLs: benzene and lead. Benzene was selected as a COPC based on comparison to RBCs. Lead was selected as an additional COPC in groundwater based on comparison to the MCL of 15 μg/L.

2.4 DISTRIBUTIONAL ANALYSIS OF THE DATA

This section presents the approaches taken for distributional analysis of the OFFTA site analytical data. Distributional analysis of the sampling data is important in determining the appropriate technique for estimating the chemical concentration to which a receptor is assumed to be continuously exposed (see Section 2.4) and to gain knowledge about the variation and uncertainty in the concentration used to quantitatively estimate risks at the site. Statistical analyses discussed in this section adhere to the guidance referenced in several EPA documents and related publications (EPA, 1989, 1992a, 1992b, 1992d, and 1996a). The underlying statistical distribution of data was determined for each COPC. The Shapiro-Wilk W test or the Shapiro-Francia Test (EPA, 1992d) were performed to determine if the data set of chemical concentrations matched the shape of a normal or lognormal distribution. [The latter test is required

if there are greater than 50 samples (EPA, 1992d, 1996a).] Normally distributed data exhibit a characteristic "bell-shape" curve that is symmetrical, whereas lognormal data have a skewed shape with a longer tail at the high-concentration end. For each COPC, the W test was performed once using the original data and once after data were converted to their logarithms. A 5 percent level of significance was used to determine if the data deviated from either hypothesized distribution. If taking the natural logarithms (base e) of the data provided a better match than a normal distribution, a lognormal transformation of data was assumed before the mean concentration was computed. If neither distribution matched the data set of interest, the distribution having the better apparent fit was selected.

The distributional analysis results for COPCs in groundwater is shown in Table 2-2.

2.5 EXPOSURE POINT CONCENTRATIONS

In this groundwater risk evaluation, an exposure point concentration (EPC) represents an estimated chemical concentration to which a receptor is assumed to be continuously exposed while in contact with groundwater. The EPC was calculated using the latest risk evaluation guidance from EPA (1985, 1989a, 1992b, 1994c, and 1998b) and Gilbert (1987).

2.5.1 Reasonable Maximum and Central Tendency Exposure EPCs

Two types of EPCs are possible for use in this risk evaluation, reasonable maximum exposure (RME) EPCs and central tendency exposure (CTE) EPCs. RME is the exposure that is expected to represent an upper-bound exposure in a given medium of interest. RME EPCs were selected as the maximum value in accordance with Region I EPA guidance for groundwater (EPA, 1994b).

CTE is the exposure that is expected to represent an average exposure in a given medium of interest. Note: CTE analysis at OFFTA was performed for the groundwater exposure pathway because estimated cancer risks were above 1×10^{-4} and the noncancer HIs based on the same target organ were above 1.0. (CTE analysis not only involves a modified EPC, but also involves changes to input parameters for each exposure pathway.) CTE EPCs were selected as the arithmetic mean of the sample concentrations (for a normal distribution) or the minimum variance unbiased estimate of the population's arithmetic mean (for a lognormal distribution) in all cases except those where the mean estimate was greater than the maximum detected concentration (which may happen if trace level detections are all less than one-half of the quantitation limit). In the latter case, CTE used the minimum among the two quantities, mean estimate or maximum detected concentration, as the CTE EPC. The minimum variance unbiased estimate of the population's arithmetic mean for a lognormal distribution estimates the arithmetic mean for an infinite number of observations taken from a lognormal population, when data are only available for a finite

number of observations. It involves a correction factor applied to the arithmetic mean. The equations below are taken from Gilbert, 1987:

$$\text{Mean-T} = \exp\{u_L\}Psi_n(s_y^2/2)$$

Where: u_L = arithmetic mean of log-transformed data

s_y = standard deviation of log-transformed data

$Psi_n(t)$, with $t = s_y^2/2$, is the infinite series:

$$Psi_n(t) = 1 + (n-1)t/n + (n-1)^3t^2/(2!n^2(n+1)) + (n-1)^5t^3/(3!n^3(n+1)(n+3)) + (n-1)^7t^4/(4!n^4(n+1)(n+3)(n+5)) + \ldots$$

2.5.2 Treatment of Data in EPC Calculations

Validated laboratory data were used to calculate EPCs for all data. Estimated values (J qualified) and biased values (L and K qualified) were used as the reported value. Rejected results (R qualified) were eliminated from further consideration. Blank-qualified results were treated as non-detects based on EPA regional data validation guidance.

For chemicals with at least one positive detection in each data set, a value of one-half the sample quantitation limit was assumed for non-detect (U qualified) results when calculating EPCs.

Duplicate samples were represented in the quantitative risk evaluation for a location as the maximum detected result of the two samples analyzed.

2.5.3 EPCs for Exposure Pathways

The RME and CTE EPCs for COPCs in groundwater are shown on Table 2-3.

3.0 EXPOSURE ASSESSMENT

The exposure assessment evaluates the potential for human exposure to the chemicals detected in the environmental media of concern at the OFFTA site investigated during the RI. This section presents a characterization of the exposure setting, characterizes the exposed populations, identifies actual or potential exposure routes, and summarizes the methods used to generate exposure estimates. The nature and extent of contamination for each media of concern for which exposures were based were presented in the RI Report (TtNUS, 2000 Section 4.0).

3.1 CHARACTERIZATION OF THE EXPOSURE SETTING

OFFTA is located at the Northern end of Coasters Harbor Island. The site occupies approximately 5.5 acres and is bordered to the west, north, and east by Narragansett Bay and Coasters Harbor. Contact with groundwater is the only medium of exposure evaluated in this risk evaluation, because exposures to soil, sediment, and ingestion of shellfish were previously evaluated quantitatively in the baseline human health risk evaluation (TtNUS, 2001).

Residential tap water ingestion and household bathing/showering are impractical future exposure scenarios at the OFFTA site because of the high salinity of groundwater at the site, the RIDEM classification as not suitable for such use, and the availability of nearby alternative potable water supplies. However, actions (institutional controls) might be advisable to restrict other types of contact with groundwater - for example, lawn or garden sprinklers, car washing, swimming pools, etc. In addition, restrictions may be necessary to document groundwater conditions should the current groundwater classification be changed by RIDEM or if groundwater were developed for a source of drinking water after treatment. To generate an upper bound estimate of risks from all potential uses of groundwater, a standard residential scenario is useful because the degree of exposure to contaminants from this scenario would be greater than with other exposure scenarios. In this manner, the risk evaluation can yield standards for protectiveness that are assured to encompass the full range of possible exposures that might occur at the site.

3.2 POTENTIAL RECEPTORS

The potential receptors chosen for OFFTA site are presented in this section. These receptors are listed as follows:

- Future Residential Child - This receptor is a child (age 1 - 6) who resides at or near the OFFTA site. This receptor is potentially exposed to COPCs in groundwater via ingestion of tap water and

dermal absorption while bathing. As discussed above, the rationale for including this scenario is to ensure that the risk evaluation can yield standards for protectiveness that are assured to encompass the full range of possible exposures that might occur at the site.

- Future Residential Adult - This receptor is an adult (24 years exposure duration) who resides at or near the OFFTA site. This receptor is potentially exposed to COPCs in groundwater via ingestion of tap water, dermal absorption while bathing or showering, and inhalation of COPCs during showering. The rationale for including this scenario was discussed above.

- Future Lifetime Resident - This receptor is a person who resides at or near the OFFTA site and is exposed to groundwater for a duration of 30 years, including the cumulative exposures to a residential child (age 1 - 6) and a residential adult (24 years exposure duration). This receptor is potentially exposed to groundwater via ingestion, dermal absorption, and inhalation (showering for an adult only) of COPCs. The lifetime cancer risk is estimated by adding the cancer risk under a 24-year adult exposure to the cancer risk under a 6-year child exposure.) The rationale for including this scenario was discussed above.

3.3 EXPOSURE ESTIMATES

The exposure routes, methods, and models presented in this section are consistent with current EPA risk assessment guidance (EPA, 1989, 1992a, 1992c, 1994b, 1997b, 2000b). Exposure assumptions associated with the groundwater exposure route are presented below. All exposure scenarios incorporate RME and CTE EPCs in the estimation of intakes.

Noncarcinogenic risks were estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. This is used along with the "averaging time," which converts the total annual exposure to an average daily dose by dividing by 365 days per year of exposure. Noncarcinogenic risks for some exposure routes were generally greater for children than for adults because of differences in body weight and intake. Carcinogenic risks, on the other hand, were estimated as an incremental lifetime risk and, therefore, incorporate terms to average the exposure duration (years) over the course of a lifetime (70 years).

Tables 3.1 and 3.2 present the RME and CTE input parameters selected for groundwater ingestion and dermal exposure pathways, respectively, for a residential child. Tables 3.3 and 3.4 present the RME and CTE input parameters selected for groundwater ingestion and dermal exposure pathways, respectively, for a residential adult. Table 3-5 presents the RME and CTE input parameters selected for the groundwater inhalation exposure pathway for a residential adult.

For the groundwater exposure pathways, the following items are noteworthy:

- Chemical-specific permeability constants associated with modeling of dermal absorption are not shown on the exposure input tables. The dermal permeability constants are available from Dermal Exposure Guidance (EPA, 2000b) and are presented in Table 3-6 for each COPC.

- Derivations of the surface areas used in all dermal exposure equations in this risk evaluation for each potential receptor were based on surface areas for available body parts. Surface areas were compiled from several sources (EPA, 1997b and EPA, 1985) and are shown in Table 3-7 for each potential receptor.

- Several chemical-specific parameters associated with modeling of inhalation of airborne vapors during showering are not shown on the exposure input tables. These chemical-specific constants were obtained from several sources, including EPA (1996b) and Foster and Chrostowski (1987) and are listed in Table 3-8 for each COPC.

4.0 TOXICITY ASSESSMENT

Toxicity assessment identifies the potential health hazards associated with exposure to each of the COPCs. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that the COPCs have the potential to cause carcinogenic and/or noncarcinogenic health effects in humans. Although the COPCs may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the intake with the probability of toxic effects, as discussed below. Toxicity information for the COPCs in groundwater at the OFFTA site are presented in Tables 4.1, 4.2, 4.3, and 4.4 (RAGs D Tables 5.1, 5.2, 6.1, and 6.2, respectively).

An important component of the risk evaluation process is the relationship between the intake of a compound (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts can be quantified. The published information of doses and responses is used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

Dose-response values [reference doses (RfDs) and slope factors (SFs)] have been developed by EPA and other sources for many organics and inorganics. This section provides a brief description of these parameters.

4.1 REFERENCE DOSES

The RfD is developed by EPA for chronic and/or subchronic human exposure to hazardous chemicals and is based solely on the noncarcinogenic effects of chemical substances. Subchronic RfDs are specifically developed to be protective for a portion of a lifetime exposure to a compound (as a Superfund program guideline, short term is considered two weeks to 7 years). Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, long term is defined as 7 years or more). The RfD is usually expressed as a dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a No-Observed-(Adverse)-Effect-Level (NOAEL or NOEL) or a Lowest-Observed-Adverse-Effect-Level (LOAEL) by an appropriate uncertainty factor. NOAELs, etc. are determined from laboratory or epidemiological toxicity studies. The uncertainty factor is based on the availability of toxicity data.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect

sensitive subpopulations), when test results from animals are extrapolated to humans (to account for interspecies variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop the RfD, and when a LOAEL is used instead of a NOAEL. In addition, EPA reserves the use of a modifying factor of up to 10 for professional judgment of uncertainties in the database not already accounted for. The default value of the modifying factor is 1.

The RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus, the RfD is an acceptable guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation. Oral and dermal RfDs, primary target organs, uncertainty/modifying factors, and sources of noncancer toxicity information for COPCs are provided in Table 4-1 (RAGs D Table 5-1). Inhalation RfDs, primary target organs, uncertainty/modifying factors, and sources of toxicity information for selected COPCs in groundwater are provided in Table 4-2 (RAGs D Table 5-2). Inhalation RfDs (mg/kg/day) were derived from inhalation reference concentrations (RfCs) (mg/m^3) by dividing by 70 kg (an assumed human body weight), multiplying by 20 m^3/day (an assumed human inhalation rate), and adjusting by an appropriate absorption factor (EPA, 1997a).

Target organ data have been extracted from the Integrated Risk Information System (IRIS; EPA, 2001), Health Effect Assessment Summary Tables (HEAST; EPA, 1997a), or other applicable sources. Only the target organs that are affected in the applicable study in which the RfD was derived have been included in Tables 4.1 and 4.2 (RAGs D Tables 5.1 and 5.2, respectively).

Noncarcinogenic risks for lead were not quantified and compared to RfDs, because EPA has implemented an approach to evaluating lead risks that does not provide a single-point estimate output. Instead, potential lead exposures are evaluated using a biokinetic model to estimate expected blood-lead increases. The blood-lead model is discussed in Section 4.7. A discussion of the results of the blood-lead model estimates is presented in Section 5.6.

4.2 CANCER SLOPE FACTORS (SFS)

SFs are applicable for estimating the lifetime probability (assumed 70-year lifespan) of human receptors developing cancer as a result of exposure to known or potential carcinogens. This factor is generally reported in units of 1/(mg/kg/day) and is derived through an assumed low-dosage linear relationship of extrapolation from high to low dose responses determined from animal studies. The value used in reporting the slope factor is the upper 95 percent confidence limit.

Oral and dermal SFs, weight of evidence, and sources of toxicity information for selected COPCs are provided in Table 4-3 (RAGs D Table 6-1). Inhalation SFs, weight of evidence, and sources of toxicity information for selected COPCs in groundwater are provided in Table 4-4 (RAGs D Table 6-2). Inhalation SFs $(mg/kg/day)^{-1}$ were derived from inhalation unit risks $(\mu g/m^3)^{-1}$ by multiplying by 70 kg (an assumed human body weight), dividing by 20 m^3/day (an assumed human inhalation rate), and multiplying by the appropriate conversion factor (1000 μg/mg) (EPA, 1997a).

Carcinogenic risks for lead were not quantified, because EPA has not published a SF for inorganic lead. Instead, potential lead exposures were evaluated using a biokinetic model to estimate expected blood-lead increases. A discussion of these results is presented in Section 5.6.

4.3 EPA WEIGHT OF EVIDENCE

The weight-of-evidence designations indicate the preponderance of evidence regarding carcinogenic effects in humans and animals. The categories are defined as follows (EPA, 1992a):

WEIGHT OF EVIDENCE CATEGORY	DEFINITION
A	Known human carcinogen
B1	Probably human carcinogen, limited human data are available
B2	Probable human carcinogen, sufficient animal data are available but inadequate human data are available
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity in humans

4.4 ADJUSTMENT OF DOSE-RESPONSE PARAMETERS FOR DERMAL EXPOSURE

Risks associated with dermal exposures were evaluated using toxicity values that are specific to absorbed dermal doses. Most oral toxicity values are based on administered doses rather than absorbed doses. Therefore, in accordance with EPA Region I (2000b) and EPA (1989) guidance, the toxicity values based on administered doses were adjusted before they were used for evaluating absorbed doses.

Dermal RfDs and SFs were obtained from oral RfDs and SFs via the following relationships:

$$RfD_{Adjusted} = RfD_{Oral} * GI_{Oral}$$

$$SF_{Adjusted} = {SF_{Oral}}/{GI_{Oral}}$$

where:

GI_{Oral} = Gastrointestinal (GI) Absorption Efficiency (EPA, 2000b)

RfD_{Oral} = Oral Reference Dose (EPA, 2001; EPA, 2000a; EPA, 1997a; or EPA-NCEA)

SF_{Oral} = Oral Slope Factor (EPA, 2001; EPA, 2000a; EPA, 1997a; or EPA-NCEA)

Dermally adjusted RfDs and SFs for COPCs are presented in Tables 4.1 (RAGs D Table 5-1) and 4.3 (RAGs D Table 6-1), respectively.

4.5 TOXICITY CRITERIA FOR CHROMIUM

The toxicity criteria for hexavalent chromium (Cr^{+6}) were used in this groundwater risk evaluation because speciation data (i.e., trivalent versus hexavalent) were not available for samples collected in areas/media of concern at the OFFTA site. Hexavalent chromium is considered to be more toxic than trivalent chromium, therefore, this assumption is conservative in nature.

4.6 TOXICITY CRITERIA FOR MERCURY

The toxicity criteria for methyl mercury were used in this groundwater risk evaluation because data indicating the form of mercury in environmental media was not available at the OFFTA site. Methyl mercury is considered to be more toxic than inorganic mercury, therefore, this assumption is conservative in nature.

4.7 TOXICITY CRITERIA FOR 2-METHYLNAPHTHALENE AND PHENANTHRENE

EPA has not developed toxicity values for all chemicals for use in quantitative risk characterization. These COPCs include 2-methylnaphthalene and phenanthrene. Therefore, these chemicals were evaluated in this report using surrogates (similar PAHs), naphthalene and fluoranthene, which is consistent with previous EPA Region I risk assessment projects. PRG screening criteria were applied and resulted in phenanthrene present at a level less than the screening criterion, while 2-methylnaphthalene was present greater than the screening level, so that associated risks were evaluated using the surrogate RfD for naphthalene.

4.8 BLOOD-LEAD MODELING

As outlined in OSWER Directive 9355.4-12, EPA (1994c) has developed an approach to evaluating lead risks that recognizes the multimedia nature of lead exposures, incorporating absorption and

pharmacokinetic information. Research has been conducted concerning lead intake and resultant blood-lead levels. Determination of lead uptake from tap water consumption was considered. Potential blood-lead level increases are estimated and are discussed, along with the potential implications of blood-lead results for residential children and subsistence fishermen. The following discussion presents information that is useful in estimating lead exposure.

No threshold has been defined for effects related to blood-lead increases. Effects below blood-lead levels of 10 μg/L are difficult to define. Inhibition of certain enzymes involved in red blood cell metabolism has been reported to occur at 10 to 15 μg/dL and possibly lower. Small increases in blood pressure have been observed in adults with blood-lead levels down to 7 μg/dL (EPA, 1994a). The most sensitive subpopulation to effects below 7 μg/dL, would be infants, whose early neurological development can be affected by blood-lead concentrations reportedly down to 5 μg/dL (EPA, 1994a). Lead is also a fairly common environmental contaminant and, for this reason, typical blood-lead levels in the population at large may already exceed the concentrations discussed here.

For drinking water exposure, children 0 through 6 months old are expected to experience blood lead increases at the rate of 0.26 μg/dL per μg/L lead in water up to 15 μg/L and at the rate of 0.04 μg/dL for every μg/L lead in water above 15 μg/L (EPA, 1994a). For older children, the ratio is 0.12 μg/dL blood lead per μg/L lead in water up to 15 μg/L and 0.06 μg/dL for every μg/L lead in water above 15 μg/L (EPA, 1994a). For adults, the ratio is approximately 0.06 μg/dL blood lead per μg/L in water (EPA, 1994a). Dietary intake of lead is assumed to produce increases of 0.02 to 0.04 μg/dL blood lead per μg/day ingested by adults and 0.16 μg/dL blood lead per μg/day ingested by infants (EPA, 1986a). Blood-lead levels are estimated to increase by 0.6 to 6.8 μg/dL per 1,000 mg/kg lead in soil (EPA, 1986a).

Blood-lead levels resulting from groundwater exposure in residential children (age 1 - 6) were estimated using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA (EPA, 1994a).

The output of the IEUBK Model is a histogram that presents the estimated percentage of children with a blood-lead level above 10 μg/dL (considered to be the threshold significance level above which adverse effects cannot be ruled out). When the percentage of the population estimated to have blood-levels above 10 μg/dL is greater than five percent, then EPA considers the potential for adverse effects to be significant (EPA, 1994c). These histograms, along with input information particular to each run of the IEUBK model, are presented in Section 5.6. The estimated percentages of children with blood-lead levels above 10 μg/dL are also presented in Section 5.6. Uncertainties associated with the IEUBK model are discussed in Section 7.

For the assessment of lead in tap water ingested by residential children, default values in the model are used to represent the fraction of ingested particulates from soil versus house dust, and the level of maternal contribution. Additionally, the model's default values are used to represent respiratory rate, soil and water ingestion rates, and the percent of lead absorption by the various exposure routes. The only site-specific factors put into the IEUBK model are the concentrations of lead (EPC) in groundwater and soil.

5.0 RISK CHARACTERIZATION

Potential human health risks resulting from the exposures outlined in the preceding sections are characterized on a quantitative and qualitative basis in this section. Quantitative risk estimates were generated based on risk evaluation methods outlined in current EPA guidance (EPA, 1989).

Noncarcinogenic risk estimates were presented in the form of HQs and HIs that are determined through comparison of estimated intakes with published RfDs. Incremental cancer risk estimates were provided in the form of dimensionless probabilities based on SFs.

Estimated human intakes were developed for each of the specific exposure routes discussed in the preceding sections. Both noncarcinogenic and carcinogenic risks were summarized for each exposure route on a series of tables in this section.

5.1 NONCARCINOGENIC RISKS

Noncarcinogenic risk was assessed using the concept of HQs and HIs. The HQ is defined as the ratio of the estimated intake and the RfD for a selected chemical of concern, as follows:

$$HQ = \frac{Intake}{RfD}$$

HIs were generated by summing the individual HQs for the COPCs. If the value of the HI exceeds unity (1.0), the potential for noncarcinogenic health risks associated with exposure to that particular chemical mixture cannot be ruled out (EPA, 1986b). In that case, particular attention should be paid to the target organ(s) affected by each chemical because these are generally the organ(s) associated with RfD-derived effects, and results (HIs) for different organs are not truly additive. The HI is not defined as a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of exceedence of the acceptable threshold for noncarcinogenic effects. Above an HI of 1, toxic effects would not necessarily occur, but can no longer be ruled out.

5.2 CARCINOGENIC RISKS

Incremental cancer risk (ICR) estimates were generated for each of the exposure pathways using the estimated intakes and published SFs, as follows:

$$Risk = Intake * SF$$

The risk determined using this equation is defined as a unitless expression of an individual's increased likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An ICR of 1×10^{-6} indicates that the exposed receptor has a one in a million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons. The calculated cancer risks should be recognized as upper-limit estimates. SFs are defined as the upper 95 percent confidence limit of a dose-response curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on the SFs and may, in fact, be lower.

5.3 COMPARISON OF QUANTITATIVE RISK ESTIMATES TO BENCHMARK CRITERIA

In order to interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site, quantitative risk estimates are compared to typical benchmarks.

A HI exceeding unity (1) indicates that there may be potential noncarcinogenic health risks associated with exposure. If a HI exceeds unity, target organ effects from individual COPCs contributing to the risk are considered. Only those chemicals that impact the same target organ(s) or exhibit similar critical effect(s) will be regarded as truly additive. Thus, COPCs contributing to an HI greater than 1 on the basis of a single target organ/effect are considered to be COCs.

EPA has defined the range of 1×10^{-4} to 1×10^{-6} as the incremental cancer risk (ICR) "target range" for most hazardous waste facilities evaluated. Cumulative ICRs greater than 1×10^{-4} generally indicate that EPA will require some degree of remediation, and ICRs below 1×10^{-6} normally will not require that EPA initiate remedial efforts. Whenever ICRs fall between 1×10^{-4} to 1×10^{-6}, decisions for remediation will be made on a case-specific basis. Individual chemicals contributing significantly to risks above the target range are considered to be chemicals of concern (COCs). In addition, RIDEM has defined a threshold of 1×10^{-5} as the incremental cancer risk (ICR) for consideration for remediation. Both benchmarks will be referenced in the discussion of risk characterization at the OFFTA site.

Potential RME and CTE hazard indices and RME and CTE cancer risks were estimated for future potential receptors. The following sections present a summary of the results of the estimation of risk at areas/media of concern at the OFFTA site.

Receptor risks are presented for each media of concern in the form of tables and summary text. Each of these sections includes summaries of risks estimated by the exposure scenarios. It should be noted that, in each risk summary table where HQs are reported as "N/A", the HQs were not calculable because no

RfD has been established. Usually in such cases, carcinogenicity is considered to be more important, since carcinogenicity will generally be seen at lower doses than noncarcinogenic effects. Cancer risks that are reported as "N/A" generally indicate that the chemical is not carcinogenic or that an SF has not yet been developed.

5.4 SITE-SPECIFIC NONCARCINOGENIC RISKS

Site-specific noncarcinogenic risks were estimated for potential future receptors at the OFFTA site. These risks are discussed below and presented on Tables 5.1, 5.2, 5.4, and 5.5 (RAGs D Table 9's).

RME Risks

The estimated RME HI for a residential child at the OFFTA site exceeded 1.0 (Table 5-1), which by itself is not an indicator of unacceptable risk but rather is a criterion for requiring that noncancer risks should be added separately for chemicals affecting the same target organ. When risks were segregated by target organ, the target organs exceeding 1.0 and the principal COPCs contributing to noncancer risk were: CNS (HI of 43 - manganese), skin and vascular system (HI of 12.4 - arsenic), kidney (HI of 2.7 - barium, cadmium, chromium, and dibenzofuran), weight loss (HI of 2.3 - naphthalene and 2-methylnaphthalene, and blood (HI of 1.3 - benzene and zinc).

The estimated RME HI for a residential adult at the OFFTA site exceeded 1.0 (Table 5-2). When risks were segregated by target organ, the target organs exceeding 1.0 and the principal COPCs contributing to noncancer risk were: CNS (HI of 15.1 - manganese), skin and vascular system (HI of 4.6 - arsenic), respiratory tract (HI of 3.4 - naphthalene), and blood (HI of 1.1 - benzene primary contributor).

CTE Risks

The estimated CTE HI for a residential child at the OFFTA site exceeded 1.0 (Table 5-4), which by itself is not an indicator of unacceptable risk but rather is a criterion for requiring that noncancer risks should be added separately for chemicals affecting the same target organ. When risks were segregated by target organ, the CNS was the only target organ associated with an HI exceeding 1.0 (HI of 8.7 - manganese).

The estimated CTE HI for a residential adult at the OFFTA site exceeded 1.0 (Table 5-5). When risks were segregated by target organ, the CNS was the only target organ associated with an HI exceeding 1.0 (HI of 3.4 - manganese).

5.5 SITE-SPECIFIC CANCER RISKS

Site-specific cancer risks were estimated for potential receptors at the OFFTA site. These risks are discussed below and presented on Tables 5.1 through 5.6 (RAGs D Table 9's).

RME Risks

The estimated RME ICR for a child resident exposed to groundwater at OFFTA site was 4.9×10^{-4} (see Table 5-1 for contribution from ingestion/dermal absorption). The ICR exceeded EPA's target risk range of 1×10^{-4} to 1×10^{-6}. The primary contributors to the cancer risk were arsenic via ingestion (ICR = 4.8×10^{-4}) and benzene via ingestion (ICR = 1.2×10^{-5}).

The estimated RME ICR for an adult resident exposed to groundwater at OFFTA site was 7.3×10^{-4} (see Table 5-2 for contribution from ingestion/dermal absorption and inhalation of VOCs during showering). The ICR exceeded EPA's target risk range of 1×10^{-4} to 1×10^{-6}. The primary contributors to the cancer risk were arsenic via ingestion (ICR = 7.0×10^{-4}) and benzene via inhalation (ICR = 1.1×10^{-5}) and ingestion (ICR = 1.7×10^{-5}).

The estimated RME incremental cancer risk (ICR) for a lifetime resident exposed to groundwater at OFFTA site was 1.2×10^{-3} (see Table 5-3 for contribution from ingestion/dermal absorption and inhalation of VOCs during showering). The ICR exceeded EPA's target risk range of 1×10^{-4} to 1×10^{-6}. The primary contributors to the cancer risk were arsenic via ingestion (ICR = 1.2×10^{-3}) and benzene via inhalation (ICR = 1.1×10^{-5}) and ingestion (ICR = 2.9×10^{-5}).

CTE Risks

The estimated CTE ICR for a child resident exposed to groundwater at OFFTA site was 1.0×10^{-5} (see Table 5-4 for contribution from ingestion/dermal absorption). The ICR is within EPA's target risk range of 1×10^{-4} to 1×10^{-6} and is equal to the 1×10^{-5} RIDEM criterion. The primary contributor to the cancer risk was arsenic via ingestion (ICR = 9.2×10^{-6}).

The estimated CTE ICR for an adult resident exposed to groundwater at OFFTA site was 1.6×10^{-5} (see Table 5-5 for contribution from ingestion/dermal absorption and inhalation of VOCs during showering). The ICR is within EPA's target risk range of 1×10^{-4} to 1×10^{-6}, but exceeds the 1×10^{-5} RIDEM criterion. The primary contributor to the cancer risk was arsenic via ingestion (ICR = 1.4×10^{-5}).

The estimated CTE ICR for a lifetime resident exposed to groundwater at OFFTA site was 2.6 x 10^{-5} (see Table 5-6 for contribution from ingestion/dermal absorption and inhalation of VOCs during showering). The ICR is within EPA's target risk range of 1 x 10^{-4} to 1 x 10^{-6}, but exceeds the 1 x 10^{-5} RIDEM criterion. The primary contributors to the cancer risk were arsenic via ingestion (ICR = 2.4 x 10^{-5}) and benzene via ingestion (ICR = 1.2 x 10^{-6}).

5.6 BLOOD-LEAD RISK CHARACTERIZATION

Blood-lead levels resulting from groundwater exposure in residential children (age 1 - 6) were estimated using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA (EPA, 1994a). The model is applied using the EPCs in each applicable medium of concern where lead was selected as a COPC at the OFFTA site. See the site specific EPC tables for specific lead values - groundwater EPCs in Table 2-1 in this report and soil EPCs in Tables and in the previous RI for OFFTA (TtNUS, 2000).

The output of the IEUBK Model is a histogram that presents the estimated percentage of children with a blood-lead level above 10 μg/dL (considered to be the threshold significance level above which adverse effects cannot be ruled out). When the percentage of the population estimated to have blood-levels above 10 μg/dL is greater than five percent, then EPA considers the potential for adverse effects to be significant (EPA, 1994c). These histograms, along with input information particular to each run of the IEUBK model, are presented in Figures 5.1 and 5.2 and in Tables 5.7 and 5.8. Uncertainties associated with the IEUBK model are discussed in Section 6.4.

5.6.1 Exposure to Lead in Groundwater and Surface Soil

Lead was selected as a COPC in groundwater (EPC of 207 μg/L) and surface soil (EPC of 49.7 mg/kg). The estimated percentage of children exposed to groundwater and surface soil that are predicted to exhibit a blood lead level above 10 μg/dL is 72.7 percent (Figure 5-1 and Table 5-7). This exceeds EPA's protective level cutoff of 5 percent and indicates that adverse effects to residential children under these conditions cannot be ruled out.

The majority of blood lead risk is attributable to exposure to groundwater rather than surface soil, as the groundwater concentration exceeded by more than an order of magnitude the lead screening level that is based on the 15 μg/L MCL, while the soil concentration was almost an order of magnitude less than the OSWER 400 mg/kg screening level that is associated with a blood lead risk near the 10 μg/dL threshold for 5 percent of the population.

5.6.2 Exposure to Lead in Groundwater and Subsurface Soil

Lead was selected as a COPC in groundwater (EPC of 207 μg/L) and subsurface soil (EPC of 507 mg/kg). The estimated percentage of children exposed to groundwater and subsurface soil that are predicted to exhibit a blood lead level above 10 μg/dL is 83.8 percent (Figure 5-2 and Table 5-8). This exceeds EPA's protective level cutoff of 5 percent and indicates that adverse effects cannot be ruled out from lead exposure to residential children under these conditions.

In this combined exposure scenario, the majority of blood lead risk is attributable to exposure to groundwater rather than to subsurface soil. Note that the groundwater concentration exceeded by more than an order of magnitude the MCL-based groundwater screening level, in contrast to the subsurface soil concentration, which exceeded the screening level by only 25 percent. The conclusion that groundwater rather than soil is the main risk driver for lead when dealing with combined exposures is also evident when one compares the relative blood lead risks of the two exposure scenarios -- 72.7 percent of children would exhibit elevated blood lead levels from groundwater exposure in combination with exposure to surface soil having minimal lead concentrations, while only a marginal further increase in lead risk (from 72.7 percent to 83.8 percent) would occur in the case of exposure to much higher lead concentrations found in subsurface soil, which were an order of magnitude greater than concentrations in surface soil.

6.0 UNCERTAINTY ANALYSIS

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the groundwater risk evaluation. As discussed in EPA (1989), the risk measures used in Superfund site risk evaluations are not fully probabilistic estimates of risk, but rather are conditional estimates based on a considerable number of assumptions about exposure and toxicity. There are uncertainties associated with each aspect of risk evaluation, from environmental data collection through risk characterization.

6.1 UNCERTAINTIES ASSOCIATED WITH DATA COLLECTION/EVALUATION

Major uncertainties associated with data collection/evaluation are highlighted below.

6.1.1 Selection of Well Locations and Groundwater Sampling Timeframe

The location of the monitoring well sampling points and the timeframe covered by the sampling rounds can impact the selection of COPCs, the calculation of EPCs, and consequently the risks estimated for a site. Generally, sample collection should include areas that contain the most significant contamination and should span a timeframe that is representative of current conditions in the groundwater plume. For this risk evaluation, one round of groundwater sampling data was used, consisting of 13 samples collected in 1997. Using only these data, the risk evaluation cannot document whether concentrations of VOCs in groundwater are gradually increasing or degreasing over time. Other rounds of data were generated prior to 1997 and groundwater contamination was evaluated and discussed in earlier reports (Brown & Root, 1994).

6.1.2 Data Collection Impacts on Selection of COPCs

Too few upgradient samples were collected to perform meaningful statistical background comparison tests, which precluded using background comparisons to eliminate COPCs in groundwater. Additional background monitoring wells might have been useful to demonstrate whether site-related concentrations of some inorganics are not elevated above background. A qualitative comparison of inorganic analytes found in the two background monitoring wells versus site monitoring wells is presented in Table 6-1. Descriptive statistics (mean, minimum, maximum, frequency of detection) were evaluated for similarity between the site-related monitoring wells versus the two background wells. Several metals were suggested to be elevated in site-related wells. Arsenic, cadmium, and lead were not detected in background wells and manganese and barium exhibited substantially greater maximum and mean detected levels in the site-related data set.

Of the inorganic substances found to be primary contributors to cancer or noncancer risks (arsenic, barium, cadmium, chromium, lead, and manganese), only chromium was similar in mean concentration among site and background data sets. If additional background data for groundwater had been available, then it might have been possible to conclude that chromium concentrations on-site are consistent with background concentrations. This would have eliminated chromium as one of the groundwater noncancer risk drivers for the target organ kidney for a residential child. However, chromium was not the most significant contributor among noncancer risk drivers for groundwater and the kidney and other target organs would still exhibit noncancer risks exceeding the benchmark HI of 1.0.

6.1.3 Data Collection Impacts on EPCs and Risks

Collecting only one round of samples for groundwater can impact the calculation of EPCs. According to Region I EPA guidance, the RME EPC for any COPC in groundwater is based on data associated with the well displaying the highest level of contamination for that compound. The RME EPC is calculated as the average concentration for that well, considering all sampling rounds. Therefore, if only one round of sampling is considered, as is the case for the OFFTA site, this approach equates to using the maximum detected value for each COPC. This introduces uncertainty because a more representative concentration for any particular well could have been calculated if more than one round of sampling data were to be used to estimate the average concentration for that well.

Data collection involved sampling a total of 13 on-site groundwater wells, with only two out of 13 wells revealing detectable levels of the primary cancer risk drivers benzene (detected in MW101 and MW102) and arsenic (found in MW101 and MW3S). Similarly, the noncarcinogenic risk drivers naphthalene and 2-methylnaphthalene were also only found in two wells (MW101 and MW102). These low frequencies of detection for the primary risk driver compounds suggests that the use of the maximum detected value as the RME EPC yields exposure estimates that are biased high and not representative of average groundwater conditions throughout the majority of the site. Therefore, RME cancer and noncancer risks associated with future residential exposure to groundwater may be overestimated across the majority of the OFFTA site for benzene, naphthalene, and 2-methylnaphthalene. In contrast, CTE risks, which are based on the average detected concentration, are considered more representative of conditions across most of the site.

For manganese, groundwater concentrations exceeded risk-based screening levels across the board, and associated noncancer risks would be significant whether based on the average manganese concentration detected in all wells (as presented for CTE risks in Table 5-4) or the maximum detected concentration (as presented for RME risks in Table 5-1).

6.1.4 Uncertainties in Laboratory Data Quality

Established data validation procedures were applied to define analytical uncertainties in terms of qualifying data as inaccurate or imprecise and to eliminate data points that are unusable for risk evaluation. This treatment does not eliminate all uncertainty but focuses attention on potential areas of concern regarding accuracy, precision, and data gaps. Validation was conducted by Navy contractors (TtNUS - Phase III) using EPA Region I and National Guidance.

6.1.5 Uncertainties in Risk-Based Screening Levels

The risk-based screening criteria account only for exposure to tap water ingestion and VOC inhalation from various uses of household water. This method does not account for dermal exposure and is not an accurate method for estimating VOC inhalation during showering; therefore, use of these screening levels might lead to the selection of too few COPCs. However, this problem is unlikely to have led to elimination of too many COPCs because a conservative 10-fold safety factor was used to adjust screening levels for noncarcinogens (derived from a target Hazard Index of 0.1), and carcinogens used a target risk of 1×10^{-6}, which is at the lower end of the acceptable risk range of 1×10^{-6} to 1×10^{-4}.

6.2 UNCERTAINTIES ASSOCIATED WITH EXPOSURE ASSESSMENT

This section identifies and quantifies, to the extent possible, the uncertainties associated with the exposure assessment for the site. The potential areas of uncertainty include the selection of current and anticipated future land uses, selection of exposure pathways, calculation and modeling of EPCs, and the selection of specific receptors and exposure parameters.

Residential tap water ingestion and household bathing/showering are impractical future exposure scenarios at the OFFTA site because of the current groundwater classification, high salinity of groundwater at the site and the availability of nearby alternative potable water supplies. However, institutional controls might be advisable to restrict other types of contact with groundwater - for example, to prevent contact with groundwater associated with lawn or garden sprinklers, car washing, swimming pools, etc.

To generate an upper bound estimate of risks from all potential uses of groundwater, a standard residential scenario was used because the degree of exposure to contaminants from this scenario would be greater than with other exposure scenarios. In this manner, the risk evaluation yielded standards for protectiveness that are assured to encompass the full range of possible exposures that might occur at the site.

Although cancer and noncancer risks were found to be notable under the unrealistic assumption of hypothetical household use of groundwater, there is actually a very low likelihood of significant risks occurring in association with outdoor watering, car washing, and swimming, which are the only plausible future receptor activity patterns involving use of groundwater. This is because daily drinking water ingestion and not dermal contact or inhalation were shown to be the primary exposure pathways contributing to the majority of groundwater risks under a residential exposure scenario. In contrast, plausible future activities at the OFFTA site would involve only sporadic incidental water ingestion – including an intake rate of at least 100-fold smaller than that assumed for drinking water consumption. This would result in proportionately lower ingestion risks (100-fold lower) relative to those in Table 5-1 and Table 5-3, yielding HIs generally less than 1.0 and lifetime cancer risks approximately 1.2×10^{-5}, which is within the acceptable risk range used by EPA.

Other exposure pathways would also be unlikely to generate significant risks in association with plausible future receptor activity patterns. As shown in Table 5-1 and Table 5-3, the dermal exposure pathway for household water use yielded no significant carcinogenic risks and displayed significant noncancer risks only for manganese (HQ = 4.2) and naphthalene and 2-methylnaphthalene (combined target organ HI for weight loss of 1.1). However, given that future exposures would be unlikely to involve whole-body dermal contact on a daily basis throughout the year, any plausible exposure scenario would involve either a dermal exposure frequency or a dermal contact surface area that was at least 4-fold smaller. In such a case, dermal risks would be proportionately lower than those estimated for the residential household water use scenario, and would yield noncancer risks having an HI of less than 1.0, the threshold below which adverse effects are not anticipated. Therefore, occasional outdoor dermal contact with groundwater, even for an extended period of time, would not be expected to yield unacceptable risks at the OFFTA site.

With respect to the inhalation pathway, a cancer risk of 7.8×10^{-5} from residential showering exceeds RIDEM's 1×10^{-5} benchmark. However, a more plausible scenario would be limited to exposures to unheated water sprayed outdoors, with rapid dispersion of volatiles from an unconfined space rather than concentration of vapors within a shower stall. Exposure to VOC vapors under such conditions would yield an inhalation intake more than one order of magnitude smaller than that estimated for residential showering, resulting in a proportionately lower cancer risk that would fall within EPA's and RIDEM's acceptable risk range.

There are limitations to using various models and/or equations to estimate exposure doses or contaminant concentrations.

Uncertainties associated with the lack of modeling future groundwater concentrations at the site include the assumption that current conditions are indicative of future concentrations of contaminants. Contaminants may increase (due to leaching or chemical transformation) or decrease (due to migration or transformation) over time and vary from area to area.

Prediction of absorption rates for lipophilic compounds is difficult due to, among other reasons, the possibility of a second absorption pathway that depends on the lipid content of the stratum corneum at the application site. Experimental determination of absorption rates indicates that interspecies differences are considerable, which, along with other variability's related to condition and age of skin, differences in lag time, and site of application effects, yields appreciable uncertainty in estimated dermal exposures by using published chemical-specific permeation functions. In addition, literature data indicate a variation by as much as a factor of 300 in chemical absorption rates for skin in different anatomical areas of the body. It should also be noted that children generally have greater absorption rates than adults.

6.3 UNCERTAINTIES ASSOCIATED WITH TOXICITY ASSESSMENT

6.3.1 RfDs and SFs

There is uncertainty associated with the RfDs and SFs. The uncertainty results from the extrapolation of animal data to humans, the extrapolation of carcinogenic effects from the laboratory high-dose to the environmental low-dose scenarios, and interspecies and intraspecies variations in toxicological endpoints caused by chemical exposure. The use of EPA RfD values is generally considered to be conservative because the doses are based on no-effect or lowest-observed-effect levels and then further reduced with uncertainty factors to increase the margin of safety by a factor in the neighborhood of 10 to 1,000-fold.

The RfDs and SFs of some chemicals have not been established, and therefore toxicity could not be quantitatively assessed. In most cases, where RfDs were unavailable for carcinogens, the carcinogenic risk is considered to be much more significant since carcinogenic effects usually occur at much lower doses.

The uncertainty associated with the dermal exposure is high because of the derivation of the dermal slope factor and reference dose. The dermal toxicity factors are based on default oral absorption factors. This can result in an overestimation of the toxicity factors. In general, dermal exposures at OFFTA site did not drive the carcinogenic or noncarcinogenic risks, therefore, the effects of this uncertainty are expected to be minimal.

As discussed in Section 4.2, established RfDs have an inherent amount of uncertainty. Uncertainty factors for RfDs used in this risk evaluation are presented on Tables 4.1 and 4.2. Some chemical specific uncertainties should be noted as follows:

- Although the accepted basis for evaluating risk associated with exposure to arsenic is to assume it is a carcinogen, there is uncertainty whether carcinogenic effects are the primary health effects expected to be manifested upon exposure to arsenic. There is some scientific information to indicate that humans are capable of metabolizing arsenic to expedite its elimination from the body (ATSDR, 1988). [Specifically, the body methylates the arsenic to form monomethyl arsenic and dimethyl arsenic]. There is a limited capacity for the body to metabolize methylate arsenic, but this limit is generally reached when the body's intake of arsenic approximately exceeds 500 µg/day. Generally, concentrations of arsenic in groundwater at OFFTA site would be expected to correspond to levels that are well within the body's ability to metabolize arsenic. On the other hand, arsenic has been associated with a variety of cancers in epidemiological studies. This adds to the uncertainty regarding carcinogenic risks associated with arsenic exposure.

- In nature, chromium (III) predominates over chromium (VI) (Langård and Norseth 1986). Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly. Toxicity criteria are available for two different forms of chromium, the trivalent state and the hexavalent state; the latter is considered to be more toxic. No chromium speciation was performed at the OFFTA site, therefore, it was conservatively assumed that chromium is present in the hexavalent form. This could tend to overestimate the noncarcinogenic risks at the site.

- Quantitative risks were not calculated for aluminum, cobalt, copper, and iron because these metals do not have accepted toxicity values for use in quantitative risk evaluation. Their concentrations in groundwater at the OFFTA Newport site do not exceed risk-based screening criteria [derived from provisional RfDs developed by the EPA National Center for Environmental Assessment (NCEA)] as listed in the EPA Region IX PRG table (EPA, 2000a). Therefore, the uncertainty from lack of toxicity factors for aluminum, cobalt, copper, and iron is not expected to result in underestimation of potential human health risks at the OFFTA Newport site.

- 2-Methylnaphthalene and phenanthrene were detected in groundwater. Although published RfDs were not available for these substances, surrogate screening values were adopted using other PAH compounds with published RfD values (naphthalene and fluoranthene, respectively). Phenanthrene was found to be present below screening levels and so was not selected as a COPC. 2-Methylnaphthalene was present at a concentration exceeding the screening level;

therefore, risks associated with this compound were estimated using the RfD for the surrogate compound naphthalene. 2-Methylnaphthalene is an appropriate surrogate compound because it is structurally very similar to naphthalene. Accounting for potential noncancer risks in this manner reduces the chance of underestimating risks from compounds without published toxicity factors.

6.4 UNCERTAINTIES ASSOCIATED WITH LEAD RISK CHARACTERIZATION

The IEUBK model accounts for the multimedia nature of lead exposure, incorporates absorption and pharmacokinetic information, and allows the risk manager to consider the potential distributions of exposure and risk likely to occur at a site (the model goes beyond providing a single point estimate output). Although uncertainties are associated with blood lead modeling using the IEUBK model, these uncertainties are considered lower than those that conceivably would result from similar lead evaluations performed using a traditional toxicity slope-based approach. Important uncertainties and limitations in the use of the IEUBK model are listed below.

The IEUBK model uses a default of 30 percent lead absorption from soil. However, the bioavailability of lead from different sources may be variable due to differences in lead speciation, particle size, and mineral matrix and may also vary as a function of physiological parameters such as age, nutritional status, gastric pH, and transit time. For example, lead absorption from paint chips in soil may be different than lead absorption from other chemical forms.

Blood lead variability in the IEUBK model is characterized by a single number, the geometric standard deviation, which is set to a default value of 1.6. This value represents the aggregate uncertainty in all sources of population variability, including biological, uptake, exposure, sampling, and analytical components.

Child blood lead level predictions obtained using the IEUBK model reflect only the contributions of sources entered into the model and do not take into account any existing body burden that may be the result of prior exposures or any exposures that may have taken place at alternate locations away from the household or neighborhood level, such as parks or daycare centers.

7.0 SUMMARY

This section summarizes the groundwater risk evaluation for OFFTA site. The groundwater risk evaluation for the OFFTA site considered potential exposures to residents (future exposures to children, age 1 - 6, and adults). Residential tap water ingestion and household bathing/showering are impractical future exposure scenarios at the OFFTA site because of the groundwater classification, high salinity of groundwater at the site and the availability of nearby alternative potable water supplies. However, if the site were released for unrestricted residential use, other types of future residential contact with groundwater are conceivable - for example, contact with groundwater associated with lawn or garden sprinklers, car washing, swimming pools, etc.

To generate an upper bound to risks from all potential uses of groundwater, a standard residential scenario was applied because the degree of exposure to contaminants from this scenario would be greater than with other exposure scenarios. In this manner, the risk evaluation can be used to generate standards for protectiveness that are assured to encompass the full range of possible exposures that might occur at the site. However, it is likely that the groundwater risk evaluation overestimated the probable risks associated with these secondary residential exposure pathways because tap water ingestion, residential bathing, and residential showering are associated with greater contact and uptake of contaminants than with other activities.

7.1 RME NONCANCER RISKS

The estimated RME HI for a residential child at the OFFTA site exceeded the acceptable level of 1.0. The target organs exceeding 1.0 and the principal COPCs contributing to noncancer risk were: CNS (manganese), skin and vascular system (arsenic), kidney (barium, cadmium, chromium, and dibenzofuran), weight loss (naphthalene and 2-methylnaphthalene, and blood (benzene and zinc).

The estimated RME HI for a residential adult at the OFFTA site also exceeded the acceptable level of 1.0 (target organs and principal COPCs contributing to noncancer risk were a subset of those for child risks).

Although noncancer risks were found to be notable under the unrealistic assumption of hypothetical household use of groundwater, there is actually a very low likelihood of significant risks occurring in association with outdoor watering, car washing, and swimming, which are the only plausible future receptor activity patterns involving use of groundwater. This is because drinking water ingestion contributed the majority of noncancer risk under a residential groundwater exposure scenario, while plausible future scenarios would involve only sporadic incidental water ingestion – including an intake rate of at least 100-fold smaller than that assumed for drinking water consumption. This would result in

proportionately lower ingestion risks (100-fold lower) relative to those presented for a residential exposure scenario, yielding HIs generally less than 1.0.

Other exposure pathways would also be unlikely to generate significant risks in association with plausible future receptor activity patterns. Given that future exposures would be unlikely to involve whole-body dermal contact on a daily basis throughout the year, any plausible exposure scenario would involve either a dermal exposure frequency or a dermal contact surface area that was at least 4-fold smaller than those estimated for the residential household water use scenario, and would yield noncancer risks having an HI of less than 1.0, the threshold below which adverse effects are not anticipated.

Of the inorganic substances found to be primary contributors to noncancer risks (arsenic, barium, cadmium, chromium, and manganese), only chromium was similar in mean concentration among site and background data sets. If additional background data for groundwater had been available, then it might have been possible to conclude that chromium concentrations on-site are consistent with background concentrations.

The low frequencies of detection (two out of 13 on-site wells) for three compounds contributing to noncancer HIs exceeding 1.0, benzene, naphthalene, and 2-methylnaphthalene, suggests that the use of the maximum detected value as the groundwater EPC yields exposure estimates that are biased high and not representative of average groundwater conditions throughout the majority of the site. Therefore, RME noncancer risks associated with future residential exposure to groundwater may be overestimated across the majority of the OFFTA site for benzene, naphthalene, and 2-methylnaphthalene. In contrast, CTE risks, which are based on the average detected concentration, are considered more representative of conditions across most of the site.

7.2 CTE NONCANCER RISKS

The estimated CTE HI for a residential child at the OFFTA site exceeded the acceptable level of 1.0. The CNS was the only target organ associated with an HI exceeding 1.0 (manganese). The estimated CTE HI for a residential adult at the OFFTA site also exceeded the acceptable level of 1.0.

7.3 RME CANCER RISKS

The estimated RME ICRs for a child resident, an adult resident, and a lifetime resident exposed to groundwater at OFFTA site exceeded EPA's target risk range of 1×10^{-4} to 1×10^{-6}. The primary contributors to these cancer risks were arsenic via ingestion and benzene via inhalation and ingestion.

Although cancer risks were found to be notable under the unrealistic assumption of hypothetical household use of groundwater, there is actually a very low likelihood of significant risks occurring in association with outdoor watering, car washing, and swimming, which are the only plausible future receptor activity patterns involving use of groundwater. This is because drinking water ingestion contributed the majority of cancer risk under a residential groundwater exposure scenario, while plausible future scenarios would involve only sporadic incidental water ingestion – including an intake rate of at least 100-fold smaller than that assumed for drinking water consumption. This would result in proportionately lower ingestion risks (100-fold lower) relative to those presented under a residential exposure scenario, yielding lifetime cancer risks approximately 1.2×10^{-5}, which is within the acceptable risk range used by EPA.

With respect to the inhalation pathway, a cancer risk of 7.8×10^{-5} from residential showering exceeds RIDEM's 1×10^{-5} benchmark. However, a more plausible scenario would be limited to exposures to unheated water sprayed outdoors, with rapid dispersion of volatiles from an unconfined space rather than concentration of vapors within a shower stall. Exposure to VOC vapors under such conditions would yield an inhalation intake more than one order of magnitude smaller than that estimated for residential showering, resulting in a proportionately lower cancer risk that would fall within EPA's and RIDEM's acceptable risk range.

The low frequencies of detection (two out of 13 on-site wells) for benzene, one of the compounds associated with significant cancer risk, suggests that the use of the maximum detected value as the groundwater EPC yields exposure estimates that are biased high and not representative of average groundwater conditions throughout the majority of the site. Therefore, RME cancer risks associated with future residential exposure to groundwater may be overestimated across the majority of the OFFTA site for benzene. In contrast, CTE risks, which are based on the average detected concentration, are considered more representative of conditions across most of the site.

7.4 CTE CANCER RISKS

The estimated CTE ICR for a child resident exposed to groundwater at OFFTA site was within EPA's target risk range of 1×10^{-4} to 1×10^{-6}, and equals the 1×10^{-5} RIDEM criterion. The primary contributor to the cancer risk was arsenic via ingestion.

The estimated CTE ICR for an adult resident exposed to groundwater at OFFTA site was within EPA's target risk range of 1×10^{-4} to 1×10^{-6}, but exceeds the 1×10^{-5} RIDEM criterion. The primary contributor to the cancer risk was arsenic via ingestion.

The estimated CTE ICR for a lifetime resident exposed to groundwater at OFFTA site was within EPA's target risk range of 1×10^{-4} to 1×10^{-6}, but exceeds the 1×10^{-5} RIDEM criterion. The primary contributors to the cancer risk were arsenic via ingestion and benzene via ingestion.

7.5 BLOOD-LEAD RISK CHARACTERIZATION

Blood-lead levels resulting from groundwater exposure in residential children (age 1 - 6) were estimated using the Integrated Exposure and Uptake Biokinetic (IEUBK) Model (version 0.99) developed by EPA (EPA, 1994a). When the percentage of the population estimated to have blood-levels above 10 μg/dL is greater than five percent, then EPA considers the potential for adverse effects to be significant (EPA, 1994c). The estimated percentage of children exposed to groundwater and surface soil that are predicted to exhibit a blood lead level above 10 μg/dL is 72.7 percent, which exceeds EPA's protective level cutoff of 5 percent and indicates that adverse effects to residential children under these conditions cannot be ruled out. The estimated percentage of children exposed to groundwater and subsurface soil that are predicted to exhibit a blood lead level above 10 μg/dL is 83.8 percent, which also exceeds EPA's protective level cutoff of 5 percent.

In this combined exposure scenario, the majority of blood lead risk is attributable to exposure to groundwater rather than to surface or subsurface soil. The conclusion that groundwater rather than soil is the main risk driver for lead when dealing with combined exposures is evident when one compares the relative blood lead risks of the two exposure scenarios -- 72.7 percent of children would exhibit elevated blood lead levels from groundwater exposure in combination with exposure to surface soil having minimal lead concentrations, while only a marginal further increase in lead risk (from 72.7 percent to 83.8 percent) would occur in the case of exposure to much higher lead concentrations found in subsurface soil, which were an order of magnitude greater than concentrations in surface soil.

TABLES

TABLE 2-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN IN GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact with tap water

CAS Number	Chemical	Minimum (1) Concentration	Minimum Qualifier	Maximum (1) Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening	Screening (3) Toxicity Value	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for (4) Contaminant Deletion or Selection
7429-90-5	Aluminum	645	J	13000	J	ug/L	OFF-A-MW3S-01	6/13	14.3-564	13000	0 N			Y	NTX
7440-38-2	Arsenic	44.5		49.8		ug/L	OFF-A-MW3S-01	2/13	1.8-6.9	49.8	0.045 C	50	MCL	Y	ASL
7440-39-3	Barium	5.3		390		ug/L	OFF-A-MW102-01	12/13	3.5-3.6	390	260 N	2000	MCL	Y	ASL
7440-43-9	Cadmium	2.4	J	3.4	J	ug/L	OFF-A-MW3S-01	3/13	0.19-0.52	3.4	1.8 N	5	MCL	Y	ASL
7440-70-2	Calcium	16200	J	281000	J	ug/L	OFF-A-MW2S-01	13/13	N/A	281000	0 N			N	NUT
7440-47-3	Chromium	3.2		39.9		ug/L	OFF-A-MW11R-01	12/13	1.3-1.3	39.9	11 N	100	MCL	Y	ASL
7440-48-4	Cobalt	6.1		87		ug/L	OFF-A-MW7S-01	9/13	0.94-3.8	87	0 N			Y	NTX
7440-50-8	Copper	13.6	J	166	J	ug/L	OFF-A-MW3S-01	4/13	1.4-12.3	166	0 N	1300 (TT)	MCL	Y	NTX
7439-89-6	Iron	934	J	129000	J	ug/L	OFF-A-MW3S-01	12/13	183-187	129000	0 N			Y	NTX
7439-92-1	Lead	1.6	J	207	J	ug/L	OFF-A-MW3S-01	10/13	1.4-1.4	207	15 C	15 (TT)	MCL	Y	ASL
7439-95-4	Magnesium	11100	J	718000	J	ug/L	OFF-A-MW2S-01	13/13	N/A	718000	0 N			N	NUT
7439-96-5	Manganese	396	J	12500	J	ug/L	OFF-A-MW4S-01	13/13	N/A	12500	88 N			Y	ASL
7439-97-6	Mercury	0.02	J	0.24		ug/L	OFF-A-MW3S-01	3/13	0.01-0.01	0.24	0.36 N	2	MCL	N	BSL
7440-09-7	Potassium	5700	J	258000	J	ug/L	OFF-A-MW2S-01	13/13	N/A	258000	0 N			N	NUT
7440-22-4	Silver	0.82	J	1.9	J	ug/L	OFF-A-MW11S-01	2/13	0.82-6.5	1.9	18 N			N	BSL
7440-23-5	Sodium	39300	J	5960000	J	ug/L	OFF-A-MW2S-01	12/13	1010000-1010000	5960000	0 N			N	NUT
7440-62-2	Vanadium	0.59	J	37.5		ug/L	OFF-A-MW3S-01	7/13	0.57-0.57	37.5	26 N			Y	ASL
7440-66-6	Zinc	8	J	1570		ug/L	OFF-A-MW2S-01	5/13	4.8-52	1570	1100 N			Y	ASL
91-57-6	2-Methylnaphthalene	3	J	190		ug/L	OFF-A-MW101-01	2/13	10-11	190	0.62 N			Y	ASL
83-32-9	Acenaphthene	3	J	9	J	ug/L	OFF-A-MW101-01	2/13	10-11	9	37 N			N	BSL
86-74-8	Carbazole	1	J	2	J	ug/L	OFF-A-MW101-01	2/13	10-11	2	3.4 C			N	BSL
132-64-9	Dibenzofuran	2	J	8	J	ug/L	OFF-A-MW101-01	2/13	10-11	8	2.4 N			Y	ASL
86-73-7	Fluorene	3	J	9	J	ug/L	OFF-A-MW101-01	2/13	10-11	9	24 N			N	BSL
91-20-3	Naphthalene	11		150		ug/L	OFF-A-MW101-01	2/13	10-11	150	0.62 N			Y	ASL
85-01-8	Phenanthrene	3	J	7	J	ug/L	OFF-A-MW101-01	2/13	10-11	7	150 N			N	BSL
108-95-2	Phenol	2	J	5	J	ug/L	OFF-A-MW11R-01	2/13	10-11	5	2200 N			N	BSL
71-43-2	Benzene	8	J	33		ug/L	OFF-A-MW102-01	2/13	10-10	33	0.35 C	5	MCL	Y	ASL
100-41-4	Ethylbenzene	38		38		ug/L	OFF-A-MW102-01	1/13	10-10	38	130 N	700	MCL	N	BSL

(1) Minimum/maximum detected concentration.
(2) Due to a limited size data set, background values were not used in decisions to selected COPCs and are presented for informational purposes only.
(3) Screening toxicity values obtained from EPA Region IX PRGs.
(4) Rationale Codes Selection Reason: Above Screening Levels (ASL)
(TT) -- Treatment Technique requires systems to control the corrosiveness of water supply if more than 10% of samples exceed the listed action levels.

Deletion Reason:
Essential Nutrient (NUT)
Below Screening Level (BSL)
Essential Nutrient (NUT)
No Toxicity Information (NTX)

TABLE 2-2
STATISTICAL DISTRIBUTION OF COPCS IN GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

						Parameter Used in UCL Calculation						
Substance	Number of Sample Results	Statistical Distribution of Site Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Type of UCL Calc	Coefficient for $H_{0.95}$ (Lognorm.) or $T_{0.95}$ (Normal)	Std. Dev. Or Log Std. Dev.	Arithmetic Mean or Anti-log of Mean of Logs	Upper Confidence Limit (UCL) on Mean	Maximum Positive Site Concentration	RME Exposure Point Concentration
			W-norm.	W-lognorm.	W-Table							
Aluminum	13	lognormal	0.4397	0.9815	0.866	Max	4.6458	1.92	307	25700	13000	13000
Arsenic	13	nonparametric (assumed lognorm.)	0.4786	0.612	0.866	Max	3.6939	1.45	2.01	27.3	49.8	49.8
Barium	13	lognormal	0.6786	0.9835	0.866	Max	3.8728	1.54	27.4	508	390	390
Cadmium	13	nonparametric (assumed lognorm.)	0.5891	0.6396	0.866	Max	3.7113	1.46	0.232	3.25	3.4	3.4
Calcium	13	lognormal	0.8691	0.9538	0.866	Max	2.5942	0.847	75300	203000	281000	281000
Chromium	13	lognormal	0.8543	0.9389	0.866	Max	3.1349	1.16	9.4	52.6	39.9	39.9
Cobalt	13	lognormal	0.8105	0.9282	0.866	Max	4.1037	1.66	9.41	266	87	87
Copper	13	nonparametric (assumed lognorm.)	0.5188	0.8529	0.866	Max	4.3287	1.77	4.98	218	166	166
Iron	13	lognormal	0.4034	0.9456	0.866	Max	4.2345	1.72	3110	113000	129000	129000
Lead	13	lognormal	0.4191	0.9277	0.866	Max	4.1453	1.68	4.88	149	207	207
Magnesium	13	lognormal	0.7293	0.9166	0.866	Max	3.6423	1.43	64300	800000	718000	718000
Manganese	13	lognormal	0.7807	0.9603	0.866	Max	3.0677	1.12	2230	11300	12500	12500
Mercury	13	nonparametric (assumed lognorm.)	0.4868	0.5505	0.866	Max	3.54	1.38	0.00973	0.102	0.24	0.24
Potassium	13	lognormal	0.7669	0.9314	0.866	Max	3.3897	1.3	29700	245000	258000	258000
Silver	13	nonparametric (assumed lognorm.)	0.738	0.8137	0.866	Max	2.3159	0.661	0.707	1.37	1.9	1.9
Sodium	13	lognormal	0.7019	0.9275	0.866	Max	4.0119	1.61	470000	11200000	5960000	5960000
Vanadium	13	nonparametric (assumed lognorm.)	0.3531	0.7417	0.866	Max	3.5674	1.39	0.775	8.51	37.5	37.5
Zinc	13	lognormal	0.5932	0.8723	0.866	Max	5.1655	2.17	30.8	8280	1570	1570
2-Methylnaphthalene	13	nonparametric (assumed lognorm.)	0.3144	0.4037	0.866	Max	2.8954	1.03	6.45	25.8	190	190
Acenaphthene	13	nonparametric (assumed lognorm.)	0.6114	0.6603	0.866	Max	1.8501	0.227	5.1	5.91	9	9
Carbazole	13	nonparametric (assumed normal)	0.5589	0.5119	0.866	Max	1.7823	1.38	4.54	5.22	2	2
Dibenzofuran	13	nonparametric (assumed normal)	0.6573	0.5847	0.866	Max	1.7823	1.24	5.08	5.69	8	8
Fluorene	13	nonparametric (assumed lognorm.)	0.6114	0.6603	0.866	Max	1.8501	0.227	5.1	5.91	9	9
Naphthalene	13	nonparametric (assumed lognorm.)	0.3262	0.4157	0.866	Max	2.7551	0.946	7	23.2	150	150
Phenanthrene	13	nonparametric (assumed normal)	0.6932	0.6519	0.866	Max	1.7823	0.838	5.08	5.49	7	7
Phenol	13	nonparametric (assumed normal)	0.395	0.3631	0.866	Max	1.7823	0.855	4.81	5.23	5	5
Benzene	13	nonparametric (assumed lognorm.)	0.3512	0.4016	0.866	Max	2.1459	0.529	5.99	9.56	33	33
Ethylbenzene	13	nonparametric (assumed lognorm.)	0.3063	0.3063	0.866	Max	2.1873	0.563	5.84	9.77	38	38

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are considered as one result. Non-detected results are treated as present at one-half the detection limit in all calculations.
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05.
A normal distribution is assumed if the test statistic W-norm. is >= than the reference value (W-table), and W-norm. > W-lognorm.
A lognormal distribution is assumed if the test statistic W-lognorm. is >= the reference value (W-table), and W-lognorm. >= W-norm. The better fitting distribution is assumed if neither distribution passes Shapiro test.
Arithmetic mean includes positive detections and non-detected results (detection limits are divided by two).
95%UCL-H: Parameters used in UCL Calculation consist of the H-coefficient, the standard deviation, the arithmetic mean, and the H-distribution upper 95% confidence limit.
95%UCL-T: Parameters used in UCL Calculation consist of the T-coefficient, the standard deviation, the arithmetic mean, and the T-distribution upper 95% confidence limit.

TABLE 2-3
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY - GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact with tap water

Chemical of Potential Concern	Units	Arithmetic Mean	95% UCL of Normal Data	Maximum Detected Concentration	Maximum Qualifier	EPC Units	Reasonable Maximum Exposure			Central Tendency		
							Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale	Medium EPC Value	Medium EPC Statistic	Medium EPC Rationale
Aluminum	ug/L	1480	25700	13000	J	ug/L	13000	Max	GW, use Max	1440	Mean-T	Mean-T <=Max
Arsenic	ug/L	8.32	27.3	49.8		ug/L	49.8	Max	GW, use Max	5.04	Mean-T	Mean-T <=Max
Barium	ug/L	72.9	508	390		ug/L	390	Max	GW, use Max	76.5	Mean-T	Mean-T <=Max
Cadmium	ug/L	0.758	3.25	3.4	J	ug/L	3.4	Max	GW, use Max	0.587	Mean-T	Mean-T <=Max
Chromium	ug/L	15.2	52.8	39.9		ug/L	39.9	Max	GW, use Max	17.1	Mean-T	Mean-T <=Max
Cobalt	ug/L	22.6	266	87		ug/L	87	Max	GW, use Max	30.5	Mean-T	Mean-T <=Max
Copper	ug/L	27.2	218	166	J	ug/L	166	Max	GW, use Max	18.7	Mean-T	Mean-T <=Max
Iron	ug/L	13800	113000	129000	J	ug/L	129000	Max	GW, use Max	11000	Mean-T	Mean-T <=Max
Lead	ug/L	22.5	149	207	J	ug/L	207	Max	GW, use Max	16.2	Mean-T	Mean-T <=Max
Manganese	ug/L	3820	11300	12500	J	ug/L	12500	Max	GW, use Max	3910	Mean-T	Mean-T <=Max
Vanadium	ug/L	3.58	8.51	37.5		ug/L	37.5	Max	GW, use Max	1.8	Mean-T	Mean-T <=Max
Zinc	ug/L	244	8280	1570		ug/L	1570	Max	GW, use Max	210	Mean-T	Mean-T <=Max
2-Methylnaphthalene	ug/L	19.2	25.8	190		ug/L	190	Max	GW, use Max	10.3	Mean-T	Mean-T <=Max
Dibenzofuran	ug/L	5.08	5.69	8	J	ug/L	8	Max	GW, use Max	5.08	Mean-N	Avg <= Max
Naphthalene	ug/L	16.7	23.2	150		ug/L	150	Max	GW, use Max	10.5	Mean-T	Mean-T <=Max
Benzene	ug/L	7.38	9.56	33		ug/L	33	Max	GW, use Max	6.81	Mean-T	Mean-T <=Max

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-H); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 3-1
VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL CHILD INGESTION OF GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact (via consumption of tap water) with Groundwater
Receptor Population: Resident
Receptor Age: Child (Age 1 to 6)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Chronic Daily Intake (CDI) (mg/kg-day) =
	IR-W	Ingestion Rate of Water	liters/day	1.29	EPA, 1997	0.74	EPA, 1997	(CW x IR-W x ET x EF x ED x CF1)/(BW x AT)
	EF	Exposure Frequency	days/year	350	EPA, 1994	350	EPA, 1994	
	ED	Exposure Duration	years	6	EPA, 1994	2	EPA, 1994	
	CF1	Conversion Factor	mg/ug	0.001	--	0.001	--	
	BW	Body Weight	kg	16.6	EPA, 1997	16.6	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	730	EPA, 1989	

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1994: USEPA Region I Waste Management Division, USEPA Risk Update No. 2, Aug. 1994.

EPA, 1997: Exposure Factors Handbook. Volume I, Aug. 1997, EPA/600/P-25/002FA.

EPA, 1998: working draft, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance, November, 1998.

TABLE 3-2
VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL CHILD DERMAL CONTACT WITH GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact (via dermal absorption during bathing) with Groundwater
Receptor Population: Resident
Receptor Age: Child (age 1-6)

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Dermal Absorption	CW	Chemical Concentration in Water	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Dermal Absorbed Dose (mg/kg-day) =
	SA-ADJ	Age-Adjusted Skin Surface Area/Body Wt. Ratio	cm2-years/kg	2682	(a)	2682	(a)	CW x SA-ADJ x KP x Function(ET) x EF x CF1 x
	KP	Permeability Constant (Dermal for Liquids)	cm/hr	Chemical-Specific	EPA, 2000	Chemical-Specific	EPA, 2000	CF2 x 1 / AT
	ET	Exposure Time	hr/day	0.75	EPA, 1997	0.33	EPA 1997	Where: Function(ET) = ET for inorganics, or
	EF	Exposure Frequency	days/year	350	EPA, 1994	350	EPA, 1994	2 x 2.45 x (Tau x ET / PI)^0.5 for organics where ET < T*, or
	ED	Exposure Duration	years	6	EPA, 1994	2	EPA, 1994	[ET/(1+B)] + Tau x (2+6B+6B^0.5)/(1+B)^0.5 for organics, ET > T*.
	CF1	Conversion Factor 1	mg/ug	0.001	--	0.001	--	See EPA,2000 for chemical-specific constants Tau, B, T*
	CF2	Conversion Factor 2	l/cm3	0.001	--	0.001	--	
	BW	Body Weight	kg	16.6	EPA, 1997	16.6	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	2190	EPA, 1989	730	EPA, 1989	

Notes/Sources:

(a). Surface Area represented by whole body (child age 1 through 6 years). Age-adjusted term surface area equals sum, i = 1 to 6, of (surface area at age i) x (1 year ED at age i) / (body weight at age i) Data from EPA, 1997.

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.

EPA, 1994: USEPA Region I Waste Management Division, USEPA Risk Update No. 2, Aug. 1994.

EPA, 1997. Exposure Factors Handbook. Update to Exposure Factors Handbook. EPA/600/8-89/043 - May 1989. Office of Research and Development.

EPA, 2000: working draft, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

TABLE 3-3

VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL ADULT INGESTION OF GROUNDWATER

OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION

NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact (via consumption of tap water) with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Ingestion	CW	Chemical Concentration in Water	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Chronic Daily Intake (CDI) (mg/kg-day) =
	IR-W	Ingestion Rate of Water	liters/day	2	EPA, 1997	1.4	EPA, 1997	(CW x IR-W x ET x EF x ED x CF1)/(BW x AT)
	EF	Exposure Frequency	days/year	350	EPA, 1994	350	EPA, 1994	
	ED	Exposure Duration	years	24	EPA, 1994	7	EPA, 1994	
	CF1	Conversion Factor	mg/ug	0.001	--	0.001	--	
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1994: USEPA Region I Waste Management Division, USEPA Risk Update No. 2, Aug. 1994.

EPA, 1997: Exposure Factors Handbook. Volume I, Aug. 1997, EPA/600/P-25/002FA.

TABLE 3-4

VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL ADULT DERMAL CONTACT WITH GROUNDWATER

OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION

NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Dermal Contact (during showering) with Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CT Value	CT Rationale/ Reference	Intake Equation/ Model Name
Dermal Absorption	CW	Chemical Concentration in Water	ug/l	See Table 3	See Table 3	See Table 3	See Table 3	Dermal Absorbed Dose (DAD) (mg/kg-day) =
	CWD	VOC Water Conc. lost in Shower by Evaporation	ug/l	See Shower Model	Foster & Chros.,1987	See Shower Model	Foster & Chros.,1987	(CW - CWD) x SA x KP x Function(ET) x EF x ED x CF1 x
	t	Exposure Time	min/event	15	EPA, 1997	15	EPA, 1997	CF2 x 1 / (BW x AT)
	Kp	Permeability Coefficient	cm/hr	chemical-specific	EPA, 2000	chemical-specific	EPA, 2000	Where: Function(ET) = ET for inorganics, or
	EV	Events	events/day	1	EPA, 1997	1	EPA, 1997	2 x 2.45 x (Tau x ET / PI)^0.5 for organics where ET < T*, or
	SA	Skin Surface Area Available for Contact	cm2	18150	EPA, 1997	18150	EPA, 1997	[ET/(1+B)] + Tau x (2+6B+6B^0.5)/(1+B)^0.5 for organics, ET > T*.
	EF	Exposure Frequency	days/year	350	EPA, 1994	350	EPA, 1994	See EPA,2000 for chemical-specific constants Tau, B, T*
	ED	Exposure Duration	years	24	EPA, 1994	7	EPA, 1994	
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	

(1) Professional Judgement.

(2) DAevent depends on exposure- and chemical-specific factors.

EPA, 1989: Risk Assessment Guidance for Superfund. Vol. 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

EPA, 1994: USEPA Region I Waste Management Division, USEPA Risk Update No. 2, Aug. 1994.

EPA, 1997: Exposure Factors Handbook. Volume I, Aug. 1997, EPA/600/P-25/002FA.

EPA, 2000: working draft, Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Dermal Risk Assessment, Interim Guidance.

Foster, S. A. and P.C. Chrostowski. 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower. Presented at the 80th Annual Meeting of the Air Pollution Control Association. New York, NY. June.

TABLE 3-5
VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL ADULT INHALATION OF VOLATILES FROM GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Airborne Vapors
Exposure Point: Inhalation of Volatiles (during showering) in Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
Inhalation	EF	Exposure Frequency	days/year	350	EPA, 1994	350	EPA, 1994	Intake (mg/kg-day) = (D x EF x ED)/AT
	ED	Exposure Duration	years	24	EPA, 1994	7	EPA, 1994	See Foster and Chrotowski, 1987
	AT-C	Averaging Time (Cancer)	days	25550	EPA, 1989	25550	EPA, 1989	
	AT-N	Averaging Time (Non-Cancer)	days	8760	EPA, 1989	2555	EPA, 1989	
	D	Inhalation Dose for Each Shower	mg/kg/shower	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: D = [(IR x S) / (BW x Ra x CF1)] x Q
	IR-SH	Inhalation Rate in Shower	l/min	14	EPA, 2000	9.2	EPA, 1997	
	BW	Body Weight	kg	70	EPA, 1997	70	EPA, 1997	
	CF1	Conversion Factor	(ug x l)/(mg x m3)	1.00E+06		1.00E+06		
	Q	Function of Air Exchange Rate & Time in Shower & Shower Room	min	2.7897	Foster & Chros.,1987	2.7897	Foster & Chros.,1987	where: Q = Ds + [(exp(-Ra x Dt))/Ra] - [(exp(Ra x (Ds - Dt)))/Ra]
	Ds	Duration of Shower	min	15	EPA, 1997	15	EPA, 1997	
	Dt	Total Time in Shower Room	min	20	EPA, 1997	20	EPA, 1997	
	Ra	Rate of Air Exchange	1/min	1.68E-02	Foster & Chros.,1987	1.68E-02	Foster & Chros.,1987	
	S	Indoor VOC Generation Rate	ug/m3/min	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: S = CWD x FR/SV
	FR	Shower Flow Rate	l/min	12.87	EPA, 1997	12.87	EPA, 1997	
	SV	Shower Room Air Volume	m3	6	EPA, 1997	6	EPA, 1997	
	CWD	Chemical Concentration Leaving Water Droplet after time ts	ug/l	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: CWD = CW x CF2 x [1-exp[(-KaL x ts)/60d])
	CW	Chemical Concentration in Water	ug/l	Chemical Specific	See Table 3	Chemical Specific	See Table 3	
	CF2	Conversion Factor	ug/mg	1000		1000		
	ts	Shower Droplet Time	sec	2	Foster & Chros.,1987	2	Foster & Chros.,1987	
	d	Shower Droplet Diameter	mm	1	Foster & Chros.,1987	1	Foster & Chros.,1987	
	KaL	Adjusted overall mass transfer coefficient	cm/hr	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: KaL = KL/SQRT[(T1 x us)/(Ts x u1)]
	T1	Calibration Water Temperature of KL	K	293	Foster & Chros.,1987	293	Foster & Chros.,1987	
	Ts	Shower Water Temperature	K	318	Foster & Chros.,1987	318	Foster & Chros.,1987	
	u1	Water Viscosity at T1	centipose	1.002	Foster & Chros.,1987	1.002	Foster & Chros.,1987	
	us	Water Viscosity at Ts	centipose	0.596	Foster & Chros.,1987	0.596	Foster & Chros.,1987	

TABLE 3-5 (continued)
VALUES USED FOR DAILY INTAKE CALCULATIONS - RME AND CTE RESIDENTIAL ADULT INHALATION OF VOLATILES FROM GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT RHODE ISLAND

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Airborne Vapors
Exposure Point: Inhalation of Volatiles (during showering) in Groundwater
Receptor Population: Resident
Receptor Age: Adult

Exposure Route	Parameter Code	Parameter Definition	Units	RME Value	RME Rationale/ Reference	CTE Value	CTE Rationale/ Reference	Intake Equation/ Model Name
	KL	Mass Transfer Coefficient	cm/hr	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: KL = 1/[(1/KL) + ((R x T)/(H x kg))]
	R	Ideal Gas law Constant	atm m3/mole/K	8.21E-05	Foster & Chros.,1987	8.21E-05	Foster & Chros.,1987	
	T	Absolute Temperature	K	293	Foster & Chros.,1987	293	Foster & Chros.,1987	
	H	Henry's law Constant	atm m3/mole	Chemical Specific	EPA, 1996	EPA, 1996	Foster & Chros.,1987	
	kg	Gas-film Mass Transfer Coefficient	cm/hr	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: kg = kH x SQRT[MWH/MW]
	kl	Liquid-film Mass Transfer Coefficient	cm/hr	Chemical Specific	Foster & Chros.,1987	Chemical Specific	Foster & Chros.,1987	where: kl = kC x SQRT[MWC/MW]
	kH	Gas-film Mass Transfer Coefficient for Water	cm/hr	3000	Foster & Chros.,1987	3000	Foster & Chros.,1987	
	kC	Liquid-film Mass Transfer Coefficient for Carbon Dioxide	cm/hr	20	Foster & Chros.,1987	20	Foster & Chros.,1987	
	MWH	Molecular Weight of Water	g/mole	18	Foster & Chros.,1987	18	Foster & Chros.,1987	
	MWC	Molecular Weight of Carbon Dioxide	g/mole	44	Foster & Chros.,1987	44	Foster & Chros.,1987	
	MW	Molecular Weight of COPC	g/mole	Chemical Specific		Chemical Specific		

Notes/Sources:

EPA, 1989. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A). EPA 540/1-89/002. Office of Emergency and Remedial Response. Washington, DC.

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Foster, S. A. and P.C. Chrostowski. 1987. Inhalation Exposures to Volatile Organic Contaminants in the Shower. Presented at the 80th Annual Meeting of the Air Pollution Control Association. New York, NY. June.

TABLE 3-6
DERMAL PERMEABILITY CONSTANTS
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Substance	KP	TAU	TSTAR	B
2-methylnaphthalene	0.098	0.66	1.58	0.4
cadmium	0.001			
zinc	0.0006			
aluminum	0.001			
iron	0.001			
manganese	0.001			
benzene	0.015	0.29	0.69	0.1
dibenzofuran	0.1	0.92	2.21	0.5
arsenic	0.001			
chromium	0.002			
copper	0.001			
lead	0.001			
naphthalene	0.049	0.55	1.32	0.2
barium	0.001			
cobalt	0.001			
vanadium	0.001			

TABLE 3-7
SURFACE AREAS USED IN DERMAL EXPOSURE ASSESSMENT
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AGE	Male Body Wt. (1) kg	Female Body Wt. (1) kg	Avg. Body Wt. kg	Male SA (1) cm^2	Female SA (1) cm^2	Avg. SA (1) cm^2
1-2	11.8	10.8		---	---	
2-3	13.6	13.0		6030	5790	
3-4	15.7	14.9		6640	6490	
4-5	17.8	17.0		7310	7060	
5-6	19.8	19.6		7930	7790	
6-7	23.0	22.1		8660	8430	
1 through 6 yr			**16.6**			7213

AGE		Avg. SA (1) cm^2****
Adult Male		19400
Adult Female		16900
Average Adult		18150

(1) All values obtained from EPA Exposure Factors Handbook, 1997.

TABLE 3-8
SHOWERING CONSTANTS
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Substance	Henry's Law Constant	Mol. Weight
2-Methylnaphthalene	0.000518	142.19
Benzene	0.0055	78.12
Dibenzofuran	0.000213	168.2
Naphthalene	0.00048	128.19

TABLE 4-1
NON-CANCER TOXICITY DATA - ORAL/DERMAL
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Oral to Dermal Adjustment Factor (1)	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3) (MM/DD/YY)
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	Chronic	3.00E-04	mg/kg-day	1.00E+00	3.00E-04	mg/kg-day	Skin/Vascular	3	IRIS	08/16/01
Barium	Chronic	7.00E-02	mg/kg-day	7.00E-02	4.90E-03	mg/kg-day	Kidney	3	IRIS	08/16/01
Cadmium	Chronic	5.00E-04	mg/kg-day	5.00E-02	2.50E-05	mg/kg-day	Kidney	10	IRIS	08/16/01
Chromium	Chronic	3.00E-03	mg/kg-day	2.50E-02	7.50E-05	mg/kg-day	Kidney	900	IRIS	08/16/01
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	Chronic	2.40E-02	mg/kg-day	4.00E-02	9.60E-04	mg/kg-day	CNS	1	IRIS	08/16/01
Vanadium	Chronic	7.00E-03	mg/kg-day	2.60E-02	1.82E-04	mg/kg-day	NOAEL	100	HEAST	1997
Zinc	Chronic	3.00E-01	mg/kg-day	1.00E+00	3.00E-01	mg/kg-day	Blood	3	IRIS	08/16/01
2-Methylnaphthalene	Chronic	2.00E-02	mg/kg-day	1.00E+00	2.00E-02	mg/kg-day	Weight Loss		EPA-NCEA	05/01/01
Dibenzofuran		4.00E-03	mg/kg-day	1.00E+00	4.00E-03	mg/kg-day	Kidney		EPA-NCEA	05/01/01
Naphthalene	Chronic	2.00E-02	mg/kg-day	1.00E+00	2.00E-02	mg/kg-day	Weight Loss	3000	IRIS	08/16/01
Benzene		3.00E-03	mg/kg-day	1.00E+00	3.00E-03	mg/kg-day	Blood/Immune		EPA-NCEA	05/01/01

N/A = Not Applicable

(1) Refer to RAGS, Part A

(2) Adjusted RfD = oral RfD x GI absorption value in toxicity study upon which the RfD is based. To be used for dermal pathway only.

(3) IRIS - Integrated Risk Information System (EPA, 2001)

HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

TABLE 4-2
NON-CANCER TOXICITY DATA -- INHALATION
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC	Units	Adjusted Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (MM/DD/YY)
Aluminum	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Barium		---	---	1.43E-04	mg/kg-day	Fetal Toxicity		HEAST Alternative	1997
Cadmium		---	---	5.70E-05	mg/kg-day			EPA-NCEA	05/01/01
Chromium	Subchronic	---	---	2.86E-05	mg/kg-day	Lung	300	IRIS	08/16/01
Cobalt	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Copper	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	Chronic	---	---	1.43E-05	mg/kg-day	CNS	1000	IRIS	08/16/01
Vanadium	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Dibenzofuran	N/A	---	---	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene		---	---	9.00E-04	mg/kg-day	Respiratory	1000	IRIS	08/16/01
Benzene		---	---	1.70E-03	mg/kg-day	Blood		EPA-NCEA	05/01/01

N/A = Not Applicable

(1) IRIS - Integrated Risk Information System (EPA, 2001)

TABLE 4-3
CANCER TOXICITY DATA -- ORAL/DERMAL
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical of Potential Concern	Oral Cancer Slope Factor	Oral to Dermal Adjustment Factor	Adjusted Dermal Cancer Slope Factor (1)	Units	Weight of Evidence/ Cancer Guideline Description	Source Target Organ	Date (MM/DD/YY)
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	1.50E+00	1.00E+00	1.50E+00	1/(mg/kg-day)	A	IRIS	08/16/01
Barium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cadmium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chromium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Copper	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dibenzofuran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	5.50E-02	1.00E+00	5.50E-02	1/(mg/kg-day)	A	IRIS	08/16/01

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

Weight of Evidence:
Known/Likely
Cannot be Determined
Not Likely

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

(1) Adjusted SF dermal = oral SF/GI absorption value in toxicity study upon which the SF is based. To be used for dermal pathway only.
(2) IRIS - Integrated Risk Information System (EPA, 2001)
HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

TABLE 4-4
CANCER TOXICITY DATA -- INHALATION
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical of Potential Concern	Unit Risk	Units	Adjustment	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description	Source	Date (MM/DD/YY)
Aluminum	---	---	---	N/A	N/A	N/A	N/A	N/A
Arsenic	---	---	---	1.51E+01	1/(mg/kg-day)	A	IRIS	08/16/01
Barium	---	---	---	N/A	N/A	N/A	N/A	N/A
Cadmium	---	---	---	6.30E+00	1/(mg/kg-day)	B1	IRIS	08/16/01
Chromium	---	---	---	4.10E+01	1/(mg/kg-day)	A	IRIS	08/16/01
Cobalt	---	---	---	N/A	N/A	N/A	N/A	N/A
Copper	---	---	---	N/A	N/A	N/A	N/A	N/A
Iron	---	---	---	N/A	N/A	N/A	N/A	N/A
Lead	---	---	---	N/A	N/A	N/A	N/A	N/A
Manganese	---	---	---	N/A	N/A	N/A	N/A	N/A
Vanadium	---	---	---	N/A	N/A	N/A	N/A	N/A
Zinc	---	---	---	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	---	---	---	N/A	N/A	N/A	N/A	N/A
Dibenzofuran	---	---	---	N/A	N/A	N/A	N/A	N/A
Naphthalene	---	---	---	N/A	N/A	N/A	N/A	N/A
Benzene	---	---	---	2.90E-02	1/(mg/kg-day)	A	IRIS	08/16/01

IRIS = Integrated Risk Information System
HEAST= Health Effects Assessment Summary Tables

Weight of Evidence:

EPA Group:
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C - Possible human carcinogen
D - Not classifiable as a human carcinogen
E - Evidence of noncarcinogenicity

(1) IRIS - Integrated Risk Information System (EPA, 2001)
HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

TABLE 5-1
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	4.77E-04	--	2.06E-06	4.79E-04	Arsenic	Skin/Vascular	1.24E+01	--	5.34E-02	1.24E+01
			Barium	--	--	--	--	Barium	Kidney	4.15E-01	--	2.56E-02	4.41E-01
			Cadmium	--	--	--	--	Cadmium	Kidney	5.07E-01	--	4.37E-02	5.50E-01
			Chromium	--	--	--	--	Chromium	Kidney	9.91E-01	--	3.42E-01	1.33E+00
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	3.88E+01	--	4.19E+00	4.30E+01
			Vanadium	--	--	--	--	Vanadium	NOAEL	3.99E-01	--	6.62E-02	4.65E-01
			Zinc	--	--	--	--	Zinc	Blood	3.90E-01	--	1.01E-03	3.91E-01
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	Weight Loss	7.08E-01	--	7.76E-01	1.48E+00
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	1.49E-01	--	1.97E-01	3.46E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	5.59E-01	--	2.80E-01	8.39E-01
			Benzene	1.16E-05	--	1.32E-06	1.29E-05	Benzene	Blood/Immune	8.20E-01	--	9.33E-02	9.13E-01
			(Total)	4.89E-04	--	3.38E-06	4.92E-04	(Total)		5.61E+01	--	6.06E+00	6.22E+01
						Total Risk Across Groundwater	4.92E-04					Total Hazard Index* Across Groundwater	6.22E+01
						Total Risk Across All Media and All Exposure Routes	4.92E-04					Total Hazard Index* Across All Media and All Exposure Routes	6.22E+01

Total Blood HI =	1.30E+00
Total CNS HI =	4.30E+01
Total Immune HI =	9.13E-01
Total Kidney HI =	2.67E+00
Total Skin HI =	1.24E+01
Total Vascular HI =	1.24E+01
Total Weight Loss HI =	2.32E+00

*- Total Hazard Index by itself is not an indicator of unacceptable risk but rather is a criterion for requiring that noncancer risks should be examined separately for chemicals affecting the same target organ.

TABLE 5-2
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT EXPOSURE TO GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	7.02E-04	--	1.59E-06	7.03E-04	Arsenic	Skin/Vascular	4.55E+00	--	1.03E-02	4.56E+00
			Barium	--	--	--	--	Barium	Kidney	1.53E-01	--	4.95E-03	1.58E-01
			Cadmium	--	--	--	--	Cadmium	Kidney	1.86E-01	--	8.45E-03	1.95E-01
			Chromium	--	--	--	--	Chromium	Kidney	3.64E-01	--	6.61E-02	4.31E-01
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.43E+01	--	8.09E-01	1.51E+01
			Vanadium	--	--	--	--	Vanadium	NOAEL	1.47E-01	--	1.28E-02	1.60E-01
			Zinc	--	--	--	--	Zinc	Blood	1.43E-01	--	1.95E-04	1.44E-01
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	Weight Loss	2.60E-01	--	1.85E-01	4.46E-01
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	5.48E-02	--	5.33E-02	1.08E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	2.05E-01	--	6.62E-02	2.72E-01
			Benzene	1.70E-05	--	9.05E-07	1.80E-05	Benzene	Blood/Immune	3.01E-01	--	1.60E-02	3.17E-01
			(Total)	7.19E-04	--	2.50E-06	7.21E-04	(Total)		2.06E+01	--	1.23E+00	2.19E+01
	Air	Inhalation of Groundwater Vapors During Showering											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	--	NA	--	--	Arsenic	N/A	--	--	--	--
			Barium	--	--	--	--	Barium	Fetal Toxicity	--	NA	--	--
			Cadmium	--	NA	--	--	Cadmium		--	NA	--	--
			Chromium	--	NA	--	--	Chromium	Lung	--	NA	--	--
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	--	NA	--	--
			Vanadium	--	--	--	--	Vanadium	N/A	--	--	--	--
			Zinc	--	--	--	--	Zinc	N/A	--	--	--	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	--	--	--
			Naphthalene	--	--	--	--	Naphthalene	Respiratory	--	3.36E+00	--	3.36E+00
			Benzene	--	1.08E-05	--	1.08E-05	Benzene	Blood	--	6.36E-01	--	6.36E-01
			(Total)	--	1.08E-05	--	1.08E-05	(Total)		--	4.00E+00	--	4.00E+00
						Total Risk Across Groundwater	7.32E-04					Total Hazard Index Across Groundwater	2.59E+01
						Total Risk Across All Media and All Exposure Routes	7.32E-04					Total Hazard Index Across All Media and All Exposure Routes	2.59E+01

Total Blood HI =	1.10E+00
Total CNS HI =	1.51E+01
Total Immune HI =	3.17E-01
Total Kidney HI =	8.91E-01
Total Respiratory HI =	3.36E+00
Total Skin HI =	4.56E+00
Total Vascular HI =	4.56E+00
Total Weight Loss HI =	7.17E-01

TABLE 5-3
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO GROUNDWATER
REASONABLE MAXIMUM EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	N/A	--	N/A	--
			Arsenic	1.18E-03	--	3.65E-06	1.18E-03	Arsenic	N/A	N/A	--	N/A	--
			Barium	--	--	--	--	Barium	N/A	N/A	--	N/A	--
			Cadmium	--	--	--	--	Cadmium	N/A	N/A	--	N/A	--
			Chromium	--	--	--	--	Chromium	N/A	N/A	--	N/A	--
			Cobalt	--	--	--	--	Cobalt	N/A	N/A	--	N/A	--
			Copper	--	--	--	--	Copper	N/A	N/A	--	N/A	--
			Iron	--	--	--	--	Iron	N/A	N/A	--	N/A	--
			Lead	--	--	--	--	Lead	N/A	N/A	--	N/A	--
			Manganese	--	--	--	--	Manganese	N/A	N/A	--	N/A	--
			Vanadium	--	--	--	--	Vanadium	N/A	N/A	--	N/A	--
			Zinc	--	--	--	--	Zinc	N/A	N/A	--	N/A	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	N/A	--	N/A	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	N/A	--	N/A	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	N/A	--	N/A	--
			Benzene	2.86E-05	--	2.22E-06	3.09E-05	Benzene	N/A	N/A	--	N/A	--
			(Total)	1.21E-03	--	5.87E-06	1.21E-03	(Total)		--	--	--	--
	Air	Inhalation of Groundwater Vapors During Showering											
			Aluminum	--	--	--	--	Aluminum	N/A	--	N/A	--	--
			Arsenic	--	--	--	--	Arsenic	N/A	--	N/A	--	--
			Barium	--	--	--	--	Barium	N/A	--	N/A	--	--
			Cadmium	--	--	--	--	Cadmium	N/A	--	N/A	--	--
			Chromium	--	--	--	--	Chromium	N/A	--	N/A	--	--
			Cobalt	--	--	--	--	Cobalt	N/A	--	N/A	--	--
			Copper	--	--	--	--	Copper	N/A	--	N/A	--	--
			Iron	--	--	--	--	Iron	N/A	--	N/A	--	--
			Lead	--	--	--	--	Lead	N/A	--	N/A	--	--
			Manganese	--	--	--	--	Manganese	N/A	--	N/A	--	--
			Vanadium	--	--	--	--	Vanadium	N/A	--	N/A	--	--
			Zinc	--	--	--	--	Zinc	N/A	--	N/A	--	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	--	N/A	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	N/A	--	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	--	N/A	--	--
			Benzene	--	1.08E-05	--	1.08E-05	Benzene	N/A	--	N/A	--	--
			(Total)	--	1.08E-05	--	1.08E-05	(Total)		--	--	--	--
						Total Risk Across Groundwater	1.22E-03					Total Hazard Index Across Groundwater	--

TABLE 5-4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO GROUNDWATER
CENTRAL TENDENCY EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	9.23E-06	--	9.17E-08	9.32E-06	Arsenic	Skin/Vascular	7.18E-01	--	7.13E-03	7.25E-01
			Barium	--	--	--	--	Barium	Kidney	4.67E-02	--	6.62E-03	5.33E-02
			Cadmium	--	--	--	--	Cadmium	Kidney	5.02E-02	--	9.96E-03	6.01E-02
			Chromium	--	--	--	--	Chromium	Kidney	2.44E-01	--	1.94E-01	4.37E-01
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	6.96E+00	--	1.73E+00	8.69E+00
			Vanadium	--	--	--	--	Vanadium	NOAEL	1.10E-02	--	4.20E-03	1.52E-02
			Zinc	--	--	--	--	Zinc	Blood	2.99E-02	--	1.78E-04	3.01E-02
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	Weight Loss	2.20E-02	--	8.37E-02	1.06E-01
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	5.43E-02	--	2.49E-01	3.03E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	2.24E-02	--	3.90E-02	6.14E-02
			Benzene	4.57E-07	--	1.76E-07	6.34E-07	Benzene	Blood/Immune	9.70E-02	--	3.74E-02	1.34E-01
			(Total)	9.69E-06	--	2.68E-07	9.96E-06	(Total)		8.26E+00	--	2.36E+00	1.06E+01
						Total Risk Across Groundwater	9.96E-06					Total Hazard Index* Across Groundwater	1.06E+01
						Total Risk Across All Media and All Exposure Routes	9.96E-06					Total Hazard Index* Across All Media and All Exposure Routes	1.06E+01

Total Blood HI =	1.65E-01
Total CNS HI =	8.69E+00
Total Immune HI =	1.34E-01
Total Kidney HI =	8.54E-01
Total Skin HI =	7.25E-01
Total Vascular HI =	7.25E-01
Total Weight Loss HI =	1.67E-01

*- Total Hazard Index by itself is not an indicator of unacceptable risk but rather is a criterion for requiring that noncancer risks should be examined separately for chemicals affecting the same target organ.

TABLE 5-5
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT EXPOSURE TO GROUNDWATER
CENTRAL TENDENCY EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	1.45E-05	--	4.70E-08	1.45E-05	Arsenic	Skin/Vascular	3.22E-01	--	1.04E-03	3.23E-01
			Barium	--	--	--	--	Barium	Kidney	2.10E-02	--	9.70E-04	2.19E-02
			Cadmium	--	--	--	--	Cadmium	Kidney	2.25E-02	--	1.46E-03	2.40E-02
			Chromium	--	--	--	--	Chromium	Kidney	1.09E-01	--	2.83E-02	1.38E-01
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	3.12E+00	--	2.53E-01	3.38E+00
			Vanadium	--	--	--	--	Vanadium	NOAEL	4.93E-03	--	6.15E-04	5.55E-03
			Zinc	--	--	--	--	Zinc	Blood	1.34E-02	--	2.61E-05	1.35E-02
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	Weight Loss	9.88E-03	--	1.01E-02	1.99E-02
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	2.44E-02	--	3.39E-02	5.82E-02
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	1.01E-02	--	4.64E-03	1.47E-02
			Benzene	7.18E-07	--	5.45E-08	7.73E-07	Benzene	Blood/Immune	4.35E-02	--	3.30E-03	4.68E-02
			(Total)	1.52E-05	--	1.01E-07	1.53E-05	(Total)		3.71E+00	--	3.37E-01	4.04E+00
	Air	Inhalation of Groundwater Vapors During Showering											
			Aluminum	--	--	--	--	Aluminum	N/A	--	--	--	--
			Arsenic	--	NA	--	--	Arsenic	N/A	--	--	--	--
			Barium	--	--	--	--	Barium	Fetal Toxicity	--	NA	--	--
			Cadmium	--	NA	--	--	Cadmium		--	NA	--	--
			Chromium	--	NA	--	--	Chromium	Lung	--	NA	--	--
			Cobalt	--	--	--	--	Cobalt	N/A	--	--	--	--
			Copper	--	--	--	--	Copper	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	--	NA	--	--
			Vanadium	--	--	--	--	Vanadium	N/A	--	--	--	--
			Zinc	--	--	--	--	Zinc	N/A	--	--	--	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	--	--	--
			Naphthalene	--	--	--	--	Naphthalene	Respiratory	--	1.54E-01	--	1.54E-01
			Benzene	--	4.24E-07	--	4.24E-07	Benzene	Blood	--	8.60E-02	--	8.60E-02
			(Total)	--	4.24E-07	--	4.24E-07	(Total)		--	2.40E-01	--	2.40E-01
						Total Risk Across Groundwater	1.57E-05					Total Hazard Index Across Groundwater	4.28E+00
						Total Risk Across All Media and All Exposure Routes	1.57E-05					Total Hazard Index Across All Media and All Exposure Routes	4.28E+00

Total Blood HI =	1.46E-01
Total CNS HI =	3.38E+00
Total Immune HI =	4.68E-02
Total Kidney HI =	2.42E-01
Total Respiratory HI =	1.54E-01
Total Skin HI =	3.23E-01
Total Vascular HI =	3.23E-01
Total Weight Loss HI =	3.46E-02

TABLE 5-6
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO GROUNDWATER
CENTRAL TENDENCY EXPOSURE
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT - NEWPORT, RHODE ISLAND

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Tap Water Contact with Groundwater											
			Aluminum	--	--	--	--	Aluminum	N/A	N/A	--	N/A	--
			Arsenic	2.37E-05	--	1.39E-07	2.39E-05	Arsenic	N/A	N/A	--	N/A	--
			Barium	--	--	--	--	Barium	N/A	N/A	--	N/A	--
			Cadmium	--	--	--	--	Cadmium	N/A	N/A	--	N/A	--
			Chromium	--	--	--	--	Chromium	N/A	N/A	--	N/A	--
			Cobalt	--	--	--	--	Cobalt	N/A	N/A	--	N/A	--
			Copper	--	--	--	--	Copper	N/A	N/A	--	N/A	--
			Iron	--	--	--	--	Iron	N/A	N/A	--	N/A	--
			Lead	--	--	--	--	Lead	N/A	N/A	--	N/A	--
			Manganese	--	--	--	--	Manganese	N/A	N/A	--	N/A	--
			Vanadium	--	--	--	--	Vanadium	N/A	N/A	--	N/A	--
			Zinc	--	--	--	--	Zinc	N/A	N/A	--	N/A	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	N/A	--	N/A	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	N/A	--	N/A	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	N/A	--	N/A	--
			Benzene	1.18E-06	--	2.31E-07	1.41E-06	Benzene	N/A	N/A	--	N/A	--
			(Total)	2.49E-05	--	3.70E-07	2.53E-05	(Total)		--	--	--	--
	Air	Inhalation of Groundwater Vapors During Showering											
			Aluminum	--	--	--	--	Aluminum	N/A	--	N/A	--	--
			Arsenic	--	--	--	--	Arsenic	N/A	--	N/A	--	--
			Barium	--	--	--	--	Barium	N/A	--	N/A	--	--
			Cadmium	--	--	--	--	Cadmium	N/A	--	N/A	--	--
			Chromium	--	--	--	--	Chromium	N/A	--	N/A	--	--
			Cobalt	--	--	--	--	Cobalt	N/A	--	N/A	--	--
			Copper	--	--	--	--	Copper	N/A	--	N/A	--	--
			Iron	--	--	--	--	Iron	N/A	--	N/A	--	--
			Lead	--	--	--	--	Lead	N/A	--	N/A	--	--
			Manganese	--	--	--	--	Manganese	N/A	--	N/A	--	--
			Vanadium	--	--	--	--	Vanadium	N/A	--	N/A	--	--
			Zinc	--	--	--	--	Zinc	N/A	--	N/A	--	--
			2-Methylnaphthalene	--	--	--	--	2-Methylnaphthalene	N/A	--	N/A	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	N/A	--	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	--	N/A	--	--
			Benzene	--	4.24E-07	--	4.24E-07	Benzene	N/A	--	N/A	--	--
			(Total)	--	4.24E-07	--	4.24E-07	(Total)		--	--	--	--
						Total Risk Across Groundwater	2.57E-05					Total Hazard Index Across Groundwater	--

TABLE 5-7
BLOOD LEAD CONCENTRATIONS AND LEAD UPTAKES
GROUNDWATER AND SURFACE SOIL EXPOSURES
OLD FIRE FIGHTING TRAINING AREA – GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 ug Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 207.00 ug Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-1	49.7	49.7
1-2	49.7	49.7
2-3	49.7	49.7
3-4	49.7	49.7
4-5	49.7	49.7
5-6	49.7	49.7
6-7	49.7	49.7

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil+Dust Uptake (ug/day)
0.5-1:	10.3	19.66	1.01
1-2:	15.2	39.50	1.40
2-3:	15.3	42.53	1.45
3-4:	15.1	44.71	1.50
4-5:	15.0	47.06	1.14
5-6:	14.8	50.21	1.04
6-7:	14.2	51.90	1.00

YEAR	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	2.20	16.44	0.00	0.02
1-2:	2.01	36.05	0.00	0.03
2-3:	2.33	38.69	0.00	0.06
3-4:	2.32	40.82	0.00	0.07
4-5:	2.30	43.55	0.00	0.07
5-6:	2.46	46.61	0.00	0.09
6-7:	2.75	48.05	0.00	0.09

TABLE 5-8
BLOOD LEAD CONCENTRATIONS AND LEAD UPTAKES
GROUNDWATER AND SUBSURFACE SOIL EXPOSURES
OLD FIRE FIGHTING TRAINING AREA – GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

LEAD MODEL Version 0.99d

AIR CONCENTRATION: 0.100 ug Pb/m3 DEFAULT
Indoor AIR Pb Conc: 30.0 percent of outdoor.
Other AIR Parameters:

Age	Time Outdoors (hr)	Vent. Rate (m3/day)	Lung Abs. (%)
0-1	1.0	2.0	32.0
1-2	2.0	3.0	32.0
2-3	3.0	5.0	32.0
3-4	4.0	5.0	32.0
4-5	4.0	5.0	32.0
5-6	4.0	7.0	32.0
6-7	4.0	7.0	32.0

DIET: DEFAULT

DRINKING WATER Conc: 207.00 ug Pb/L
WATER Consumption: DEFAULT

SOIL & DUST:
Soil: constant conc.
Dust: constant conc.

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
0-1	507.0	507.0
1-2	507.0	507.0
2-3	507.0	507.0
3-4	507.0	507.0
4-5	507.0	507.0
5-6	507.0	507.0
6-7	507.0	507.0

Additional Dust Sources: None DEFAULT

PAINT Intake: 0.00 ug Pb/day DEFAULT

MATERNAL CONTRIBUTION: Infant Model
Maternal Blood Conc: 2.50 ug Pb/dL

CALCULATED BLOOD Pb and Pb UPTAKES:

YEAR	Blood Level (ug/dL)	Total Uptake (ug/day)	Soil+Dust Uptake (ug/day)
0.5-1:	13.8	26.59	9.44
1-2:	18.7	48.29	13.18
2-3:	18.5	51.85	13.70
3-4:	18.3	54.65	14.28
4-5:	17.6	54.94	11.11
5-6:	17.0	57.54	10.23
6-7:	16.2	59.03	9.83

YEAR	Diet Uptake (ug/day)	Water Uptake (ug/day)	Paint Uptake (ug/day)	Air Uptake (ug/day)
0.5-1:	2.02	15.11	0.00	0.02
1-2:	1.86	33.22	0.00	0.03
2-3:	2.17	35.92	0.00	0.06
3-4:	2.17	38.14	0.00	0.07
4-5:	2.19	41.57	0.00	0.07
5-6:	2.37	44.85	0.00	0.09
6-7:	2.66	46.44	0.00	0.09

TABLE 6-1
OCCURRENCE AND DISTRIBUTION OF INORGANICS IN GROUNDWATER
OLD FIRE FIGHTING TRAINING AREA - GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

	Background Data					Site-Related Data						
Substance	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Freq. of Detection	Range of Positive Detection Min.	Range of Positive Detection Max.	Mean of All Data	Sampling Round and Location of Maximum	Range of Detection Limits Min.	Range of Detection Limits Max.	Representative Concentration
Aluminum	2/2	958 J	1300 J	1130	OFF-A-MW5S-01	6/13	645 J	13000 J	1480	OFF-A-MW3S-01	14.3	564	13000
Arsenic	0/2	-				2/13	44.5	49.8	8.32	OFF-A-MW3S-01	1.8	6.9	49.8
Barium	2/2	12.2	16.1	14.2	OFF-A-MW6R-01	12/13	5.3	390	72.9	OFF-A-MW102-01	3.5	3.6	390
Cadmium	0/2	-				3/13	2.4 J	3.4 J	0.758	OFF-A-MW3S-01	0.19	0.52	3.4
Calcium	2/2	30200 J	76800 J	53500	OFF-A-MW5S-01	13/13	16200 J	281000 J	101000	OFF-A-MW2S-01	-		281000
Chromium	2/2	12.1	15.6	13.9	OFF-A-MW5S-01	12/13	3.2	39.9	15.2	OFF-A-MW11R-01	1.3	1.3	39.9
Cobalt	1/2	5 J	5 J	2.85	OFF-A-MW6R-01	9/13	6.1	87	22.6	OFF-A-MW7S-01	0.94	3.8	87
Copper	0/2	-				4/13	13.6 J	166 J	27.2	OFF-A-MW3S-01	1.4	12.3	166
Iron	2/2	2580 J	3180 J	2880	OFF-A-MW5S-01	12/13	934 J	129000 J	13800	OFF-A-MW3S-01	183	187	129000
Lead	0/2	-				10/13	1.6 J	207 J	22.5	OFF-A-MW3S-01	1.4	1.4	207
Magnesium	2/2	20500 J	24100 J	22300	OFF-A-MW6R-01	13/13	11100 J	718000 J	159000	OFF-A-MW2S-01	-		718000
Manganese	2/2	216 J	578 J	397	OFF-A-MW5S-01	13/13	396 J	12500 J	3820	OFF-A-MW4S-01	-		12500
Mercury	0/2	-				3/13	0.02 J	0.24	0.0354	OFF-A-MW3S-01	0.01	0.01	0.24
Potassium	2/2	5570 J	6740 J	6160	OFF-A-MW6R-01	13/13	5700 J	258000 J	61900	OFF-A-MW2S-01	-		258000
Silver	0/2	-				2/13	0.62 J	1.9 J	0.887	OFF-A-MW11S-01	0.82	6.5	1.9
Sodium	2/2	46500 J	129000 J	87800	OFF-A-MW6R-01	12/13	39300 J	5960000 J	1410000	OFF-A-MW2S-01	1010000	1010000	5960000
Vanadium	2/2	1.4	1.6	1.5	OFF-A-MW5S-01	7/13	0.59 J	37.5	3.58	OFF-A-MW3S-01	0.57	0.57	37.5

Notes:

Units are ug/L.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are considered as one result.
Mean of all data includes positive detections and non-detected results. Detection limits are divided by two.
The determination of representative concentrations is based on the maximum detected result.
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples.
Number of samples may vary based on the number of usable results.

FIGURES

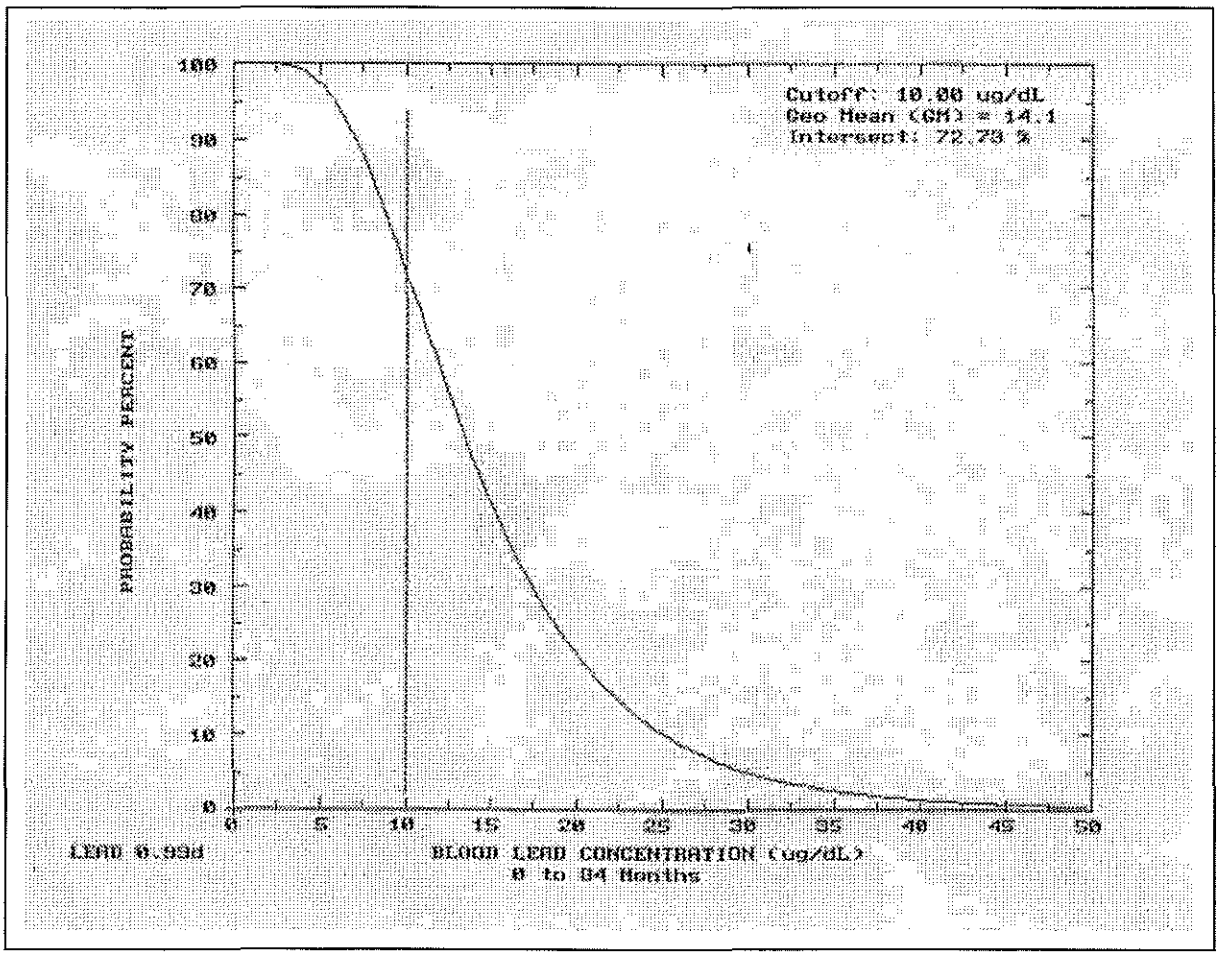

FIGURE 5-1
BLOOD LEAD CONCENTRATION VERSUS PROBABILITY PERCENT
GROUNDWATER AND SURFACE SOIL
OLD FIRE FIGHTING TRAINING AREA – GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

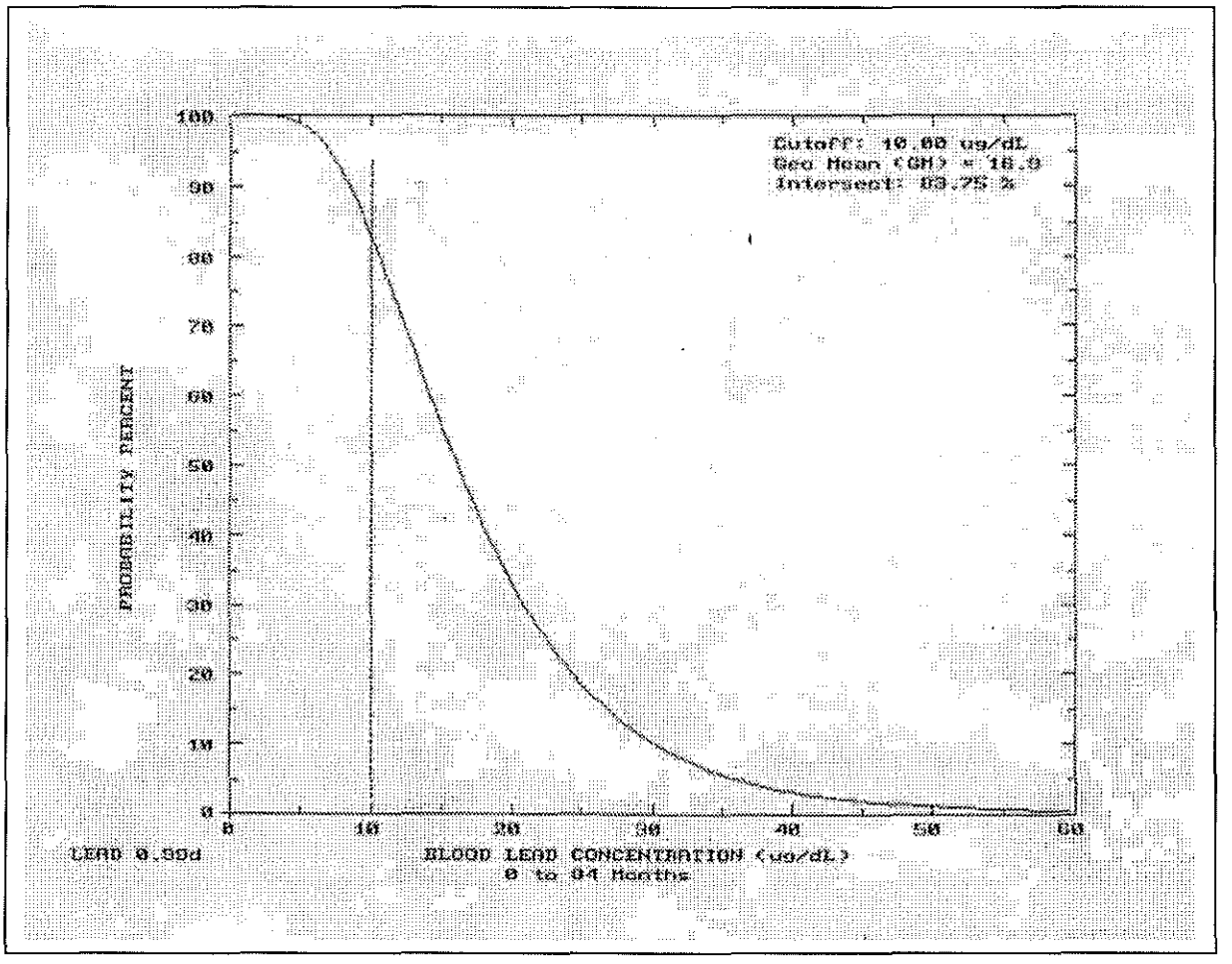

FIGURE 5-2
BLOOD LEAD CONCENTRATION VERSUS PROBABILITY PERCENT
GROUNDWATER AND SUBSURFACE SOIL
OLD FIRE FIGHTING TRAINING AREA – GROUNDWATER RISK EVALUATION
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

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APPENDIX C

PRG DEVELOPMENT FOR SOIL

APPENDIX C
PRG DEVELOPMENT FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

This appendix provides the supporting documentation for the development of soil PRGs.

C.1 RISK-BASED CONCENTRATIONS

The risk-based concentrations (to be used in the PRG development process) were calculated based on data used in the HHRA. RBCs for carcinogens were based on a risk of 1×10^{-6} for carcinogens and an HQ of 1.0 for non-carcinogens. The scenario used to calculate the carcinogenic RBCs was the lifetime resident, which was the most conservative carcinogenic risk scenario in the HHRA. The scenario used to calculate the non-carcinogenic RBCs was the child resident, which was the most conservative non-carcinogenic risk scenario in the HHRA. For each chemical, the more conservative of the carcinogenic RBC and the non-carcinogenic RBC was chosen during the PRG selection process.

The equations and spreadsheet showing the calculations for the risk-based concentrations are included in this appendix.

C.2 RIDEM DIRECT EXPOSURE CRITERIA

The RIDEM Remediation Regulations provide the methodology for determining remedial objectives for soil. Method 1 Soil Objectives are published in tables in the regulation, and site concentrations are compared directly to these numbers. If no Method 1 Soil Objective has been promulgated for a specific chemical, then a Method 2 Soil Objective is calculated for the site using the prescribed method and assumptions provided in the regulation. For direct exposure, the Method 2 calculations use the same equations and assumptions as those for the Method 1.

Many of the chemicals detected at OFFTA have Method 1 Objectives listed in the tables. For those chemicals not listed, Method 2 Direct Exposure Criteria were calculated for use in the screening process. The procedure for the calculations is outlined in Appendix D of the RIDEM Remediation Regulations. A copy of that appendix from the Remediation Regulations and the spreadsheets used to calculate the Method 2 criteria for chemicals at OFFTA are included in this appendix.

EQUATIONS FOR RISK-BASED CONCENTRATIONS

The following equations were used to calculate the risk-based concentrations. The assumptions are the same as those in the HHRA found in the RI, and the equations directly correspond to the HHRA, except that they have been rearranged to calculate the concentration instead of the risk. The values used for each variable are provided on the accompanying spreadsheet.

Non-Carcinogenic Ingestion (child resident)

$$C = \frac{HI \cdot RfD \cdot BW_{child} \cdot 365 \frac{days}{yr}}{EF \cdot 10^{-6} \frac{kg}{mg} \cdot IR_{soil-child}}$$

Non-Carcinogenic Dermal Contact (child resident)

$$C = \frac{HI \cdot RfD \cdot AT_{non-child}}{EF \cdot EV \cdot 10^{-6} \frac{kg}{mg} \cdot SAADJ_{child} \cdot SSAF_{child} \cdot DABS}$$

Carcinogenic Ingestion (lifetime resident)

$$C = \frac{TargetRisk \cdot AT_{car}}{CSF \cdot EF \cdot 10^{-6} \frac{kg}{mg} \cdot IF_{soil-adj}}$$

Carcinogenic Dermal Contact (lifetime resident)

$$C = \frac{TargetRisk \cdot AT_{car}}{CSF \cdot EV \cdot EF \cdot 10^{-6} \frac{kg}{mg} \cdot SAADJ_{life} \cdot SSAF_{life} \cdot DABS}$$

Carcinogenic Inhalation (lifetime resident)

$$C = \frac{TargetRisk \cdot AT_{car} \cdot PEF}{CSF \cdot EF \cdot IR_{air-adj}}$$

where:

C	=	Soil Concentration (mg/kg)
HI	=	Hazard Index (unitless)
RfD	=	Reference Dose (mg/kg-day)
BW_{child}	=	Body Weight, child (kg)
EF	=	Exposure Frequency (days)
$IR_{soil\text{-}child}$	=	Soil Ingestion Rate, child (mg/day)
$AT_{non\text{-}child}$	=	Averaging Time, non-carcinogen, child
EV	=	Event Frequency (events/day)
$SAADJ_{child}$	=	Age-Adjusted Skin Surface Area/Body Weight Ratio, child (cm^2-yr/kg)
$SSAF_{child}$	=	Soil-to-Skin Adherence Factor (mg/cm^2-event)
$SSAF_{life}$	=	Age-Adjusted Soil-to-Skin Adherence Factor (mg/cm^2-event)
DABS	=	Dermal Absorption Factor (unitless)
TargetRisk	=	Target Risk
AT_{car}	=	Averaging Time, carcinogen (days)
CSF	=	Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
$IF_{soil\text{-}adj}$	=	Age-Adjusted Ingestion Rate/Body Weight Ratio (mg-yr/kg-day)
$SAADJ_{life}$	=	Age-Adjusted Skin Surface Area/Body Weight Ratio (cm^2-yr/kg)
PEF	=	Particulate Emission Factor
$IR_{air\text{-}adj}$	=	Age-Adjusted Inhalation Rate/Body Weight Ratio (m^3-yr/kg-day)

TABLE C-1
RISK-BASED CONCENTRATIONS FOR SOIL
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

INPUT PARAMETER	VALUE
IR soil adult (mg/day)	100
IR soil child (mg/day)	200
IF soil adj (mg-yr/kg-day)	106.6
IR air adult (m^3/day)	28.8
IR air child (m^3/day)	38.4
IR air adj (m^3-yr/kg-day)	23.8
EF (days/year)	240
ED (years)	30
ED child (years)	6
BW adult (kg)	70
BW child (kg)	16.6
ATcar (days)	25550
ATnon child (days)	2190
SA adult (cm^2)	7014
SA-ADJ life (cm^2-yr/kg)	3541
SA-ADJ child (cm^2-yr/kg)	1136
SSAF child (mg/cm^2-event)	0.2
SSAF adult (mg/cm^2-event)	0.08
SSAF life (mg/cm^2-event)	0.118
EV (events/day)	1
PEF (m^3/kg)	1.32E+09
Target HI	1
Target Risk	1.00E-06

CHEMICAL OF POTENTIAL CONCERN	Toxicity and Other Chemical-Specific Data						NON-CARCINOGEN child resident			CARCINOGEN lifetime resident			
	RfD_{oral} (mg/kg/d)	CSF_{oral} $(mg/kg/d)^{-1}$	RfD_{derm} (mg/kg/d)	CSF_{derm} $(mg/kg/d)^{-1}$	CSF_{inh} $(mg/kg/d)^{-1}$	DABS (unitless)	ingestion (mg/kg)	dermal (mg/kg)	combined* (mg/kg)	ingestion (mg/kg)	dermal (mg/kg)	inhalation (mg/kg)	combined* (mg/kg)
4-Chloro-3-Methylphenol													
4,6-Dinitro-2-Methylphenol													
Benzo(a)anthracene		7.30E-01		7.30E-01		0.13				1.37E+00	2.68E+00		9.06E-01
Benzo(a)pyrene		7.30E+00		7.30E+00	3.10E+00	0.13				1.37E-01	2.68E-01	1.91E+03	9.06E-02
Benzo(b)fluoranthene		7.30E-01		7.30E-01		0.13				1.37E+00	2.68E+00		9.06E-01
Benzo(k)fluoranthene		7.30E-02		7.30E-02		0.13				1.37E+01	2.68E+01		9.06E+00
Carbazole		2.00E-02		2.00E-02		0.13				4.99E+01	9.80E+01		3.31E+01
Chrysene		7.30E-03		7.30E-03		0.13				1.37E+02	2.68E+02		9.06E+01
Dibenzo(a,h)anthracene		7.30E+00		7.30E+00		0.13				1.37E-01	2.68E-01		9.06E-02
Indeno(1,2,3-cd)pyrene		7.30E-01		7.30E-01		0.13				1.37E+00	2.68E+00		9.06E-01
delta-BHC													
Dieldrin	5.00E-05	1.60E+01	5.00E-05	1.60E+01	1.60E+01		6.31E+00		6.31E+00	6.24E-02		3.70E+02	6.24E-02
Aroclor-1254	2.00E-05	2.00E+00	2.00E-05	2.00E+00	2.00E+00	0.14	2.52E+00	5.74E+00	1.75E+00	4.99E-01	9.10E-01	2.96E+03	3.22E-01
Antimony	4.00E-04		6.00E-05				5.05E+01		5.05E+01				
Arsenic	3.00E-04	1.50E+00	3.00E-04	1.50E+00	1.51E+01	0.03	3.79E+01	4.02E+02	3.46E+01	6.66E-01	5.66E+00	3.92E+02	5.95E-01
Chromium	3.00E-03		7.50E-05		4.10E+01		3.79E+02		3.79E+02			1.44E+02	1.44E+02
Lead													
Manganese	7.20E-02		4.32E-03				9.09E+03		9.09E+03				
Mercury	1.00E-04		7.00E-06				1.26E+01		1.26E+01				
Nickel	2.00E-02		8.00E-04				2.52E+03		2.52E+03				
Vanadium	7.00E-03		1.82E-04				8.84E+02		8.84E+02				
Zinc	3.00E-01		3.00E-01				3.79E+04		3.79E+04				
2,3,7,8-TCDD		1.50E+05		1.50E+05	1.50E+05	0.03				6.66E-06	5.66E-05	3.94E-02	5.96E-06

*Column for "combined" gives a concentration that will not exceed the target risk level summed over multiple pathways.
The value can be calculated by taking the inverse of the sum of the inverses of the individual exposure path concentrations.

TABLE C-2
SUMMARY OF RIDEM METHOD 2 DIRECT EXPOSURE CRITERIA
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Chemical	Residential Ingestion (mg/kg)			Res. Inhalation (mg/kg)		Csat (mg/kg)	Selected Method 2 Concentration (mg/kg)
	carcin	non-carcin	acute	carcin	non-carcin		
2-hexanone						4557	
carbon disulfide		7821			121	440	121
chloroethane							
chloromethane	49.1		400	0.494		680	0.494
4,6-dinitro-2-methylphenol						175	
4-chloro-3-methylphenol							
9H-carbazole	31.9						31.9
benzoic acid		312857				344	344
butylbenzylphthalate		15643				334	334
carbazole	31.9						31.9
di-n-butylphthalate		7821				27160	7821
di-n-octylphthalate		1564				47424	1564
dibenzofuran		313				164	164
n-nitrosodiphenylamine	130					94.1	94.1
4,4'-DDD	2.66					320	2.66
4,4'-DDE	1.88					358	1.88
4-4'-DDT	1.88	39.1		511		16.3	1.88
aldrin	0.038	2.35	0.300	2.18		4949	0.038
alpha-BHC	0.101			0.514		3.58	0.101
beta-BHC	0.355			6.67		0.341	0.341
delta-BHC						203	
endosulfan I and II		469				2.32	2.32
endosulfan sulfate							
endrin		23.5	5			5.43	5
endrin aldehyde							
endrin ketone							
gamma-BHC	0.491	23.5	1000			3.14	0.491
heptachlor	0.142	39.1	10	2.67		282	0.142
heptachlor epoxide	0.070	1.02		3.20		58.3	0.070
methoxychlor		391	50			7.82	7.82
2,3,7,8-TCDD	4.26E-06			6.12E-06		1.85E-03	4.26E-06

The following pages support the calculations for each individual exposure pathway.

TABLE C-2
METHOD 2 DIRECT EXPOSURE CRITERIA
BASED ON RESIDENTIAL INGESTION

Residential Default Input Parameters			
Oral Ingestion			
Term	**Description**	**Units**	**Value**
C	Concentration of Contaminant in Soil	mg/kg	calculated
CPSo	Carincogenic Potentcy Slope Factor (Oral)	(mg/kg/d)-1	chem-specific
RfDo	Reference Dose (Oral)	mg/kg/d	'chem-specific
RISK	Target Cancer Risk Level	dimensionless	1.E-06
HI	Hazard Index	dimensionless	1
BWa	Body Weight (Adult)	kg	70
BWc	Body Weight (Child Ages 1-6)	kg	15
AT	Averaging Time (Carcinogens)	yr	70
ATc	Averaging Time (Child Ages 1-6)	yr	6
IRSa	Soil Ingestion (Adult)	mg/d	100
IRSc	Soil Ingestion (Child Ages 1-6)	mg/d	200
CF	Conversion Factor	mg-d/kg-yr	3.65E+08
EF	Exposure Frequency	d/yr	350
EDa	Exposure Duration (Adult)	yr	24
EDc	Exposure Duration (Child Ages 1-6)	yr	6

Chemical	CPSo (mg/kg/d)-1	RfDo (mg/kg/d)	Res. Ingestion (mg/kg)	
			carcin	non-carcin
2-hexanone				
carbon disulfide		1.00E-01		7821.4286
chloroethane				
chloromethane	1.30E-02		49.134615	
4,6-dinitro-2-methylphenol				
4-chloro-3-methylphenol				
9H-carbazole	2.00E-02		31.9375	
benzoic acid		4.00E+00		312857.14
butylbenzylphthalate		2.00E-01		15642.857
carbazole	2.00E-02		31.9375	
di-n-butylphthalate		1.00E-01		7821.4286
di-n-octylphthalate		2.00E-02		1564.2857
dibenzofuran		4.00E-03		312.85714
n-nitrosodiphenylamine	4.90E-03		130.35714	
4,4'-DDD	2.40E-01		2.6614583	
4,4'-DDE	3.40E-01		1.8786765	
4-4'-DDT	3.40E-01	5.00E-04	1.8786765	39.107143
aldrin	1.70E+01	3.00E-05	0.0375735	2.3464286
alpha-BHC	6.30E+00		0.1013889	
beta-BHC	1.80E+00		0.3548611	
delta-BHC				
endosulfan I and II		6.00E-03		469.28571
endosulfan sulfate				
endrin		3.00E-04		23.464286
endrin aldehyde				
endrin ketone				
gamma-BHC	1.30E+00	3.00E-04	0.4913462	23.464286
heptachlor	4.50E+00	5.00E-04	0.1419444	39.107143
heptachlor epoxide	9.10E+00	1.30E-05	0.0701923	1.0167857
methoxychlor		5.00E-03		391.07143
2,3,7,8-TCDD	1.50E+05		4.258E-06	

TABLE C-3
METHOD 2 DIRECT EXPOSURE CRITERIA
BASED ON ACUTE INGESTION

Residential Default Input Parameters			
Oral Acute Toxicity			
Term	**Description**	**Units**	**Value**
TDHA	Ten Day Health Advisory (10 kg child)	mg/l	chem-specific
IRat-w	Ingestion Rate of Water	l/d	1
IRat-s	Ingestion Rate of Soil	g/d	1
CFat	Conversion Factor (Acute Toxicity)	kg/g	1.00E-03

Chemical	TDHA (mg/l)	Non-carcin (mg/kg)
2-hexanone		
carbon disulfide		
chloroethane		
chloromethane	4.00E-01	4.00E+02
4,6-dinitro-2-methylphenol		
4-chloro-3-methylphenol		
9H-carbazole		
benzoic acid		
butylbenzylphthalate		
carbazole		
di-n-butylphthalate		
di-n-octylphthalate		
dibenzofuran		
n-nitrosodiphenylamine		
4,4'-DDD		
4,4'-DDE		
4-4'-DDT		
aldrin	3.00E-04	3.00E-01
alpha-BHC		
beta-BHC		
delta-BHC		
endosulfan I and II		
endosulfan sulfate		
endrin	5.00E-03	5.00E+00
endrin aldehyde		
endrin ketone		
gamma-BHC	1.00E+00	1.00E+03
heptachlor	1.00E-02	1.00E+01
heptachlor epoxide		
methoxychlor	5.00E-02	5.00E+01
2,3,7,8-TCDD		

TABLE C-4
METHOD 2 DIRECT EXPOSURE CRITERIA
BASED ON RESIDENTIAL INHALATION

Residential Default Input Parameters			
Inhalation			
Term	**Description**	**Units**	**Value**
C	Concentration of Contaminant in Soil	mg/kg	calculated
RISK	Target Cancer Risk Level (Carcinogens)	dimensionless	1.E-06
HI	Hazard Index (Noncarcinogens)	dimensionless	1
AT	Averaging Time (Carcinogens)	yr	70
AT	Averaging Time (Noncarcinogens)	yr	30
URF	Inhalation Unit Risk Factor (Carcinogens)	(ug/m3)-1	chem-specific
RfC	Inhalation Reference Conc. (Noncarcinogen	mg/m3	chem-specific
EF	Exposure Frequency	d/yr	350
ED	Exposure Duration	yr	30
VF	Soil-to-Air Volatilization Factor	m3/kg	chem-specific
PEF	Particulate Emission Factor	m3/kg	4.51E+09
TA	Time Adjustment Factor	dimensionless	1

Chemical	URF (ug/m3)-1	RfC (mg/m3)	VF (m3/kg)	Res. Inhalation (mg/kg)	
				carcin	non-carcin
2-hexanone					
carbon disulfide		7.00E-01	1.66E+02		121.17711
chloroethane					
chloromethane	1.80E-06		3.65E+02	0.4935932	
4,6-dinitro-2-methylphenol			5.22E+05		
4-chloro-3-methylphenol					
9H-carbazole			1.00E+07		
benzoic acid			1.12E+04		
butylbenzylphthalate			6.81E+06		
carbazole			1.00E+07		
di-n-butylphthalate			1.18E+08		
di-n-octylphthalate			3.82E+07		
dibenzofuran					
n-nitrosodiphenylamine			3.82E+05		
4,4'-DDD			1.62E+07		
4,4'-DDE			1.62E+07		
4-4'-DDT	9.70E-05		2.05E+07	511.30762	
aldrin	4.90E-03		4.39E+06	2.1798828	
alpha-BHC	1.80E-03		3.80E+05	0.5135748	
beta-BHC	5.30E-04		1.45E+06	6.6657114	
delta-BHC					
endosulfan I and II			5.42E+05		
endosulfan sulfate					
endrin			1.52E+06		
endrin aldehyde					
endrin ketone					
gamma-BHC			3.08E+05		
heptachlor	1.30E-03		1.43E+06	2.6738459	
heptachlor epoxide	2.60E-03		3.42E+06	3.2011931	
methoxychlor			2.65E+06		
2,3,7,8-TCDD	1.50E+02		3.77E+05	6.116E-06	

TABLE C-5
METHOD 2 DIRECT EXPOSURE CRITERIA
VOLATILIZATION FACTOR CALCULATION

Default Input Parameters	
Volatilization Factor	
Term and Units	**Value**
Q/C ($g/m^2/s$ per kg/m^3)	101.8
T (s)	7.90E+08
Θ (cm^3 water/g soil)	0.1
β (g/cm^3)	1.5
ρ_s (g/cm^3)	2.65
P_t (g/cm^3)	0.434
P_a (g/cm^3)	0.284
OC (fraction)	0.02

Chemical	D_i (cm^2/s)	H (unitless)	K_{oc} (cm^3/g)	D_{ei} (cm^2/s)	K_d (cm^3/g)	K_{as} (g-soil/cm^3-air)	α	VF (m^3/kg)
2-hexanone			1.51E+01	0.00E+00	0.302			
carbon disulfide	1.04E-01	1.24E+00	4.57E+01	8.35E-03	0.914	5.56E+01	7.45E-03	166
chloroethane								
chloromethane	1.26E-01	3.62E-01	3.50E+01	1.01E-02	0.7	2.12E+01	7.69E-03	365
4,6-dinitro-2-methylphenol	2.93E-02	5.76E-05	6.34E+02	2.35E-03	12.68	1.86E-04	6.55E-08	521,873
4-chloro-3-methylphenol								
9H-carbazole	3.90E-02	6.30E-07	3.39E+03	3.13E-03	67.8	3.81E-07	1.78E-10	10,001,573
benzoic acid	5.36E-02	6.31E-05	6.00E-01	4.30E-03	0.012	2.16E-01	1.34E-04	11,162
butylbenzylphthalate	1.74E-02	5.17E-05	5.75E+04	1.40E-03	1150	1.84E-06	3.85E-10	6,807,458
carbazole	3.90E-02	6.30E-07	3.39E+03	3.13E-03	67.8	3.81E-07	1.78E-10	10,001,573
di-n-butylphthalate	4.38E-02	4.00E-08	3.39E+04	3.52E-03	678	2.42E-09	1.27E-12	118,441,481
di-n-octylphthalate	1.51E-02	2.74E-03	8.32E+07	1.21E-03	1664000	6.75E-08	1.22E-11	38,182,902
dibenzofuran		8.73E-03	8.13E+03	0.00E+00	162.56	2.20E-03		
n-nitrosodiphenylamine	3.12E-02	2.05E-04	1.29E+03	2.50E-03	25.8	3.26E-04	1.22E-07	382,385
4,4'-DDD	1.69E-02	1.64E-04	1.00E+06	1.36E-03	20000	3.36E-07	6.82E-11	16,173,564
4,4'-DDE	1.44E-02	8.61E-04	4.47E+06	1.16E-03	89400	3.95E-07	6.83E-11	16,167,466
4-4'-DDT	1.37E-02	3.32E-04	2.63E+06	1.10E-03	52600	2.59E-07	4.26E-11	20,474,795
aldrin	1.32E-02	6.97E-03	2.45E+06	1.06E-03	49000	5.83E-06	9.25E-10	4,393,904
alpha-BHC	1.42E-02	4.35E-04	1.23E+03	1.14E-03	24.6	7.25E-04	1.24E-07	379,937
beta-BHC	1.42E-02	3.05E-05	1.26E+03	1.14E-03	25.2	4.96E-05	8.46E-09	1,452,314
delta-BHC		1.76E-05	1.17E+04	0.00E+00	234	3.08E-06		
endosulfan I and II	1.15E-02	4.59E-04	2.14E+03	9.23E-04	42.8	4.40E-04	6.07E-08	542,136
endosulfan sulfate								
endrin	1.25E-02	3.08E-04	1.23E+04	1.00E-03	246	5.13E-05	7.71E-09	1,521,919
endrin aldehyde								
endrin ketone								
gamma-BHC	1.42E-02	5.74E-04	1.07E+03	1.14E-03	21.4	1.10E-03	1.88E-07	308,480
heptachlor	1.12E-02	4.47E-02	1.41E+06	8.99E-04	28200	6.50E-05	8.74E-09	1,428,946
heptachlor epoxide	1.32E-02	3.90E-04	8.32E+04	1.06E-03	1664	9.61E-06	1.52E-09	3,423,049
methoxychlor	1.56E-02	6.48E-04	9.77E+04	1.25E-03	1954	1.36E-05	2.55E-09	2,647,086
2,3,7,8-TCDD	1.43E-02	1.63E-03	4.57E+03	1.15E-03	91.42	7.31E-04	1.26E-07	377,043

TABLE C-6
METHOD 2 DIRECT EXPOSURE CRITERIA
SOIL SATURATION LIMIT

Soil Saturation (Csat) Default Input Parameters			
Term	**Description**	**Units**	**Value**
Csat	Soil Saturation Concentration	mg/kg	calculated
Kd	Soil-Water Partition Coefficient	L/kg	chem-specific
Koc	Organic Carbon Partition Coefficient	L/kg	chem-specific
OC	Organic Carbon Content of Surface Soil	%	2%
S	Solubility	mg/L-water	chem-specific
nm	Soil Moisture Content	weight fract.	0.1
Θm	Soil Moisture Content	L-water/kg-soil	0.1

Chemical	K_{oc} (L/kg)	S (mg/L-water)	K_d (L/kg)	C_{sat} (mg/kg)
2-hexanone	1.51E+01	3.50E+04	3.02E-01	4.56E+03
carbon disulfide	4.57E+01	2.30E+03	9.14E-01	4.40E+02
chloroethane		3.30E+03		
chloromethane	3.50E+01	4.00E+03	7.00E-01	6.80E+02
4,6-dinitro-2-methylphenol	6.34E+02	1.28E+02	1.27E+01	1.75E+02
4-chloro-3-methylphenol		3.85E+03		
9H-carbazole	3.39E+03		6.78E+01	
benzoic acid	6.00E-01	3.40E+03	1.20E-02	3.44E+02
butylbenzylphthalate	5.75E+04	2.90E+00	1.15E+03	3.34E+02
carbazole	3.39E+03		6.78E+01	
di-n-butylphthalate	3.39E+04	4.00E+02	6.78E+02	2.72E+04
di-n-octylphthalate	8.32E+07	2.85E-01	1.66E+06	4.74E+04
dibenzofuran	8.13E+03	1.00E+01	1.63E+02	1.64E+02
n-nitrosodiphenylamine	1.29E+03	3.51E+01	2.58E+01	9.41E+01
4,4'-DDD	1.00E+06	1.60E-01	2.00E+04	3.20E+02
4,4'-DDE	4.47E+06	4.00E-02	8.94E+04	3.58E+02
4-4'-DDT	2.63E+06	3.10E-03	5.26E+04	1.63E+01
aldrin	2.45E+06	1.01E+00	4.90E+04	4.95E+03
alpha-BHC	1.23E+03	1.40E+00	2.46E+01	3.58E+00
beta-BHC	1.26E+03	1.30E-01	2.52E+01	3.41E-01
delta-BHC	1.17E+04	8.64E+00	2.34E+02	2.03E+02
endosulfan I and II	2.14E+03	5.30E-01	4.28E+01	2.32E+00
endosulfan sulfate		1.17E-01		
endrin	1.23E+04	2.20E-01	2.46E+02	5.43E+00
endrin aldehyde		2.60E-01		
endrin ketone				
gamma-BHC	1.07E+03	1.40E+00	2.14E+01	3.14E+00
heptachlor	1.41E+06	1.00E-01	2.82E+04	2.82E+02
heptachlor epoxide	8.32E+04	3.50E-01	1.66E+03	5.83E+01
methoxychlor	9.77E+04	4.00E-02	1.95E+03	7.82E+00
2,3,7,8-TCDD	4.57E+03	2.00E-04	9.14E+01	1.85E-03

APPENDIX D

PRG DEVELOPMENT FOR SEDIMENT

DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS FOR MARINE SEDIMENT (FINAL) OLD FIREFIGHTING TRAINING AREA FEASIBILITY STUDY NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

INTRODUCTION

The Navy is mandated to develop Risk Based Preliminary Remediation Goals (PRGs) to direct remedial actions at sites under the Installation Restoration Program. This document has been prepared to support the Feasibility Study (FS) for the Old Firefighting Training Area (OFFTA) in the development of PRGs for marine sediment at and adjacent to this site.

A proposed approach for PRG development was provided to the regulatory agencies in January, 2001. Based on comments received from the USEPA and NOAA, that proposed approach was revised in a letter to EPA dated March 28, 2001. The methodology described in the revision was used to develop PRGs as described within this document.

At the OFFTA site, actionable risk from marine sediment was estimated and calculated in the Remedial Investigation report and supporting documents for sediment under three receptor scenarios. Development of the PRGs in this document are provided for each receptor scenario in the sections that follow this introduction:

Part 1 - Human lifetime resident exposure to shoreline sediment
Part 2 - Ingestion of shellfish collected from the nearshore and offshore sediment area
Part 3 - Ecological risk associated with the nearshore and offshore sediment
Part 4 - Summary and Conclusions

To establish cleanup goals for these three receptor scenarios, PRGs were developed for each scenario separately and applied to the exposure areas described below. Where PRGs overlap, the more conservative will apply. For the purposes of this document and for the FS, the following clarifications are made:

Marine Sediment - All intertidal and subtidal substrate including sand, rock, cobble, silt and other substances that underly the waters of Coasters Harbor and Narragansett Bay.

Shoreline Sediment – Area along the mid-tide line (represented by Sampling Stations SSD-333 through SSD-337). Samples were collected and used for human health risk (shoreline recreation scenario) only. Data available includes bulk chemistry.

Near Shore Marine Sediment – Area along the low-tide line (represented by Sampling Stations OFF-1 through OFF-7). Data available includes bulk sediment chemistry, some shellfish, and porewater. Samples were collected for ecological risk, but shellfish data was also used for human health risk evaluation under shellfish ingestion scenarios.

Offshore Marine Sediment – Area beyond the low tide line (represented by Sampling stations SD-08 through SD-21). Data available includes bulk sediment chemistry, fish, shellfish, benthic diversity, elutriate, toxicity, and porewater. Samples were collected for ecological risk, but shellfish data was also used for human health risk evaluation under shellfish ingestion scenarios.

PART 1 - DEVELOPMENT OF PRGS BASED ON DIRECT CONTACT WITH SEDIMENT

The human health risks associated with direct contact with contaminants in sediment are presented in the RI report (TtNUS, October 2000), Table 6-9.12 through 6-9.17. Risks are presented for a lifetime resident, child resident, adult resident, youth (age 1-12) shoreline visitor, child (age 1-4) shoreline visitor, and a youth (age 5-12) shoreline visitor. Of these, the lifetime resident would receive the greatest cumulative exposure to carcinogens and the child resident would have the greatest chronic risk associated with noncarcinogenic toxicity. No unacceptable noncancer risks were identified for the residential child, so only the lifetime resident cancer risks were considered in developing PRGs.

Chemicals selected as COCs for sediment were identified in the human health risk assessment presented in the RI report. Each contaminant associated with greater than 1E-06 lifetime residential cancer risk and include arsenic, benz(a)anthracene, benzo(a)pyrene, benz(b)fluoranthene, and dibenz(a,h)anthracene. The following equation was used to calculate PRG sediment concentrations for these substances at various target risk levels:

$$\text{PRG} = \text{Exposure Point Conc. in Sediment x } \frac{\text{Target Risk Level}}{\text{Risk at Exposure Point Conc.}}$$

Exposure point concentrations used for this calculation were those used to calculate reasonable maximum exposures for lifetime residential exposure to sediments during shoreline recreation (Table 6-8.25 of the RI report). Target cancer risk levels are 1E-06, 1E-05, and 1E-04. "Risks at the exposure point concentration" are presented in Table 6-8.25 of the RI report also, and reflect the risk from the sum of the combined exposure routes (ingestion and dermal contact).

Sediment concentrations that would yield target cancer risk levels of 1E-06, 1E-05, and 1E-04 are presented in Table 1.1. This method of PRG estimation is based on the proportionality established in the RI report between estimated risk and exposure point concentrations and therefore incorporates the same residential exposure assumptions delineated in the RI report.

PART 2 - DEVELOPMENT OF SEDIMENT PRGS BASED ON SHELLFISH CONSUMPTION BY HUMANS

The human health PRGs for shellfish consumption are based upon a lifetime cancer risk for the recreational fisherman. These receptors have the greatest exposure among the plausible receptors considered for the site.

Although the subsistence fishing scenario was evaluated in the Human Health Risk Assessment (TtNUS, 2000), the subsistence fisherman was not considered a plausible receptor because of lack of evidence for this type of activity occurring in the vicinity of the site and because land use patterns indicate that subsistence fishing is improbable in the foreseeable future.

The modeling of biouptake and risks was performed using lobster data, which is a conservative assumption because data for clams and mussels yielded lower shellfish tissue concentrations and hence lower cancer and noncancer risks for the recreational receptors.

The approach taken to estimate PRGs for sediment from shellfish ingestion risk uses three basic steps. The first is to estimate the shellfish concentrations corresponding to a threshold risk (Tissue PRG). The second is to convert the Tissue PRG to dry weight. Thirdly, the average Bioaccumulation Factor (BAF) determined in the ERA (SAIC, 2000) is used to estimate the sediment concentration that would be associated with the target tissue concentration. Table 2.1 presents the tissue EPCs for lobster, the associated cancer and noncancer risks for recreational fishing, the derived site-specific bioaccumulation factors, and the final PRGs for sediment considered protective for shellfish ingestion.

STEP 1 - Estimate Exposure Point Concentrations and Tissue PRGs

The list of COPCs used to develop the PRGs for shellfish ingestion were taken from the HHRA, presented in the RI report. These consist of chemicals that are associated with a threshold cancer risk of greater than 1E-06 or a significant noncancer toxicity as measured by a hazard quotient (HQ) exceeding 1.0. The list of COCs was developed in the most comprehensive manner considering all receptors used in the RI report, including the subsistence fisherman. COPCs selected in this manner are presented in the first column of Table 2.1.

The following equation was used to calculate PRG Tissue concentration for these substances at various target risk levels:

$$\text{Tissue PRG} = \text{Exposure point concentration in shellfish} * \frac{\text{Target Risk Level}}{\text{Risk at Exposure Point Concentration}}$$

Exposure point concentrations used for this calculation were those used to calculate reasonable maximum exposures for the lifetime recreational fishermans consumption of lobster. Target cancer risk levels are 1E-06, 1E-05, and 1E-04. Risks at exposure point concentrations (lobster ingestion) are presented in Table 6-8.32 of the RI report.

In the OFFTA RI, arsenic risks in fish were based on EPA's oral slope factor, which in turn is based on studies performed using arsenic trioxide. However, arsenic in seafood exists in an organic state known as arsenobetaine. Approximately 80 to 90 percent of the arsenic available in seafood is in the organic form, which is not toxic (taken from Guidance Document for Arsenic in Shellfish, USFDA, January, 1993). Therefore, the levels of risk estimated for arsenic in seafood at the OFFTA site are overestimates by as much as a factor of 10 because they are not based on toxicity values for arsenobetaine, but rather on inorganic arsenic, which has been demonstrated to be much more toxic than arsenobetaine. Therefore, to compensate for this overestimate of risks in the OFFTA RI, the cancer risk presented in the RI was adjusted downward by a factor of 10 to account for a low bioavailability of arsenic in seafood.

STEP 2 - Conversion of Tissue PRG to Dry Weight

Note that sediment data are in dry weight units and tissue data are in dry weight units for the BSAF and BAF values to be meaningful. This required that the tissue PRG be converted to a dry weight value as follows:

$$\text{tissue PRG (dry wt.)} = \text{tissue PRG (wet wt.)} \times \frac{100}{\text{(average percent solid of fish tissue samples)}}$$

STEP 3 - Calculate the Sediment PRG

Bioaccumulation Factors (BAFs) and Biota-Sediment Accumulation Factors (BSAFs) are used to convert tissue concentrations to sediment concentrations.

For metals, the bioaccumulation factor (BAF) equals the median across all sampling locations of the ratio of tissue concentration for shellfish caught at a given location divided by the sediment concentration at that location:

$$\text{BAF} = \frac{\text{tissue concentration (dry wt.)}}{\text{sediment concentration (dry wt.)}}$$

For organics, the biota-sediment accumulation factor (BSAF) equals the median across all sampling locations of the ratio of the tissue concentration normalized to lipid content divided by the sediment concentration normalized to TOC:

$$\text{BSAF} = \frac{[\text{tissue concentration (dry wt.)} / \text{lipid concentration (\%)}]}{[\text{sediment concentration (dry wt.)} / \text{TOC (\%)}]}$$

Calculated BAF and BSAF values are presented in Table 2.1

The sediment PRG for metals is calculated as follows:

$$\text{sediment PRG for metals} = \frac{\text{tissue PRG (dry wt.)}}{\text{BAF}}$$

The sediment PRG for organics is calculated as follows:

$$\text{sediment PRG for organics} = \frac{[\text{average TOC conc. x tissue PRG (dry wt.) /average tissue lipid conc.}]}{\text{BSAF}}$$

Sediment concentrations that would yield target cancer risk levels of 1E-06, 1E-05 , and 1E-04 for recreational consumption of shellfish are presented in Table 2.1. This method of PRG estimation is based on the proportionality established in the RI report between estimated risk and shellfish exposure point concentrations (this incorporating the same recreational fisherman exposure assumptions delineated in the RI report) and on the ration of shellfish tissue concentrations to sediment concentrations from colocated samples as determined in the ERA.

PART 3 - DEVELOPMENT OF ECOLOGICAL PRGS

PRGs for the nearshore and offshore marine sediments were developed to protect benthic and epibenthic receptors from adverse risks from contaminants present in the sediment. These PRGs were developed based on the data collected in the ecological risk assessment (SAIC, 4/00) for the site.

The basic assumption used for the development of these PRGs is that exposure of benthic and epibenthic receptors to sediment contaminants can be determined by measuring (for metals) or estimating (for organic chemicals) the contaminant concentrations in pore water. The basis of the assumption is presented in detail in the document Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by Using Equilibrium Partitioning (USEPA, 1993).

To summarize, scientific evidence indicates that the partitioning of the chemical between sediment-organic carbon and pore water is at equilibrium. Because the chemicals are at equilibrium, a benthic or epibenthic organism would likely receive an equivalent exposure from a water-only exposure or from any equilibrated phase (from sediment carbon via ingestion, from pore water via respiration, or a mixture of both pathways).

Based on this assumption, the exposure of an organism to a contaminant in the sediment can be estimated by measuring any of the exposure routes. The pore water exposure route was selected for the development of these PRGs. The following text describes the steps that are used to calculate the PRGs for this site using pore water data. Tables 3.1 through 3.11 take the data through the calculation steps as referenced in the text of each step.

Step 1 - Identify the Water Quality Screening Value (WQSV)

The primary objective of this step is to identify the WQSVs that will be compared to the pore water concentrations (see Step 2). Table 3.1 presents the WQSVs that were used for PRG development for this site, and the sources of the values.

The prioritization of use of each of the sources to obtain or calculate the WQSVs was developed as follows: The chronic saltwater RIDEM Water Quality Criteria (WQC) were given first priority. If none was available, saltwater acute RIDEM WQC were used (RIDEM, 2000). Where acute WQC were used, the acute criteria was divided by chemical-specific acute to chronic ratios to estimate the chronic value (TtNUS 2001). Freshwater WQC were used for parameters that did not have saltwater values. Chronic USEPA Recommended WQC (USEPA, 1999) were used next, followed by chronic values presented in

Buchman (1999). Finally, if no water values were available at all, the following equilibrium partitioning equation was used to calculate a WQSV from a sediment benchmark (i.e., ER-Ls from Long et al., 1995):

$$WQSV = (\text{Sediment Benchmark})/(Koc*TOC/100)$$

Where: WQSV = Water Quality Screening Value (ug/L)
Sediment Benchmark = Sediment Screening Level (ug/kg)
Koc = Organic Carbon Partition Coefficient (L/kg)
TOC = Total Organic Carbon (mg/kg) (assumed 1% TOC)

Step 2 - Determine the Pore Water Concentrations

The primary objective of this step is to obtain a pore water concentration for each contaminant detected. For metals, the pore water concentrations were obtained by extracting the pore water from the sediment sample and analyzing the pore water directly. Because a large quantity of pore water is needed to achieve low detection limits for organic chemicals, the pore water concentrations for organic chemicals were estimated by substituting the measured sediment concentration for the sediment benchmark in the equation presented in Step 1.

The sediment concentrations that are used for the pore water calculation are presented in Table 3.2. Note that one-half of the detection limit was used for non-detected parameters. Table 3.3 presents the calculated pore water concentrations (for the organic parameters) and the measured pore water concentrations (for the inorganic parameters). The pore water concentrations for the High Molecular Weight (HMW) PAHs, Low Molecular Weight (LMW) PAHs, and total PAHs were calculated by summing the calculated pore water concentrations of the applicable individual PAHs.

Step 3 - Identify Toxic and Non-Toxic Samples

The primary objective of this step is to identify which sediment samples were found to be toxic and non-toxic. using both toxicity tests (amphipods and sea urchins) conducted under the ERA for OFFTA (SAIC, 2000). A description of the tests is presented in the ERA (SAIC, 2000). For the amphipod test, toxic samples are defined as those that have a statistically significant reduction in survival versus the control and are less than 80% of the mean control survival. For the sea urchin test, toxic samples are defined as those that have abnormal development in 50 percent or less pore water concentrations. Table 3.4 summarizes the list of toxic and non-toxic samples.

Step 4 - Group Toxic and Non-Toxic Samples

The objective of this step is to group the toxic and non-toxic samples for each of the toxicity tests so that a 95% upper limit (UL) of the pore water concentrations can be calculated for each data set. The Shapiro and Wilk "W-test" (for sample sets </=50) was used to determine whether the data were normally or lognormally distributed. Then an appropriate statistic method is selected to calculate the 95% UL. If the distribution of the data is undefined, than the 95% UL detection is used as the pore water for that data group. The maximum detection is used if there are less than 11 samples in a data group.

Table 3.5 presents the summary statistics for the non-toxic and toxic sea urchin samples and the non-toxic amphipod samples. No summary statistics were calculated for the toxic amphipod sample since only one sample was toxic (that collected from station OFF-5) and the pore water concentrations for that sample are presented in Table 3.3. Also note that 95% ULs were not calculated for the toxic sea urchin samples because an inadequate number of samples was available for the calculations. Therefore, the maximum concentrations were selected as the pore water concentrations to represent this data set.

Step 5 - Develop the Non-Toxic Pore Water Concentration

The objective of this step is to determine the pore water concentration (95% Upper Limit (UL) or maximum detection) that is associated with the non-toxic samples. This concentration will then be the basis of the PRG.

The first part of this step involves comparing the selected pore water concentrations (95% UL or maximum) of the non-toxic samples for each receptor (Step 4) to the WQSV (Step 1). The second part of this step involves comparing the maximum concentration in the toxic samples to the non-toxic concentration and to the WQSV. This comparison is presented on Table 3.6.

If the non-toxic pore water concentration exceeds the WQSV, and if the toxic pore water concentration exceeds the non-toxic concentration, the non-toxic porewater value is named the No Observed Effects Concentration (NOEC) for that receptor. If the toxic pore water concentration exceeds the WQSV, but the non-toxic concentration does not exceed the WQSV, than the WQSV is selected at the NOEC for that parameter. Contaminants that are thus selected are retained for further PRG development.

For the sea urchin, NOECs were determined for two metals and fourteen PAHs (along with HMW, LMW, and total PAHs). For the amphipod, NOECs were determined for one metal and fourteen PAHs (along with HMW, LMW, and total PAHs). These chemicals are listed on Table 3.6. None of the pesticides or total PCBs had pore water concentrations that were greater than the WQSV and were retained as Aquatic NOECs.

The last part of this step is to select the lower of the two NOECs that were retained for PRG development between the two receptors as the Aquatic NOEC. Therefore, Aquatic NOECs were determined for two metals and fourteen PAHs (along with HMW, LMW, and total PAHs).

As part of Step 5, the SEM-AVS results for both sample sets were compared to the screening value of 5 umol/g. All of the data were below the screening value. This indicates that metals are not causing the toxicity measured in the urchin and amphipod tests.

USEPA has developed Draft Sediment Guidelines for six metals [Draft Equilibrium Partitioning Sediment Guidelines (ESGs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc), 2000]. The USEPA document establishes two sets of guidelines for evaluating sediment. The first guideline is based on Acid Volatile Sulfide (AVS) and Simultaneously Extracted Metal (SEM) data, and the second guideline is based on a comparison of dissolved metals concentrations in the pore water to water quality criteria. The USEPA document indicates that either of the two guidelines may be used for evaluating sediment. This discussion focuses on the SEM-AVS guideline, because the pore water samples were not filtered.

The basis premise of the SEM-AVS guideline is that if there is more AVS than SEM (on a molar basis) in a sample, than the AVS will bind the six simultaneously extracted metals (cadmium, copper, lead, nickel, silver, and zinc) and they will not be toxic (USEPA, 2000). The following equation is used to represent this process:

$$\sum \text{SEM-AVS} \leq 1.0 = \text{non-toxic sediment from the SEM metals}$$

The SEM-AVS guideline also can be normalized to the fraction of organic carbon in the sediment (f_{oc}) by dividing the SEM-AVS value by the f_{oc} (USEPA, 2000). Based on the normalized guideline, toxicity is not likely to occur when the concentration of SEM-AVS is <130 $\mu mol/g_{oc}$, toxicity is likely when the concentration is >3,000 $\mu mol/g_{oc}$, and toxicity is uncertain when the concentration is between 130 and 3,000 $\mu mol/g_{oc}$. The organic carbon normalization does not appear to work for silver (USEPA, 2000).

Table 3.7 summarizes the SEM-AVS results (normalized and un-normalized) for each station. Two of the twenty-three stations had SEM-AVS values that were slightly greater than 1.0 (1.23 at Station OFF-1 and 1.51 at Station OFF-3). With two exceptions, the remaining stations had SEM-AVS values that were well below 1.0. Only one of the stations had a normalized SEM-AVS value that was slightly greater than 130 $\mu mol/g_{oc}$ (OFF-4 = 168 $\mu mol/g_{oc}$). Finally, although silver was not included in the SEM analysis, when AVS is present, any silver in the sediment is not of toxicological concern and none should occur in the interstitial water (USEPA, 2000).

Table 3.7 also presents the metals concentrations in sediment that are included in the SEM analysis. The stations that had the overall highest concentrations of the metals [i.e., OFF-2 (zinc) OFF-7 (lead), OFF-13 (copper, lead, zinc), and OFF-14 (copper, lead, zinc)] had SEM-AVS values that were less than 1.0. In fact, Stations OFF-7, OFF-13, and OFF-18 had the lowest SEM-AVS values of -37, -13, and -36, respectively.

In summary, PRGs will not be calculated for the two SEM metals (copper, and lead) with pore water concentrations that were greater than the WQSV because based on SEM-AVS values presented on Table 3.7, none of these metals are expected to cause toxicity at most of the stations. Metals concentrations that were greater than the WQSV were probably caused by particulates in the sample, because the samples were not filtered. The metals that are bound to particulates are not expected to be bioavailable or cause toxicity to aquatic organisms. The station with the highest SEM-AVS values (normalized and non-normalized) was Station OFF-4, and neither the pore water or sediment was toxic at this station. Therefore, PRGs for these metals are not necessary.

Step 6 - Select the Toxicity Effects Value (TEV)

The objective of this step is to calculate a TEV for each parameter with an Aquatic NOEC, which will be used to select limiting Contaminants of Concern (COCs) in Step 7. This step is done to ensure that the PRGs will not be below the reference concentrations.

Table 3.8 presents the Aquatic NOEC from Step 5, the pore water concentrations for the two reference stations (OFF-22 and OFF-23), and the TEV, which is the higher of the three values. Neither reference station had higher pore water concentrations than the Aquatic NOECs, so the Aquatic NOEC becomes the TEV for all contaminants.

Step 7 - Determine the Limiting COCs

The objective of this step is to limit the number of contaminants for which PRGs are developed to the contaminants that are causing the highest risk at each station. The assumption is that if the contaminants that are causing the highest risk at a station are remediated, the remaining contaminants will be remediated in the same proportion. Therefore, the remaining contaminants will not be present at concentrations that are causing a risk to the aquatic receptors.

This step is done by dividing the pore water concentrations presented in Table 3.3 by the TEVs from Table 3.8 at each station (except the reference stations) to get a TEV-Hazard Quotient (TEV_{HQ}). These TEV_{HQ} values are presented in Table 3.9. The chemical with the highest TEV_{HQ} for a station is the

limiting COC for that station. The list of limiting COCs across all of the stations is the list of limiting COCs for the site. Note that the same chemical may be a limiting COC at more than one station. Also, a limiting COC is not determined for a station if the sum of all the TEV_{HQ}s for that station is less than 1.0, because the sum of those chemicals at the site are not expected to adversely impact the aquatic organisms.

Table 3.9 presents the limiting COC calculation for the site. The following four PAHs were retained as limiting COCs across the site: acenaphthalene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and 2-methylnaphthalene.

Step 8 - Calculate the Baseline PRG

The objective of this step is to convert the pore water-based TEVs into sediment-based PRGs. The sediment PRGs are calculated using the following equation at each station and then averaging the values for each station across all of the stations for the final PRG:

$$PRG(station) = \frac{Cs}{TEV_{HQ}}$$

Where:

PRG	=	Preliminary remediation goal (ug/kg)
Cs	=	Chemical concentration in the sediment (ug/kg)
TEV_{HQ}	=	Toxicity Effects Value Hazard Quotient (ug/L) (From Step 7)

$$PRG(Site) = \sum \frac{PRG(station)}{number\ of\ stations}$$

Table 3.10 presents the calculated PRGs for each station and the average PRGs across all of the stations. Note that the PRGs that are calculated for each station are used to calculate the average PRG for the site. They are not used as a station-specific PRG to evaluate the sediment at that station.

PART 4 - SUMMARY

This section summarizes the PRGs calculated in the previous sections, and provides some discussion of risk management. The risk management step, at this stage of the CERCLA process, is intended to assure that the cleanup criteria that are selected are applied in a sensible and logical manner. In the following sections, the calculated PRGs are compared for commonality. High risk areas for the various endpoints should correlate, and areas exceeding PRGs for these endpoints should also agree.

Recreational Exposure to Sediment

Shoreline sediment PRGs for lifetime resident recreational exposure to shoreline sediment were calculated for arsenic, benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. These PRGs are developed for site specific contaminants targeted to the 1E-6 risk level to ensure total cancer risks are less than RIDEM criteria of 1E-5. The PRGs are based on the parameters in the risk assessment. Risks were based on ingestion of sediment at rates of 100g (child) and 50g (adult) with an increased risk of cancer over a 70 year lifetime. The risk-based PRG for arsenic defaults to the agreed-on background arsenic level (6.2 mg/kg) to assure that the final PRG is not below background. Table 4.1A compares sediment contaminant concentrations to these PRGs. Those exceeding the PRGs are depicted as backlit values. This table shows that one or more of these PRGs are exceeded at all shoreline sediment stations sampled.

Shellfish Ingestion

Nearshore and offshore sediment PRGs based on lifetime recreational ingestion of shellfish were calculated for arsenic, cadmium, chromium, mercury, PCBs, and five PAH compounds. These PRGs are developed for site specific contaminants targeted to the 1E-6 risk level to ensure total cancer risks are less than RIDEM criteria of 1E-5. Table 4-1B depicts sediment data compared with these PRGs calculated for ingestion of lobster. Backlit values depict sediment contaminant concentrations exceeding PRGs for lobster ingestion.

PRGs for PAHs were exceeded at one offshore station, SD-410. Since this location is within the eelgrass bed and appears to be a local hot spot that may be more associated with a nearby outfall than with the site, the concentrations at and near this station should be verified through additional sampling during future PDI efforts.

Arsenic was adjusted to 10% of its tissue concentration to approximate the availability of this compound in shellfish tissue (Section 2). Nonetheless, the PRG for arsenic correlating to a cancer risk of 1E-6 was calculated to be 5.48 mg/kg. This value was exceeded at several offshore sample stations, and was exceeded at two nearshore sample stations (OFF-1 and OFF-2). The locations where arsenic was exceeded did not match those where PAHs were exceeded, and did not seem to have any spatial pattern at all.

The shellfish PRGs were calculated based on ingestion of lobster taken recreationally from the site over a lifetime period. In addition to predicting the risk to the persons ingesting this lobster, the PRG is also based on predicting the uptake of the contaminants by the lobsters collected and providing those

contaminants in a bioavailable form to the persons collecting them. This adds several layers of uncertainty as documented in this and the RI report.

Ecological Exposures

Marine sediment PRGs based on ecological receptors were calculated for four PAH compounds. Table 4-1C depicts sediment data compared with these PRGs calculated for ecological receptors. Contaminant concentrations in sediment exceeding PRGs are backlit values on this table. Ecological PRGs are based on complex algorithms that correlate concentrations of contaminants in sediments to contaminants in porewater, and then correlates those concentrations to measured toxicity. Table 4.1C indicates that the exceedances of these PRGs are limited to OFF-3, 5, and 6. Exceedances were also noted at OFF-18 to the east of the study area, and at SD-410 on the west side of the study area.

Risk Management

This section focuses on uncertainties noted in the risk assessments and the correlation of the COCs exceeding PRGs and locations of actionable concentrations. Table 4.2 provides a summary of the calculated PRGs for the OFFTA site, based on the three receptor scenarios described in the previous sections of this document.

Only one contaminant, dibenzo(a,h)anthracene, was selected as a COC and exceeded the calculated PRG for all three risk endpoints. Other PAHs were selected as COCs and calculated PRGs were exceeded, but not so for all three risk endpoints. Only one inorganic contaminant was found to exceed PRGs, that for arsenic, and this was exceeded under the ingestion of lobster and lifetime exposure endpoint.

Spatially, the PRGs calculated for PAHs were exceeded at the nearshore stations. This observation is supported by the conceptual site model which indicates that contaminants from oils and combustion during the firetraining exercises would have flowed down-gradient to the shoreline. The locations where arsenic exceeded the calculated PRG for lobster ingestion did not correlate to any of the locations where PAHs exceeded PRGs, nor did the locations of these exceedances show a pattern.

The exceedance of the ecological PRG at OFF-18 was limited to the 1.6-1.8 foot interval, and no exceedances were noted in surface sediments or deeper sediments at this location, or at samples taken at SD-468 and SD-469, both located nearby. Because this appears to be a small pocket of contamination beyond the zone of bioturbation, it should not be considered actionable.

The exceedances at SD-410 is notable since the concentrations of PAHs at this location were the highest found in the study area. Additional sampling should be directed at this location during future predesign work to determine the size of this apparent hot spot, and to determine if it requires action.

The value of 5.48 mg/kg for arsenic is below the 6.2 mg/kg value established by RIDEM for background soils for Coasters Harbor island. The value of 6.2 mg/kg was established to account for what appears to be anthropogenic occurrence of arsenic in soils. Such an incidence may also be found in sediments. The arsenic concentrations in surface sediment sampled at the site (those sediments to which lobsters could be exposed) range from 2.7 mg/kg to 8.5 mg/kg with an average concentration of 4.97 mg/kg.

Data review indicates that arsenic levels exceed the 5.48 mg/kg value at OFF-1 (6.3 mg/kg), OFF-2 (8.0 mg/kg), OFF-7 (6.8 mg/kg), OFF-13 (6.0 mg/kg), OFF-14 (8.5 mg/kg), and 0FF-19 (5.8 mg/kg). None of the locations where arsenic exceeds the 5.48 mg/kg value match the areas where other PRGs are exceeded. Two of the exceeding locations, OFF-14 and OFF-19, are the locations closest to the Newport treatment plant outfall (northwest of the site) and two others (OFF-1 and OFF-2) are down-current from that outfall. Arsenic in the action areas delineated by exceedances from the other PRGs range from 3.6 mg/kg to 4.3 mg/kg, showing no co-location.

Finally, if actions are taken on PAHs alone, and no actions were taken based on arsenic, the hypothetical maximum risk (based on maximum detected arsenic value {8.5} and assuming bioavailability) would be only slightly above 1E-6 and well below 1E-5. The risk based on the average of all arsenic detects (5 mg/kg) would be less than 1E-6.

These observations indicate that the PAHs exceeding the PRGs appear to be a good indicator of site related contamination, and would be better suited to direct a remedial or corrective action. Contrarily, the PRG for arsenic is not correlative with the PAHs and does not support the site model, and therefore is not recommended for use in selection or direction of remedial actions.

Figure 1 presents the action areas that are proposed based on the PRGs selected in this document, and based on the data that was available during the PRG development.

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TABLE 1.1
SHORELINE SEDIMENT PRGS
RESIDENTIAL CONTACT WITH SEDIMENT, LIFETIME RECREATIONAL EXPOSURE
NSN NEWPORT, RHODE ISLAND

Substance	Exposure Point Concentration*	Estimated Risk at Exposure Pt. Conc.	PRGs at various risk levels*		
			1.00E-04	1.00E-05	1.00E-06
Arsenic	6.53	6.09E-06	107.31	10.73	1.07
Benz(a)anthracene	1900	1.42E-06	133821	13382	1338
Benzo(a)pyrene	1400	1.05E-05	13382	1338	134
Benzo(b)fluoranthene	1700	1.27E-06	133821	13382	1338
Dibenz(a,h)anthracene	290	2.17E-06	13382	1338	134

*Units are ug/kg for organics, mg/kg for inorganics.

Table 2.1
Sediment PRG Summary
Lifetime Recreational Fisherman Exposure to Lobster
NSN, Newport, Rhode Island

Substance	Tissue EPC*	Noncancer Risk	Cancer Risk	Tissue Concentration PRGs*				Median BAF	Median BSAF	Sediment Concentration PRGs*			
				Noncancer (HI = 1)	1E-4 Cancer Risk	1E-5 Cancer Risk	1E-6 Cancer Risk			Noncancer (HI = 1)	1E-4 Cancer Risk	1E-5 Cancer Risk	1E-6 Cancer Risk
Arsenic**	8.55	0.0652	9.74E-06	1.31E+02	8.78E+01	8.78E+00	8.78E-01	0.97		819	548	54.8	5.48
Cadmium	12.7	0.291		4.36E+01				26.165		10			
Chromium	17.1	0.13		1.32E+02				0.215		3708			
Mercury	3.53	0.807		4.37E+00				11.41		2.3			
Total PCB Congeners	265	0.303	4.03E-06	8.75E+02	6.58E+03	6.58E+02	6.58E+01		1.075		17450	1745	175
Dieldrin***	4.47		5.43E-07		8.23E+02	8.23E+01	8.23E+00		***		***	***	***
Benz(a)anthracene	94.6		5.25E-07		1.80E+04	1.80E+03	1.80E+02		0.015		3426991	342699	34270
Benzo(a)pyrene	172		9.54E-06		1.80E+03	1.80E+02	1.80E+01		0.005495		936019	93602	9360
Benzo(b)fluoranthene	187		1.04E-06		1.80E+04	1.80E+03	1.80E+02		0.01		5129566	512957	51296
Dibenz(a,h)anthracene	3.74		2.07E-07		1.81E+03	1.81E+02	1.81E+01		0.007645		674211	67421	6742
Indeno(1,2,3-cd)pyrene	101		5.60E-07		1.80E+04	1.80E+03	1.80E+02		0.007095		7251925	725193	72519

Shaded values are changes in the draft final.
*EPC and PRG Units are mg/kg for inorganics, ug/kg for organics
**Arsenic tissue EPCs are adjusted for As bioavailability - see text
Average tissue % solids: 16.5
Average tissue % lipids: 5.651
Average sediment % TOC: 2.66
***Sediment PRG and BAF not calculable because substance not detected in sediment.
BAF and BSAF data from Appendix D-8-1, in Technical Support Document for the Marine Ecological Risk Assessment, OFFTA, Naval Station, Newport RI, December 1998

TABLE 3-1
WATER QUALITY SCREENING VALUES
ECOLOGICAL PRG DEVELOPMENT STEP 1
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Parameter	Koc[1]	Water Quality Screening Values (ug/L)				Sediment Benchmarks (ug/kg)		Final WQSV (ug/L)	
		Freshwater Chronic	Saltwater Acute	Saltwater Chronic	Source	Value	Source	Value	Comment
Polyaromatic Hydrocarbons									
1-Methylnaphthalene	7994							NA	
1-Methylphenanthrene	98610							NA	
2,3,5-Trimethylnaphthalene	NA							NA	
2,6-Dimethylnaphthalene	34034							NA	
2-Methylnaphthalene	7994					70	(7)	0.88	A
Acenaphthene	7139			710	(11)			710	B
Acenaphthylene	9581					44	(7)	0.46	A
Anthracene	29712					85.3	(7)	0.29	A
Benzo(a)anthracene	401218					261	(7)	0.065	A
Benzo(a)pyrene	1014869					430	(7)	0.042	A
Benzo(b,j,k)fluoranthene	1244171					1800	(11)	0.14	A
Benzo(e)pyrene	1014869							NA	
Benzo(g,h,i)Perylene	3858158					720	(8)	0.019	A
Biphenyl	7816					1100	(12)	14	A
Chrysene/triphenylene	401218					384	(7)	0.10	A
Dibenzo(a,h)Anthracene	3771812					63.4	(7)	0.0017	A
Fluoranthene	107954			16	(11)			16	B
Fluorene	13763					19	(7)	0.14	A
Indeno(1,2,3-cd)pyrene	3445323					690	(8)	0.020	A
Naphthalene	2010		2350		(11)			633	D
Perylene	885992							NA	
Phenanthrene	29712			4.6	(11)			4.6	B
Pyrene	105538					665	(7)	0.63	A
Sum PAHs (6 High Molecular Weight)	1014869					1700	(7)	0.17	A
Sum PAHs (7 Low Molecular Weight)	11483					552	(7)	4.8	A
Sum PAHs (NOAA Status &Trends)	107954					4022	(7)	3.7	A

TABLE 3-1
WATER QUALITY SCREENING VALUES
ECOLOGICAL PRG DEVELOPMENT STEP 1
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Parameter	Koc[1]	Water Quality Screening Values (ug/L)				Sediment Benchmarks (ug/kg)		Final WQSV (ug/L)	
		Freshwater Chronic	Saltwater Acute	Saltwater Chronic	Source	Value	Source	Value	Comment
PCBs/Pesticides									
1a,2a,3b,4a,5a,6b-hexachlorocyclohexane (lindane)	5566		0.16		(2)			0.160	D
2,4'-DDE	4419366			0.001	(2,6)			0.001	B
2,4'-DDT	4419366			0.001	(2)			0.001	B
4,4'-DDD	992156			0.001	(2,6)			0.001	B
4,4'-DDE	4419366			0.001	(2,6)			0.001	B
4,4'-DDT	4419366			0.001	(2)			0.001	B
Aldrin	2453466		1.3		(2)			0.16	C
alpha-Chlordane	2453466			0.004	(2)			0.004	B
Heptachlor	2453466			0.0036	(2)			0.0036	B
Heptachlor Epoxide	2453466			0.0036	(2)			0.0036	B
Hexachlorobenzene	616808					22	(8)	0.0036	A
Mirex	5931301			0.001	(4)			0.001	B
trans-Nonachlor	5668785							NA	
PCBs	NA			0.03	(2)			0.03	B
Metals									
Aluminum	NA	87			(2)			87	C
Arsenic	NA			36	(2,3)			36	B
Barium	NA							NA	
Cadmium	NA			9.4	(2,3)			9.4	B
Chromium	NA			50	(2,3)			50	B
Copper	NA			3.7	(2,3)			3.7	B
Iron	NA	1000			(4)			1000	C
Lead	NA			8.5	(2,3)			8.5	B
Manganese	NA							NA	
Mercury	NA			1.1	(3,4,5)			1.1	B
Nickel	NA			8.3	(2,3)			8.3	B
Silver	NA			0.92	(3, 13)			0.92	B
Zinc	NA			86	(2,3)			86	B

TABLE 3-1
WATER QUALITY SCREENING VALUES
ECOLOGICAL PRG DEVELOPMENT STEP 1
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Parameter	Koc(1)	Water Quality Screening Values (ug/L)				Sediment Benchmarks (ug/kg)		Final WQSV (ug/L)	
		Freshwater Chronic	Saltwater Acute	Saltwater Chronic	Source	Value	Source	Value	Comment
SEM-AVS	NA					5	(10)	5	E

Sources of Data

1 - See Table 4 for source of Koc values
2 - RIDEM Ambient Water Quality Criteria and Guidelines for Toxic Pollutants, Appendix B, amended June 2000
3 - Values are based on total metals because the pore water samples were not filtered
4 - USEPA National Recommended Water Quality Criteria (USEPA, 1999)
5 - The mercury value from USEPA (1999) was used because it is based on protecting aquatic life. The RIDEM value is based on protecting wildlife, which is not an endpoint of the PRGs.
6 - Used the DDT value as a surrogate for DDD and DDE
7 - ER-L value from Long et al., (1995)
8 - Apparent Effects Threshold value (Option 2 - with mixcotox data excluded) from PTI (1989)
9 - Used the value for benzofluoranthenes
10 - Source of SEM - AVS value of 5 umole/g dry weight is USEPA (1997)
11 - Lowest Observed Effects Levels cited in Buchman (1999)
12 - Sediment Quality Benchmark from USEPA (1996)
13 - Proposed Value in the Water Quality Criteria Summary Table (USEPA, 1991)

Comments

A - Value was calculated from sediment benchmark using the following equilibrium partitioning equation with the Total Organic Carbon=1%:
WQSV - (Sediment Benchmark)/(Koc * TOC/100)
B - Values is the saltwater chronic water quality screening value
C - Value is the freshwater chronic water quality screening value
D - Values is the saltwater acute water quality screening value divided by the following chemical-specific acute-to-chronic ratios that were developed by SAIC for Portsmouth Naval Shipyard (TtNUS, 2001):
- Naphthalene - 3.71
- Lindane - 1
- Aldrin - 8

E - Value is the USEPA recommended screening level
NA - No data available

TABLE 3.2
SEDIMENT RESULTS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-1	OFF-2	OFF-3	OFF-4	OFF-5	OFF-6	OFF-7	OFF-8	OFF-9	OFF-10	OFF-11	OFF-12	OFF-13	OFF-14	OFF-15
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/3/98	4/7/98	4/7/98
Polyaromatic Hydrocarbons (ug/kg)															
1-Methylnaphthalene	14.8 J	52.4 J	62.2 J	35.8 J	278 J	132 J	34.6	11	1.7 J	2.2 J	6.2 J	78.8 J	43.2 J	9.4	4.6 J
1-Methylphenanthrene	132	364	539	282	1460	680	104	22	4.4 J	3 J	14.8	220	177 J	20.1	11.4
2,3,5-Trimethylnaphthalene	7.7 J	45.2 J	22 J	22.6 J	121 J	36.3 J	17.7	2.3 J	0.4 J	2.4 U	2 J	20.8 J	12.9 J	2.6 J	0.8 J
2,6-Dimethylnaphthalene	18.9 J	103 J	66.9 J	53.5 J	476 J	148 J	59.8	24.5	12.4	9 J	18.5 J	88.9 J	55.2 J	15.6	7.3 J
2-Methylnaphthalene	26 J	77.6 J	89.2 J	38.1 J	330 J	170 J	54.9	14.4	3.1 J	3.1 J	17.5 J	117 J	65.6 J	15.5	9.5
Acenaphthene	23	88.1	371	54	966	344	120	34	4.1 J	2.5 J	27.9	321	110 J	11.4	5.1 J
Acenaphthylene	93	488	350	424	509	195	169	18.5	5.7	4.1 J	9	58.3	156 J	25.2	11.9
Anthracene	255 J	1100 J	1460 J	774 J	2810 J	1170 J	393	70.1	11.3	9.8 J	64 J	572 J	482 J	51.8	35
Benzo(a)anthracene	100	3600	5690	2280	9300	4250	1160	214	57.3	35.2	168	1200	1160 J	216	106
Benzo(a)pyrene	595	2410	3450 J	2090	4830	1990	1330	218	76.1	45.1	148	1420	1150 J	255	103
Benzo(b,j,k)fluoranthene	2780	7710	17300 J	3500	25000	9390	2850	411	152	94.6	284	2730	2430 J	457	366
Benzo(e)pyrene	910 J	2370 J	5250 J	1310 J	7590 J	3270 J	966	161	58.4	41.3 J	107 J	1080 J	939 J	213	140
Benzo(g,h,i)Perylene	876 J	2520 J	5370 J	1290 J	5990 J	2630 J	1020	141	52.5	40.5 J	95.2 J	815 J	744 J	195	100
Biphenyl	7.2	22.1	38.6	6.6	151	46.7	14.7	3.2 U	3.2 U	1.2 J	3.7 J	28.8	20.5 J	3.2 U	3.2 U
Chrysene/triphenylene	790	2340	4560	1850	7300	3350	519 J	196	59.6	31.8	117	998	774 J	190	87.3
Dibenzo(a,h)Anthracene	441 J	1290 J	2810 J	352 J	3410 J	1390 J	293	41.5	6.8 U	8.6 J	23.9 J	280 J	213 J	52.2	44
Fluoranthene	1950	8350	14600	5580	19200	11200	2190	455	117	86.2	388	3120	2600 J	308	185
Fluorene	40.3 J	303 J	598 J	177 J	1360 J	392 J	160	34.7	5.3 J	2.8 J	25.1 J	271 J	123 J	17.2	7.6
Indeno(1,2,3-cd)pyrene	1010	3070	6560 J	1200	7390	3030	968	136	48.1	35.3	86.3	777	646 J	172	116
Naphthalene	31.9	171	149	136	258	161	70	22.8	4.3	4	9.8	128	61.2 J	20.6	11.3
Perylene	225	818	1490 J	607	1460	734	363	60.4	21.4	12.8	34.8	257	253 J	79.4	32.9
Phenanthrene	1060	5610	10700	3030	14600	9470	1320	261	46.3	31.3	238	2510	1440 J	130	87.4
Pyrene	1780	6750	10700	4810	16900	9770	2120	401	102	87.5	337	3020	2530 J	344	187
Sum PAHs (6 High Molecular Weight)	6660	24700	41800	16700	60900	32000	7620	1530	425	294	1180	10000	8430	1360	712
Sum PAHs (7 Low Molecular Weight)	1530	7830	13700	4640	20800	11900	2280	456	80	58	391	3980	2440	271	168
Sum PAHs (NOAA Status &Trends)	14200	49600	92100	29900	132000	64000	16300	2960	858	592	2230	20100	16200	2800	1660
Pesticides/PCBs (ug/kg)															
1a,2a,3b,4a,5a,6b-hexachlorocyclohexane (gamma-BHC)	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.8 J	0.2 J	0.3 J	0.1 J	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.5 J
2,4'-DDE	0.25 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.9	0.4 U	0.4 U	0.4 U
2,4'-DDT	1.1	1.8	0.7 J	2.6	1.7	1.4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.6 J	1.2	0.5 U	0.5 U
4,4'-DDD	3 J	1.4 J	1.8 J	2.4 J	2 J	3.8 J	3.8	0.8 J	0.45 U	0.4 U	0.4 U	11.2 J	19.7 J	1.4	0.6 J
4,4'-DDE	1.25 U	1.25 U	1.1 U	1 U	1.5 U	3.8	3.1	0.7 J	0.45 U	0.45 U	0.45 U	6.2	10.8	0.9 J	0.5 J
4,4'-DDT	4.3	10	4	11.5	11.3	9.8	2.7	1.1	0.8	0.7	1.6	4.8	10.9	2	0.8
Aldrin	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.1 J	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
alpha-Chlordane	0.8	0.7 J	0.7 J	1.2	1.4	0.6 J	0.7 J	0.1 J	0.1 J	0.4 U	0.4 U	1.2	1.4	0.2 J	0.1 J
Heptachlor	0.25 U	0.25 U	0.25 U	0.7 U	0.25 U	0.25 U	0.3 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.65 U	0.2 J	0.1 J
Heptachlor Epoxide	0.25 U	0.25 U	0.25 U	0.6 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	2.8 J	2.4 J	1.1 J	0.25 U	0.25 U
Hexachlorobenzene	0.2 U	0.2 U	0.2 U	0.2 U	0.25 U	0.3 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.4 U	0.2 U	0.2 U	0.2 U
Mirex	0.3 J	0.3 U	0.3 U	0.3 U	0.6	0.5 J	0.4 J	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.4 J	0.4 J
PCB 101/90	0.6 U	1.05 U	1.2 U	2.9	1.1 U	1 U	2.7	0.55 U	0.3 U	0.35 U	1.1 U	4.1	5.9	2.2	0.45 U
PCB 105	0.3 U	0.6 U	0.7 U	0.35 U	1.7 J	0.35 U	0.65 UJ	0.3 U	0.3 U	0.15 U	0.65 U	1.7 J	3.5 J	0.45 UJ	0.3 U
PCB 118	0.7 J	2.1	1.8	1.3	1.1	1.6	2.3	1.1	0.5 J	0.7 J	2	3.2	6.6	2.3	0.8
PCB 126	0.25 U	0.9 J	1.3 J	1.7 J	2.5 J	0.25 UJ	0.4 U	0.25 UJ	0.25 U	0.25 U	0.7 J	1.8 J	4.9 J	1.1	0.25 UJ
PCB 128	0.6	0.6 J	0.8 J	2.1	0.9 J	1.8 J	1	0.3 U	0.2 UJ	0.25 U	0.6	1.8	4	0.4 U	0.2 UJ
PCB 138/163/164	1.9	10.7 J	11.2 J	11.4	16.2 J	3 J	5.2	2.4	1	1.2	3.5	7.7	13.3	3.1	1.7
PCB 153	1.5	2.5	2.5	1.9	4	2.7	3.5	2	1	1.1	3.3	5.4	9.3	3.4	1.7

TABLE 3.2
SEDIMENT RESULTS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-1	OFF-2	OFF-3	OFF-4	OFF-5	OFF-6	OFF-7	OFF-8	OFF-9	OFF-10	OFF-11	OFF-12	OFF-13	OFF-14	OFF-15
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/3/98	4/7/98	4/7/98
PCB 170	0.45 U	0.35 U	0.35 U	1.8	1.8	1.8 J	0.6 U	0.45 U	0.25 UJ	0.35 U	1.5	3.8	5.8	0.45 U	0.3 U
PCB 18	1.3 J	0.35 U	1.7	0.35 U	1.4	2.8	0.6 J	0.35 U	0.35 U	0.35 U	3.5	2.4	0.5 J	1.1	0.35 U
PCB 180	1.1	1.5	2.4	2	3.9	2.1 J	2.5	1.2	0.7	0.6	3.2	6.4	9.3	1.6	1.1
PCB 187/182/159	0.6	0.7	0.6	2.8	1.6	1.9 J	1.6	0.45 U	0.3 U	0.6	2	3.7	5.5	1.8	0.35 U
PCB 188	0.3 U	0.3 U	0.8	0.3 U	1.3	2.6	0.7	0.5 J	0.3 U	0.3 U	0.6 J	1	1.6	0.8	0.3 U
PCB 195	0.25 U	0.3 U	0.3 U	1.2	3.5	0.3 UJ	0.3 U	0.3 U	0.3 U	0.3 U	0.7	0.8 J	3.7	0.3 U	0.3 U
PCB 200	0.3 J	1.2	1	1.8	2	1.1 J	0.4 J	0.4 J	0.3 J	0.4 J	0.4 J	1.6	0.25 U	0.4 J	0.4 J
PCB 206	0.25 U	0.25 U	0.25 U	1.2 U	0.3 U	0.3 UJ	0.6	0.8	0.4 J	0.65 U	0.75 U	0.95 U	4	1	0.7
PCB 209	0.25 U	0.25 U	0.25 U	0.25 U	0.35 U	4.1 J	0.8	0.8	0.3 J	0.35 U	0.25 U	2.2	3	1.2	0.6
PCB 28/50	0.7	0.35 U	0.6 J	0.35 U	1.8	2.7	1	0.3 J	0.5 J	0.35 U	7.4	4.2	1.3	0.9	0.3 J
PCB 29	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
PCB 44	0.6 J	0.4 J	1.4 J	1.4 J	1.4 J	1.8 J	1.9	0.25 U	0.25 U	0.3 J	3.3 J	2 J	2.4 J	0.6	0.25 U
PCB 50	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
PCB 52	0.4 U	0.35 U	0.5 U	1.4 J	1.8 J	2.6 J	1.4	0.35 U	0.35 U	0.35 U	3.4 J	3.2 J	2.9 J	1.1	0.35 U
PCB 66/95	1.1	1.4	2	1.7	3.9	3.4	3.3	1.1	0.25 UJ	0.6	6.5	5	4.6	2.2	0.45 U
PCB 8	8.5 J	0.15 U	0.9 J	0.15 U	0.15 U	0.6	0.15 U	0.15 U	0.15 U	0.15 U	0.8	1.5	0.9	0.25 U	0.15 U
PCB 87	0.3 UJ	0.9 J	0.8 J	0.7 J	0.8 J	1.6 J	1	0.3 U	0.3 U	0.3 UJ	0.8 J	1.6 J	2.5 J	0.3 U	0.3 U
Sum of PCB Congeners	18.9	22.9	29.8	36.1	51.6	38.2	30.5	10.6	4.7	5.5	44.2	65.1	95.5	24.8	7.3
Sum of PCB Congeners X 2	37.8	45.8	59.6	72.2	103.2	76.4	61	21.2	9.4	11	88.4	130.2	191	49.6	14.6
trans-Nonachlor	0.6 J	0.4 U	0.7 J	0.4 U	1.3	0.4 U	0.8	0.2 J	0.1 J	0.4 U	0.4 U	0.6 J	1 J	0.4 J	0.2 J
Metals (mg/kg)															
Aluminum	21672 J	26984 J	23219 J	16492 J	16256 J	22707 J	21885 J	27137 J	26673 J	26244 J	19537 J	35681 J	40999 J	28276 J	26843 J
Arsenic	6.3 J	8 J	3.6 J	4.3 J	3.6 J	4.1 J	6.8 J	4.3 J	4.3 J	3.4 J	2.7 J	5.2 J	6 J	8.5 J	3.7 J
Cadmium	0.31	0.14	0.18	0.06	0.23	0.15	0.29	0.19	0.11	0.15	0.22	0.53	0.8	0.12	0.18
Chromium	31.1	36.6	26.5	24.3	27.4	23	43.1	42.3	38.6	32.1	30.2	58.6	73.7	44.9	41
Copper	58.3	23.7	12.3	31.4	16.9	11	32.8	11	6.9	9.8	9.1	37	80.8	18.9	11.6
Iron	24310 J	29487 J	22872 J	22908 J	17649 J	19993 J	27506 J	21704 J	24714 J	17985 J	14919 J	27717 J	33406 J	21879 J	21010 J
Lead	131.4	90.2	60.1	95.5	138.7	47.2	294	37.9	25.2	27.3	38.7	114.2	201.9	44.6	33.1
Manganese	353.6	302.2	387.4	369	166.8	257.5	331.6	356.2	515.8	357.1	331	368.1	335.9	324	366.5
Mercury	0.371	0.081	0.025 U	0.025 U	0.025 U	0.025 U	0.119	0.148	0.025 U	0.07	0.125	0.376	1.355	0.196	0.1
Nickel	34	26.2	22.2	20.2	19	19.3	28.1	15.8	18.3	12.5	5.45 U	21.4	29.7	15.9	14.2
Silver	0.46 J	0.065 UJ	0.065 UJ	0.065 UJ	0.065 UJ	0.065 UJ	0.18 J	0.17 J	0.065 UJ	0.065 UJ	0.17 J	0.48 J	1.06 J	0.23 J	0.19 J
Zinc	156.4	314.8	50.4 U	106	39.9 U	52.85 U	155.5	46.7 U	39.95 U	26.65 U	27.75 U	146.5	263.4	48.4 U	36.65 U
AVS/SEM (µmole/g dry weight)															
Acid Volatile Sulfide	0.05 U	0.05 U	0.23	0.05 U	23.82	26.06	38.21	6.21	4.44	7.29	13.03	24.03	48.59	10.3	7.1
Cadmium	0.001	0.001	0.001	0	0.002	0.002	0.002	0.003	0.001	0.002	0.002	0.005	0.009	0.002	0.002
Copper	0.341	0.0585 U	0.054 U	0.413	0.078 U	0.0885 U	0.045 U	0.397	0.269	0.212	0.0915 U	0.0395 U	0.031 U	0.417	0.393
Lead	0.505	0.215	0.119	0.507	0.386	0.168	0.221	0.122	0.061	0.079	0.094	0.249	0.589	0.15	0.121
Nickel	0.026 U	0.02 U	0.018 U	0.126	0.152	0.0385 U	0.034 U	0.0325 U	0.0245 U	0.031 U	0.033 U	0.0205 U	0.132	0.054 U	0.036 U
SEM-AVS	NA	NA	0.489 J	NA	-22.22 J	-24.97 J	-37.41 J	-4.68 J	-3.65 J	-6.394 J	-12.14 J	-23.08 J	-46.71 J	-8.4 J	-5.592 J
SEM/AVS	NA	NA	3.1261 J	NA	0.0672 J	0.0419 J	0.021 J	0.2465 J	0.178 J	0.1229 J	0.0681 J	0.0394 J	0.0387 J	0.1845 J	0.212 J
Zinc	0.407	0.549	0.527	0.517	0.982	0.794	0.499	0.976	0.435	0.572	0.667	0.632	1.12	1.277	0.957
Total Organic Carbon (percent)															
Total Organic Carbon	1.8	1.1	0.9	0.9	1	1.8	1.9	1.3	1.2	1.1	1.1	2.5	4	2	1.2
Grain Size (percent)															
CLAY	0.2	0.1	0.2	0.1	0.3	0.3	0.6	0.4	0.4	3.7	0.8	1	6.1	1.3	0.5
SAND	96	97.1	95.2	98.5	97.1	94.2	86.7	72.8	88.1	85.7	87.8	44.2	14.5	59.1	87.3
SILT	3.9	2.8	4.6	1.5	2.6	5.5	12.7	26.7	11.5	10.7	11.4	54.7	79.5	39.7	12.2

TABLE 3.2
SEDIMENT RESULTS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21	OFF-22	OFF-23
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98	3/27/98	4/3/98
Polyaromatic Hydrocarbons (ug/kg)								
1-Methylnaphthalene	17.6 J	11 J	31.4 J	18.9	43.7 J	7.7 J	2 J	27.8
1-Methylphenanthrene	43.6 J	25.3	108	20.2	44.4	19.3	2.6 J	49.9
2,3,5-Trimethylnaphthalene	6 J	2.5 J	11.5 J	3.6 J	5.6 J	2.4 J	0.3 J	8.2
2,6-Dimethylnaphthalene	37.8 J	22.1 J	45.3 J	54.3	43.9 J	13.7 J	5.8 J	38.6
2-Methylnaphthalene	23.9 J	19.7 J	63.8 J	31.5	40.4 J	13.1 J	3.1 J	43.4
Acenaphthene	37.6 J	25.6	59.7	43.8	75.3	9.4	1.8 J	89.5
Acenaphthylene	35.8 J	41.1	141	40.6	14.8	18.3	4.4 J	77.5
Anthracene	88 J	120 J	340 J	104	217 J	47.9 J	9.5 J	348
Benzo(a)anthracene	195 J	251	730	316	320	151	35.6	616
Benzo(a)pyrene	220 J	333	964	322	257	176	38.8	758
Benzo(b,j,k)fluoranthene	435 J	654	2290	618	588	375	78.6	1540
Benzo(e)pyrene	187 J	273 J	963 J	234	197 J	158 J	49.3 J	688
Benzo(g,h,i)Perylene	181 J	270 J	899 J	201	131 J	133 J	60.4 J	700
Biphenyl	9.1 J	5.6 J	17.3	18.2	17.9	5.9 J	0.8 J	12.8
Chrysene/triphenylene	151 J	203 J	631	277	296	151	26.7	540
Dibenzo(a,h)Anthracene	49.6 J	76.1 J	273 J	57.4	50.3 J	40.4 J	12.2 J	179
Fluoranthene	444 J	528 J	1880	542	882	291	65.9	1560
Fluorene	34.1 J	30.9 J	74.8 J	51.3	92.6 J	11.3 J	2.4 J	106
Indeno(1,2,3-cd)pyrene	156 J	237	785	195	150	126	33.9	511
Naphthalene	19.9 J	25	68.1	53.3	40.1	8.7	3.2 J	41.6
Perylene	62.9 J	80.5	276	85.6	63.4	43.3	12.9	205
Phenanthrene	331 J	271	918	294	828	126	23.5	770
Pyrene	513 J	544 J	1810	523	751	334	69.2	1420
Sum PAHs (6 High Molecular Weight)	1570	1930	6290	2040	2560	1140	248	5080
Sum PAHs (7 Low Molecular Weight)	570	533	1670	619	1310	234	48	1480
Sum PAHs (NOAA Status &Trends)	3280	4050	13400	4110	5150	2250	543	10300
Pesticides/PCBs (ug/kg)								
1a,2a,3b,4a,5a,6b-hexachlorocyclohexane (gamma-BHC)	0.3 U	0.3 U	0.3 U	0.9	0.3 U	0.3 U	0.3 U	0.3 U
2,4'-DDE	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
2,4'-DDT	1.2	0.7 J	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.8
4,4'-DDD	2.2 J	12.9 J	15.8 J	1.1	1.1 J	2.4 J	0.4 U	7.3
4,4'-DDE	0.9 U	1.15 U	10.5	1.2	0.55 U	0.9 U	0.45 U	3.2
4,4'-DDT	1.6	4.1	9.5	1.8	1.7	2.1	0.6 J	4.1
Aldrin	0.35 U	0.35 U	0.35 U	0.2 J	0.35 U	0.35 U	0.35 U	0.35 U
alpha-Chlordane	0.9	0.4 U	1.1	0.8	0.4 U	0.4 U	0.4 U	0.8 J
Heptachlor	0.25 U	0.25 U	0.25 U	0.25 U	0.23 U	0.25 U	0.25 U	0.25 U
Heptachlor Epoxide	0.25 U	0.25 U	1 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
Hexachlorobenzene	0.2 U	0.2 U	0.2 U	0.9	0.2 U	0.2 U	0.2 U	0.5
Mirex	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	1.1 J
PCB 101/90	0.95 U	1.05 U	4.5	1.8	0.95 U	1.1 U	0.35 U	2.9
PCB 105	0.45 U	0.5 U	2.4 J	0.3 U	0.3 U	0.45 U	0.1 U	1.7 J
PCB 118	2.3	1.7	5.5	1.4	1.8	2	0.35 U	2.7
PCB 126	1.2 J	1.3 J	1.8 J	0.35 U	1.1 J	0.7 J	0.25 U	2
PCB 128	1	0.9	2.4	0.25 U	0.7	0.9	0.25 U	2.3
PCB 138/163/164	4.9	3.2	12.2	3	4.1	2.9	0.9	7.6
PCB 153	3.3	2.8	7.5	2.4	3.6	2.7	0.7	4.2

TABLE 3.2
SEDIMENT RESULTS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21	OFF-22	OFF-23
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98	3/27/98	4/3/98
Polycyclic Aromatic Hydrocarbons (ug/kg)	1.5	0.65 U	2.9	0.45 U	1.5	0.55 U	0.25 U	2.1
PCB 18	0.3 J	0.35 U	0.35 U	1.3 J	0.35 U	0.35 U	0.35 U	0.35 U
PCB 180	1.7	1.3	5.2	1.8	1.9	1.3	0.3 J	3.4
PCB 187/182/159	1.7	1.3	3.8	1.1	1.4	1.5 J	0.5	3.1
PCB 188	1	0.3 U	1.5	0.5 J	0.6	0.6	0.3 U	1
PCB 195	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.75 UJ
PCB 200	0.25 U	0.3 J	1.2	0.6	0.4 J	0.3 J	0.2 J	1.1
PCB 206	0.3 U	0.75 U	1.15 U	0.8	0.5 U	0.55 U	0.5 U	1.2
PCB 209	0.4 U	1.4	2.6	0.9	0.5 U	0.35 U	0.25 U	1.5
PCB 28/50	0.35 U	0.35 U	0.7	0.4 J	0.35 U	0.35 U	0.35 U	1.5
PCB 29	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
PCB 44	0.8 J	0.5 J	1.2 J	1.1 J	0.4 J	0.5 J	0.2 J	1.1
PCB 50	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U
PCB 52	0.4 U	0.35 U	1.2 J	0.45 UJ	0.35 U	0.45 U	0.35 U	1.4
PCB 66/95	1.7	1.3	3.9	2.3	1.4	1.6	0.5 U	2.7
PCB 8	0.6	0.15 U	0.8	8.5	0.15 U	0.15 U	0.15 U	0.3 U
PCB 87	0.7 J	0.6 J	1.6 J	0.5 J	0.3 UJ	0.6 J	0.3 UJ	1.1
Sum of PCB Congeners	22.7	16.6	62.9	28.4	18.9	15.6	2.8	44.6
Sum of PCB Congeners X 2	45.4	33.2	125.8	56.8	37.8	31.2	5.6	89.2
trans-Nonachlor	0.4 U	0.4 U	1 J	0.7 J	0.4 U	0.4 U	0.4 U	1.2
Metals (mg/kg)								
Aluminum	29667 J	32011 J	40750 J	37770 J	33977 J	37829 J	36058 J	92358 J
Arsenic	5 J	4.7 J	6.3 J	5.8 J	4.2 J	4.9 J	3.8 J	4.8 J
Cadmium	0.36	0.38	0.69	0.21	0.25	0.39	0.19	0.43
Chromium	48	44.1	73.6	55.6	52.5	52.9	47.8	53.2
Copper	23.9	26.4	83.5	30.3	19	22.7	18.3	44.7
Iron	24706 J	24564 J	31885 J	29787 J	28355 J	25993 J	28736 J	51703 J
Lead	61.2	71.4	190.4	56	40.6	46.2	21.7	74.2
Manganese	341.6	312.4	332.9	362.9	368.4	377.9	318.5	669.7
Mercury	0.208	0.225	0.562	0.299	0.171	0.112	0.111	0.387
Nickel	18.2	18.7	28.4	24	21	26.9	21.2	42.7
Silver	0.44 J	0.4 J	1.08 J	0.18 J	0.19 J	0.16 J	0.065 UJ	0.27 J
Zinc	50.9 U	125.7	248.3	166.3	108.5	143.9	39.15 U	306.2
AVS/SEM (µmole/g dry weight)								
Acid Volatile Sulfide	23.68	14.13	39	17.26	29.52	12.93	2.74	32.95
Cadmium	0.005	0.005	0.011	0.001	0.004	0.004	0.001	0.006
Copper	0.303	0.056 U	0.22	0.232	0.285	0.0875 U	0.234	0.083 U
Lead	0.17	0.192	0.476	0.173	0.13	0.148	0.039	0.236
Nickel	0.027 U	0.03 U	0.028 U	0.023 U	0.036 U	0.0455 U	0.0215 U	0.038 U
SEM-AVS	-22.08 J	-12.74 J	-36.14 J	-15.85 J	-27.9 J	-11.6 J	-1.43 J	-30.84 J
SEM/AVS	0.067 J	0.099 J	0.0733 J	0.082 J	0.055 J	0.1026 J	0.4783 J	0.064 J
Zinc	1.091	1.11	2.123	0.984	1.166	1.042	1.015	1.753
Total Organic Carbon (percent)								
Total Organic Carbon	2.6	2.6	4	2.9	2.3	2.3	1.3	2.7
Grain Size (percent)								
CLAY	3.9	2.3	2.7	2.5	2.4	2	0.6	1.3
SAND	3.3	46.2	6.9	49.4	59.3	50.9	91.5	54.6
SILT	92.8	51.6	90.4	48.1	38.3	47.2	8	44.1

TABLE 3.3
PORE WATER CONCENTRATIONS FOR ORGANICS AND METALS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location Sample Depth Interval Date Sampled	LogKow[1]	LogKoc[2]	Koc	OFF-1 0-15 cm 3/27/98	OFF-2 0-15 cm 3/27/98	OFF-3 0-15 cm 3/27/98	OFF-4 0-15 cm 3/27/98	OFF-5 0-15 cm 3/27/98	OFF-6 0-15 cm 3/27/98	OFF-7 0-15 cm 3/27/98	OFF-8 0-15 cm 4/7/98	OFF-9 0-15 cm 4/7/98	OFF-10 0-15 cm 4/3/98
Polyaromatic Hydrocarbons (ug/L)													
1-Methylnaphthalene	3.97	3.90	7994	1.03E-01 J	5.96E-01 J	8.64E-01 J	4.98E-01 J	3.48E+00 J	9.17E-01 J	2.28E-01	1.06E-01	1.77E-02 J	2.50E-02 J
1-Methylphenanthrene	5.08	4.99	98610	7.44E-02	3.36E-01	6.07E-01	3.18E-01	1.48E+00	3.83E-01	5.55E-02	1.72E-02	3.72E-03 J	2.77E-03 J
2,3,5-Trimethylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dimethylnaphthalene	4.61	4.53	34034	3.09E-02 J	2.75E-01 J	2.18E-01 J	1.75E-01 J	1.40E+00 J	2.42E-01 J	9.25E-02	5.54E-02	3.04E-02	2.40E-02 J
2-Methylnaphthalene	3.97	3.90	7994	1.81E-01 J	8.82E-01 J	1.24E+00 J	5.30E-01 J	4.13E+00 J	1.18E+00 J	3.61E-01	1.39E-01	3.23E-02 J	3.53E-02 J
Acenaphthene	3.92	3.85	7139	1.79E-01	1.12E+00	5.77E+00	8.40E-01	1.35E+01	2.68E+00	8.85E-01	3.66E-01	4.79E-02 J	3.18E-02 J
Acenaphthylene	4.05	3.98	9581	5.39E-01	4.63E+00	4.06E+00	4.92E+00	5.31E+00	1.13E+00	9.28E-01	1.49E-01	4.96E-02	3.89E-02 J
Anthracene	4.55	4.47	29712	4.77E-01 J	3.37E+00 J	5.46E+00 J	2.89E+00 J	9.46E+00 J	2.19E+00 J	6.96E-01	1.81E-01	3.17E-02	3.00E-02 J
Benzo(a)anthracene	5.7	5.60	401218	1.38E-02	8.16E-01	1.58E+00	6.31E-01	2.32E+00	5.88E-01	1.52E-01	4.10E-02	1.19E-02	7.98E-03
Benzo(a)pyrene	6.11	6.01	1014869	3.26E-02	2.16E-01	3.78E-01 J	2.29E-01	4.76E-01	1.09E-01	6.90E-02	1.65E-02	6.25E-03	4.04E-03
Benzo(b,j,k)fluoranthene	6.2	6.09	1244171	1.24E-01	5.63E-01	1.54E+00 J	3.13E-01	2.01E+00	4.19E-01	1.21E-01	2.54E-02	1.02E-02	6.91E-03
Benzo(e)pyrene	6.11	6.01	1014869	4.98E-02 J	2.12E-01 J	5.75E-01 J	1.43E-01 J	7.48E-01 J	1.79E-01 J	5.01E-02	1.22E-02	4.80E-03	3.70E-03 J
Benzo(g,h,i)Perylene	6.7	6.59	3858158	1.26E-02 J	5.94E-02 J	1.55E-01 J	3.72E-02 J	1.55E-01 J	3.79E-02 J	1.39E-02	2.81E-03	1.13E-03	9.54E-04 J
Biphenyl	3.96	3.89	7816	5.12E-02	2.57E-01	5.49E-01	9.38E-02	1.93E+00	3.32E-01	9.90E-02	3.15E-02 U	3.41E-02 U	1.40E-02 J
Chrysene/triphenylene	5.7	5.60	401218	1.09E-01	5.30E-01	1.26E+00	5.12E-01	1.82E+00	4.64E-01	6.81E-02 J	3.76E-02	1.24E-02	7.21E-03
Dibenzo(a,h)Anthracene	6.69	6.58	3771812	6.50E-03 J	3.11E-02 J	8.28E-02 J	1.04E-02 J	9.04E-02 J	2.05E-02 J	4.09E-03	8.46E-04	1.50E-04 U	2.07E-04 J
Fluoranthene	5.12	5.03	107954	1.00E+00	7.03E+00	1.50E+01	5.74E+00	1.78E+01	5.76E+00	1.07E+00	3.24E-01	9.03E-02	7.26E-02
Fluorene	4.21	4.14	13763	1.63E-01 J	2.00E+00 J	4.83E+00 J	1.43E+00 J	9.88E+00 J	1.58E+00 J	6.12E-01	1.94E-01	3.21E-02 J	1.85E-02 J
Indeno(1,2,3-cd)pyrene	6.65	6.54	3445323	1.63E-02	8.10E-02	2.12E-01 J	3.87E-02	2.14E-01	4.89E-02	1.48E-02	3.04E-03	1.16E-03	9.31E-04
Naphthalene	3.36	3.30	2010	8.82E-01	7.73E+00	8.24E+00	7.52E+00	1.28E+01	4.45E+00	1.83E+00	8.73E-01	1.78E-01	1.81E-01
Perylene	6.05	5.95	885992	1.41E-02	8.39E-02	1.87E-01 J	7.61E-02	1.65E-01	4.60E-02	2.16E-02	5.24E-03	2.01E-03	1.31E-03
Phenanthrene	4.55	4.47	29712	1.98E+00	1.72E+01	4.00E+01	1.13E+01	4.91E+01	1.77E+01	2.34E+00	6.76E-01	1.30E-01	9.58E-02
Pyrene	5.11	5.02	105538	9.37E-01	5.81E+00	1.13E+01	5.06E+00	1.60E+01	5.14E+00	1.06E+00	2.92E-01	8.05E-02	7.54E-02
Sum PAHs (6 High Molecular Weight)[3]	NA	NA	NA	2.10E+00	1.44E+01	2.96E+01	1.22E+01	3.85E+01	1.21E+01	2.42E+00	7.12E-01	2.02E-01	1.67E-01
Sum PAHs (7 Low Molecular Weight)[4]	NA	NA	NA	4.40E+00	3.69E+01	6.96E+01	2.95E+01	1.04E+02	3.09E+01	7.65E+00	2.58E+00	5.02E-01	4.31E-01
Sum PAHs (NOAA Status &Trends)[5]	NA	NA	NA	6.50E+00	5.13E+01	9.92E+01	4.17E+01	1.43E+02	4.30E+01	1.01E+01	3.29E+00	7.03E-01	5.99E-01
Pesticides/PCBs (ug/L)													
1a,2a,3b,4a,5a,6b-hexachlorocyclohexane (gamma-BHC)	3.81	3.75	5566	2.99E-03 U	4.90E-03 U	5.99E-03 U	5.99E-03 U	5.39E-03 U	7.99E-03 J	1.89E-03 J	4.15E-03 J	1.50E-03 J	4.90E-03 U
2,4'-DDE	6.76	6.65	4419366	3.14E-06 U	8.23E-06 U	1.01E-05 U	1.01E-05 U	9.05E-06 U	5.03E-06 U	4.76E-06 U	6.96E-06 U	7.54E-06 U	8.23E-06 U
2,4'-DDT	6.76	6.65	4419366	1.38E-05	3.70E-05	1.76E-05 J	6.54E-05	3.85E-05	1.76E-05	5.95E-06 U	8.70E-06 U	9.43E-06 U	1.03E-05 U
4,4'-DDD	6.1	6.00	992156	1.68E-04 J	1.28E-04 J	2.02E-04 J	2.69E-04 J	2.02E-04 J	2.13E-04 J	2.02E-04	6.20E-05 J	3.78E-05 U	3.67E-05 U
4,4'-DDE	6.76	6.65	4419366	1.57E-05 U	2.57E-05 U	2.77E-05 U	2.51E-05 U	3.39E-05 U	4.78E-05	3.69E-05	1.22E-05 J	8.49E-06 U	9.26E-06 U
4,4'-DDT	6.76	6.65	4419366	5.41E-05	2.06E-04	1.01E-04	2.89E-04	2.56E-04	1.23E-04	3.22E-05	1.91E-05	1.51E-05	1.44E-05
Aldrin	6.5	6.39	2453466	7.93E-06 U	1.30E-05 U	1.59E-05 U	1.59E-05 U	1.43E-05 U	7.93E-06 U	7.51E-06 U	3.14E-06 J	1.19E-05 U	1.30E-05 U
alpha-Chlordane	6.5	6.39	2453466	1.81E-05	2.59E-05 J	3.17E-05 J	5.43E-05	5.71E-05	1.36E-05 J	1.50E-05 J	3.14E-06 J	3.40E-06 J	1.48E-05 U
Heptachlor	6.5	6.39	2453466	5.66E-06 U	9.26E-06 U	1.13E-05 U	3.17E-05 U	1.02E-05 U	5.66E-06 U	6.44E-06 J	7.84E-06 U	8.49E-06 U	9.26E-06 U
Heptachlor Epoxide	6.5	6.39	2453466	5.66E-06 U	9.26E-06 U	1.13E-05 U	2.72E-05 J	1.02E-05 U	5.66E-06 U	5.36E-06 U	7.84E-06 U	8.49E-06 U	9.26E-06 U
Hexachlorobenzene	5.89	5.79	616808	1.80E-05 U	2.95E-05 U	3.60E-05 U	3.60E-05 U	4.05E-05 U	2.70E-05 U	1.71E-05 U	2.49E-05 U	2.70E-05 U	2.95E-05 U
Mirex	6.89	6.77	5931301	2.81E-06 J	4.60E-06 U	5.62E-06 U	5.62E-06 U	1.01E-05	4.68E-06 J	3.55E-06 J	3.89E-06 U	4.21E-06 U	4.60E-06 U
PCB 101/90	6.38	6.27	1869907	1.78E-05 U	5.10E-05 U	7.13E-05 U	1.72E-04	5.88E-05 U	2.97E-05 U	7.60E-05	2.26E-05 U	1.34E-05 U	1.70E-05 U
PCB 105	6.65	6.54	3445323	4.84E-06 U	1.58E-05 U	2.26E-05 U	1.13E-05 U	4.93E-05 J	5.64E-06 U	9.93E-06 UJ	6.70E-06 U	7.26E-06 U	3.96E-06 U
PCB 118	6.74	6.63	4223767	9.21E-06 J	4.52E-05	4.74E-05	3.42E-05	2.60E-05	2.10E-05	2.87E-05	2.00E-05	9.86E-06 J	1.51E-05 J
PCB 126	6.89	6.77	5931301	2.34E-06 U	1.38E-05 J	2.44E-05 J	3.18E-05 J	4.21E-05 J	2.34E-06 UJ	3.55E-06 U	3.24E-06 UJ	3.51E-06 U	3.83E-06 U
PCB 128	6.74	6.63	4223767	7.89E-06	1.29E-05 J	2.10E-05 J	5.52E-05	2.13E-05 J	2.37E-05 J	1.25E-05	5.46E-06 U	3.95E-06 UJ	5.38E-06 U
PCB 138/163/164	6.83	6.71	5178095	2.04E-05	1.88E-04 J	2.40E-04 J	2.45E-04	3.13E-04 J	3.22E-05 J	5.29E-05	3.57E-05	1.61E-05	2.11E-05
PCB 153	6.92	6.80	6348045	1.31E-05	3.58E-05	4.38E-05	3.33E-05	6.30E-05	2.36E-05	2.90E-05	2.42E-05	1.31E-05	1.58E-05
PCB 170	7.27	7.15	14018127	1.78E-06 U	2.27E-06 U	2.77E-06 U	1.43E-05	1.28E-05	7.13E-06 J	2.25E-06 U	2.47E-06 U	1.49E-06 UJ	2.27E-06 U
PCB 18	5.24	5.15	141645	5.10E-04 J	2.25E-04 U	1.33E-03	2.75E-04 U	9.88E-04	1.10E-03	2.23E-04 J	1.90E-04 U	2.06E-04 U	2.25E-04 U

TABLE 3.3
PORE WATER CONCENTRATIONS FOR ORGANICS AND METALS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location Sample Depth Interval Date Sampled	LogKow[1]	LogKoc[2]	Koc	OFF-1 0-15 cm 3/27/98	OFF-2 0-15 cm 3/27/98	OFF-3 0-15 cm 3/27/98	OFF-4 0-15 cm 3/27/98	OFF-5 0-15 cm 3/27/98	OFF-6 0-15 cm 3/27/98	OFF-7 0-15 cm 3/27/98	OFF-8 0-15 cm 4/7/98	OFF-9 0-15 cm 4/7/98	OFF-10 0-15 cm 4/3/98
PCB 180	7.36	7.24	17185414	3.56E-06	7.93E-06	1.55E-05	1.29E-05	2.27E-05	6.79E-06 J	7.66E-06	5.37E-06	3.39E-06	3.17E-06
PCB 187/182/159	7.17	7.05	11178667	2.98E-06	5.69E-06	5.96E-06	2.78E-05	1.43E-05	9.44E-06 J	7.53E-06	3.10E-06 U	2.24E-06 U	4.88E-06
PCB 188	6.82	6.70	5062208	3.29E-06 U	5.39E-06 U	1.76E-05	6.58E-06 U	2.57E-05	2.85E-05	7.28E-06	7.60E-06 J	4.94E-06 U	5.39E-06 U
PCB 195	7.56	7.43	27024645	5.14E-07 U	1.01E-06 U	1.23E-06 U	4.93E-06	1.30E-05	6.17E-07 UJ	5.84E-07 U	8.54E-07 U	9.25E-07 U	1.01E-06 U
PCB 200	7.27	7.15	14018127	1.19E-06 J	7.78E-06	7.93E-06	1.43E-05	1.43E-05	4.36E-06 J	1.50E-06 J	2.19E-06 J	1.78E-06 J	2.59E-06 J
PCB 206	8.09	7.95	89691234	1.55E-07 U	2.53E-07 U	3.10E-07 U	1.49E-06 U	3.34E-07 U	1.86E-07 UJ	3.52E-07	6.86E-07	3.72E-07 J	6.59E-07 U
PCB 209	8.18	8.04	109956270	1.26E-07 U	2.07E-07 U	2.53E-07 U	2.53E-07 U	3.18E-07 U	2.07E-06 J	3.83E-07	5.60E-07	2.27E-07 J	2.89E-07 U
PCB 28/50	5.67	5.57	374878	1.04E-04	8.49E-05 U	1.78E-04 J	1.04E-04 U	4.80E-04	4.00E-04	1.40E-04	6.16E-05 J	1.11E-04 J	8.49E-05 U
PCB 29	5.6	5.51	319948	6.08E-05 U	9.94E-05 U	1.22E-04 U	1.22E-04 U	1.09E-04 U	6.08E-05 U	5.76E-05 U	8.41E-05 U	9.12E-05 U	9.94E-05 U
PCB 44	5.75	5.65	449293	7.42E-05 J	8.09E-05 J	3.46E-04 J	3.46E-04 J	3.12E-04 J	2.23E-04 J	2.23E-04	4.28E-05 U	4.64E-05 U	6.07E-05 J
PCB 50	5.63	5.53	342429	4.06E-05 U	6.64E-05 U	8.11E-05 U	8.11E-05 U	7.30E-05 U	4.06E-05 U	3.84E-05 U	5.62E-05 U	6.08E-05 U	6.64E-05 U
PCB 52	5.84	5.74	550808	4.03E-05 U	5.78E-05 U	1.01E-04 U	2.82E-04 J	3.27E-04 J	2.62E-04 J	1.34E-04	4.89E-05 U	5.30E-05 U	5.78E-05 U
PCB 66/95	6.2	6.09	1244171	4.91E-05	1.02E-04	1.79E-04	1.52E-04	3.13E-04	1.52E-04	1.40E-04	6.80E-05	1.67E-05 UJ	4.38E-05
PCB 8	5.07	4.98	96403	4.90E-03 J	1.41E-04 U	1.04E-03 J	1.73E-04 U	1.56E-04 U	3.46E-04	8.19E-05 U	1.20E-04 U	1.30E-04 U	1.41E-04 U
PCB 87	6.29	6.18	1525281	1.09E-05 UJ	5.36E-05 J	5.83E-05 J	5.10E-05 J	5.24E-05 J	5.83E-05 J	3.45E-05	1.51E-05 U	1.64E-05 U	1.79E-05 UJ
trans-Nonachlor	6.87	6.75	5668785	5.88E-06 J	6.41E-06 U	1.37E-05 J	7.84E-06 U	2.29E-05	3.92E-06 U	7.43E-06	2.71E-06 J	1.47E-06 J	6.41E-06 U
Sum of PCB Congeners				5.88E-03	1.30E-03	3.96E-03	2.25E-03	3.49E-03	2.84E-03	1.31E-03	8.27E-04	8.14E-04	8.99E-04
Sum of PCB Congeners X 2				1.18E-02	2.61E-03	7.92E-03	4.50E-03	6.98E-03	5.68E-03	2.62E-03	1.65E-03	1.63E-03	1.80E-03
Metals (ug/L)													
Aluminum				55.9	67.4	61.2	54.9	63.8	43.2	58.7	51.2	69.3	48.1
Arsenic				1.1	5.5	3.4	2.8	1	2.9	3.2	2.4	2.1	2.6
Barium				10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cadmium				0.1 J	0.5	0.8	0.9	0.5	0.6	0.5	0.7	0.8	0.4
Chromium				28.6	19.2	18.6	22.4	21.8	15.4	19	20.1	23.9	22.3
Copper				26	21	23	28	84	19	15	19	31	30
Iron				610	310	120	200	170	220	120	280	410	340
Lead				18.22	16.43	14.62	18.66	18.24	15.83	16.41	15.8	12.4	15.71
Manganese				NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury				R	R	R	R	R	R	R	R	R	R
Nickel				0.25 U	0.7	2	1.3	1.1	1.5	0.25 U	2.4	1.9	3.1
Silver				1.6	1.8	1.4	1.7	1.3	0.05 U	1.7	1.5	1.5	1.6
Zinc				170	140	100	130	260	420	170	180	200	270
Total Organic Carbon (percent)													
Total Organic Carbon				1.8	1.1	0.9	0.9	1	1.8	1.9	1.3	1.2	1.1

TABLE 3.3
PORE WATER CONCENTRATIONS FOR ORGANICS AND METALS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-11	OFF-12	OFF-13	OFF-14	OFF-15	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21	OFF-22	OFF-23
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	4/3/98	4/3/98	4/3/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98	3/27/98	4/3/98
Polyaromatic Hydrocarbons (ug/L)													
1-Methylnaphthalene	7.05E-02 J	3.94E-01 J	1.35E-01 J	5.88E-02	4.79E-02 J	8.47E-02 J	5.29E-02 J	9.82E-02 J	8.15E-02	2.38E-01 J	4.19E-02 J	1.92E-02 J	1.29E-01
1-Methylphenanthrene	1.36E-02	8.92E-02	4.49E-02 J	1.02E-02	9.63E-03	1.70E-02 J	9.87E-03	2.74E-02	7.06E-03	1.96E-02	8.51E-03	2.03E-03 J	1.87E-02
2,3,5-Trimethylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,6-Dimethylnaphthalene	4.94E-02 J	1.04E-01 J	4.05E-02 J	2.29E-02	1.79E-02 J	4.27E-02 J	2.50E-02 J	3.33E-02 J	5.50E-02	5.61E-02 J	1.75E-02 J	1.31E-02 J	4.20E-02
2-Methylnaphthalene	1.99E-01 J	5.85E-01 J	2.05E-01 J	9.69E-02	9.90E-02	1.15E-01 J	9.48E-02 J	2.00E-01 J	1.36E-01	2.20E-01 J	7.12E-02 J	2.98E-02 J	2.01E-01
Acenaphthene	3.55E-01	1.80E+00	3.85E-01 J	7.98E-02	5.95E-02 J	2.03E-01 J	1.38E-01	2.09E-01	2.12E-01	4.59E-01	5.72E-02	1.94E-02 J	4.64E-01
Acenaphthylene	8.54E-02	2.43E-01	4.07E-01 J	1.32E-01	1.03E-01	1.44E-01 J	1.65E-01	3.68E-01	1.46E-01	6.72E-02	8.30E-02	3.53E-02 J	3.00E-01
Anthracene	1.98E-01 J	7.70E-01 J	4.06E-01 J	8.72E-02	9.82E-02	1.14E-01 J	1.55E-01 J	2.86E-01 J	1.21E-01	3.18E-01 J	7.01E-02 J	2.46E-02 J	4.34E-01
Benzo(a)anthracene	3.81E-02	1.20E-01	7.23E-02 J	2.69E-02	2.20E-02	1.87E-02 J	2.41E-02	4.55E-02	2.72E-02	3.47E-02	1.64E-02	6.83E-03	5.69E-02
Benzo(a)pyrene	1.33E-02	5.60E-02	2.83E-02 J	1.26E-02	8.46E-03	8.34E-03 J	1.26E-02	2.37E-02	1.09E-02	1.10E-02	7.54E-03	2.94E-03	2.77E-02
Benzo(b,j,k)fluoranthene	2.08E-02	8.78E-02	4.88E-02 J	1.84E-02	2.45E-02	1.34E-02 J	2.02E-02	4.60E-02	1.71E-02	2.05E-02	1.31E-02	4.86E-03	4.58E-02
Benzo(e)pyrene	9.58E-03 J	4.26E-02 J	2.31E-02 J	1.05E-02	1.15E-02	7.09E-03 J	1.03E-02 J	2.37E-02 J	7.95E-03	8.44E-03 J	6.77E-03 J	3.74E-03 J	2.51E-02
Benzo(g,h,i)Perylene	2.24E-03 J	8.45E-03 J	4.82E-03 J	2.53E-03	2.16E-03	1.80E-03 J	2.69E-03 J	5.83E-03 J	1.80E-03	1.48E-03 J	1.50E-03 J	1.20E-03 J	6.72E-03
Biphenyl	4.30E-02 J	1.47E-01	6.56E-02 J	2.05E-02 U	3.41E-02 U	4.48E-02 J	2.76E-02 J	5.53E-02	8.03E-02	9.96E-02	3.28E-02 J	7.87E-03 J	6.07E-02
Chrysene/triphenylene	2.65E-02	9.95E-02	4.82E-02 J	2.37E-02	1.81E-02	1.45E-02 J	1.95E-02 J	3.93E-02	2.38E-02	3.21E-02	1.64E-02	5.12E-03	4.98E-02
Dibenzo(a,h)Anthracene	5.76E-04 J	2.97E-03 J	1.41E-03 J	6.92E-04	9.72E-04	5.06E-04 J	7.76E-04 J	1.81E-03 J	5.25E-04	5.80E-04 J	4.66E-04 J	2.49E-04 J	1.76E-03
Fluoranthene	3.27E-01	1.16E+00	6.02E-01 J	1.43E-01	1.43E-01	1.58E-01 J	1.88E-01 J	4.35E-01	1.73E-01	3.55E-01	1.17E-01	4.70E-02	5.35E-01
Fluorene	1.66E-01 J	7.88E-01 J	2.23E-01 J	6.25E-02	4.60E-02	9.53E-02 J	8.64E-02 J	1.36E-01 J	1.29E-01	2.93E-01 J	3.57E-02 J	1.34E-02 J	2.85E-01
Indeno(1,2,3-cd)pyrene	2.28E-03	9.02E-03	4.69E-03 J	2.50E-03	2.81E-03	1.74E-03 J	2.65E-03	5.70E-03	1.95E-03	1.89E-03	1.59E-03	7.57E-04	5.49E-03
Naphthalene	4.43E-01	2.55E+00	7.61E-01 J	5.12E-01	4.69E-01	3.81E-01 J	4.78E-01	8.47E-01	9.14E-01	8.67E-01	1.88E-01	1.22E-01 J	7.67E-01
Perylene	3.57E-03	1.16E-02	7.14E-03 J	4.48E-03	3.09E-03	2.73E-03 J	3.49E-03	7.79E-03	3.33E-03	3.11E-03	2.12E-03	1.12E-03	8.57E-03
Phenanthrene	7.28E-01	3.38E+00	1.21E+00 J	2.19E-01	2.45E-01	4.28E-01 J	3.51E-01	7.72E-01	3.41E-01	1.21E+00	1.84E-01	6.08E-02	9.60E-01
Pyrene	2.90E-01	1.14E+00	5.99E-01 J	1.63E-01	1.48E-01	1.87E-01 J	1.98E-01 J	4.29E-01	1.71E-01	3.09E-01	1.38E-01	5.04E-02	4.98E-01
Sum PAHs (6 High Molecular Weight)[3]	6.95E-01	2.58E+00	1.35E+00	3.69E-01	3.40E-01	3.87E-01	4.43E-01	9.74E-01	4.06E-01	7.43E-01	2.96E-01	1.13E-01	1.17E+00
Sum PAHs (7 Low Molecular Weight)[4]	2.17E+00	1.01E+01	3.60E+00	1.19E+00	1.12E+00	1.48E+00	1.47E+00	2.82E+00	2.00E+00	3.43E+00	6.90E-01	3.06E-01	3.41E+00
Sum PAHs (NOAA Status &Trends)[5]	2.87E+00	1.27E+01	4.95E+00	1.56E+00	1.46E+00	1.87E+00	1.91E+00	3.79E+00	2.40E+00	4.18E+00	9.85E-01	4.18E-01	4.58E+00
Pesticides/PCBs (ug/L)													
1a,2a,3b,4a,5a,6b-hexachlorocyclohexane (gamma-BHC)	4.90E-03 U	2.16E-03 U	1.35E-03 U	2.70E-03 U	7.49E-03 J	2.07E-03 U	2.07E-03 U	1.35E-03 U	5.58E-03	2.34E-03 U	2.34E-03 U	4.15E-03 U	2.00E-03 U
2,4'-DDE	8.23E-06 U	8.15E-06	2.26E-06 U	4.53E-06 U	7.54E-06 U	3.48E-06 U	3.48E-06 U	2.26E-06 U	3.12E-06 U	3.94E-06 U	3.94E-06 U	6.96E-06 U	3.35E-06 U
2,4'-DDT	1.03E-05 U	5.43E-06 J	6.79E-06	5.66E-06 U	9.43E-06 U	1.04E-05	6.09E-06 J	1.02E-05	3.90E-06 U	4.92E-06 U	4.92E-06 U	8.70E-06 U	6.70E-06
4,4'-DDD	3.67E-05 U	4.52E-04 J	4.96E-04 J	7.06E-05	5.04E-05 J	8.53E-05 J	5.00E-04 J	3.98E-04 J	3.82E-05	4.82E-05 J	1.05E-04 J	3.10E-05 U	2.73E-04
4,4'-DDE	9.26E-06 U	5.61E-05	6.11E-05	1.02E-05 J	9.43E-06 J	7.83E-06 U	1.00E-05 U	5.94E-05	9.36E-06	5.41E-06 U	8.85E-06 U	7.83E-06 U	2.68E-05
4,4'-DDT	3.29E-05	4.34E-05	6.17E-05	2.26E-05	1.51E-05	1.39E-05	3.57E-05	5.37E-05	1.40E-05	1.67E-05	2.07E-05	1.04E-05 J	3.44E-05
Aldrin	1.30E-05 U	5.71E-06 U	3.57E-06 U	7.13E-06 U	1.19E-05 U	5.49E-06 U	5.49E-06 U	3.57E-06 U	2.81E-06 J	6.20E-06 U	6.20E-06 U	1.10E-05 U	5.28E-06 U
alpha-Chlordane	1.48E-05 U	1.96E-05	1.43E-05	4.08E-06 J	3.40E-06 J	1.41E-05	6.27E-06 U	1.12E-05	1.12E-05	7.09E-06 U	7.09E-06 U	1.25E-05 U	1.21E-05 J
Heptachlor	9.26E-06 U	4.08E-06 U	6.62E-06 U	4.08E-06 J	3.40E-06 J	3.92E-06 U	3.92E-06 U	2.55E-06 U	3.51E-06 U	4.08E-06 U	4.43E-06 U	7.84E-06 U	3.77E-06 U
Heptachlor Epoxide	1.04E-04 J	3.91E-05 J	1.12E-05 J	5.09E-06 U	8.49E-06 U	3.92E-06 U	3.92E-06 U	1.02E-05 J	3.51E-06 U	4.43E-06 U	4.43E-06 U	7.84E-06 U	3.77E-06 U
Hexachlorobenzene	2.95E-05 U	2.59E-05 U	8.11E-06 U	1.62E-05 U	2.70E-05 U	1.25E-05 U	1.25E-05 U	8.11E-06 U	5.03E-05	1.41E-05 U	1.41E-05 U	2.49E-05 U	3.00E-05
Mirex	4.60E-06 U	2.02E-06 U	1.26E-06 U	3.37E-06 J	5.62E-06 J	1.95E-06 U	1.95E-06 U	1.26E-06 U	1.74E-06 U	2.20E-06 U	2.20E-06 U	3.89E-06 U	6.87E-06 J
PCB 101/90	5.35E-05 U	8.77E-05	7.89E-05	5.88E-05	2.01E-05 U	1.95E-05 U	2.16E-05 U	6.02E-05	3.32E-05	2.21E-05 U	2.56E-05 U	1.44E-05 U	5.74E-05
PCB 105	1.72E-05 U	1.97E-05 J	2.54E-05 J	6.53E-06 UJ	7.26E-06 U	5.02E-06 U	5.58E-06 U	1.74E-05 J	3.00E-06 U	3.79E-06 U	5.68E-06 U	2.23E-06 U	1.83E-05 J
PCB 118	4.30E-05	3.03E-05	3.91E-05	2.72E-05	1.58E-05	2.09E-05	1.55E-05	3.26E-05	1.14E-05	1.85E-05	2.06E-05	6.37E-06 U	2.37E-05
PCB 126	1.07E-05 J	1.21E-05 J	2.07E-05 J	9.27E-06	3.51E-06 UJ	7.78E-06 J	8.43E-06 J	7.59E-06 J	2.03E-06 U	8.06E-06 J	5.13E-06 J	3.24E-06 U	1.25E-05
PCB 128	1.29E-05	1.70E-05	2.37E-05	4.74E-06 U	3.95E-06 UJ	9.11E-06	8.20E-06	1.42E-05	2.04E-06 U	7.21E-06	9.26E-06	4.55E-06 U	2.02E-05
PCB 138/163/164	6.14E-05	5.95E-05	6.42E-05	2.99E-05	2.74E-05	3.64E-05	2.38E-05	5.89E-05	2.00E-05	3.44E-05	2.44E-05	1.34E-05	5.44E-05
PCB 153	4.73E-05	3.40E-05	3.66E-05	2.68E-05	2.23E-05	2.00E-05	1.70E-05	2.95E-05	1.30E-05	2.47E-05	1.85E-05	8.48E-06	2.45E-05
PCB 170	9.73E-06	1.08E-05	1.03E-05	1.61E-06 U	1.78E-06 U	4.12E-06	1.78E-06 U	5.17E-06	1.11E-06 U	4.65E-06	1.71E-06 U	1.37E-06 U	5.55E-06
PCB 18	2.25E-03	6.78E-04	8.82E-05 J	3.88E-04	2.06E-04 U	8.15E-05 J	9.50E-05 U	6.18E-05 U	3.16E-04 J	1.07E-04 U	1.07E-04 U	1.90E-04 U	9.15E-05 U

TABLE 3.3
PORE WATER CONCENTRATIONS FOR ORGANICS AND METALS
ECOLOGICAL PRG DEVELOPMENT STEP 2
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-11	OFF-12	OFF-13	OFF-14	OFF-15	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21	OFF-22	OFF-23
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	4/3/98	4/3/98	4/3/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98	3/27/98	4/3/98
Polycyclic Aromatic Hydrocarbons (ug/L)													
PCB 187/182/159	1.69E-05	1.49E-05	1.35E-05	4.66E-06	5.33E-06	3.80E-06	2.91E-06	7.56E-06	3.61E-06	4.81E-06	3.29E-06	1.34E-06 J	7.33E-06
PCB 188	1.63E-05	1.32E-05	1.23E-05	8.05E-06	2.61E-06 U	5.85E-06	4.47E-06	8.50E-06	3.39E-06	5.45E-06	5.83E-06 J	3.44E-06	1.03E-05
PCB 195	1.08E-05 J	7.90E-06	7.90E-06	7.90E-06	4.94E-06 U	7.60E-06	2.28E-06 U	7.41E-06	3.41E-06 J	5.15E-06	5.15E-06	4.56E-06 U	7.32E-06
PCB 200	2.35E-06	1.18E-06 J	3.42E-06	5.55E-07 U	9.25E-07 U	4.27E-07 U	4.27E-07 U	2.78E-07 U	3.83E-07 U	4.83E-07 U	4.83E-07 U	8.54E-07 U	1.03E-06 UJ
PCB 206	2.59E-06 J	4.57E-06	4.46E-07 U	1.43E-06 J	2.38E-06 J	6.86E-07 U	8.23E-07 J	2.14E-06	1.48E-06	1.24E-06 J	9.30E-07 J	1.10E-06 J	2.91E-06
PCB 209	7.60E-07 U	4.24E-07 U	1.11E-06	5.57E-07	6.50E-07	1.29E-07 U	3.22E-07 U	3.21E-07 U	3.08E-07	2.42E-07 U	2.67E-07 U	4.29E-07 U	4.96E-07
PCB 28/50	2.07E-07 U	8.00E-07	6.82E-07	5.46E-07	4.55E-07	1.40E-07 U	4.90E-07	5.91E-07	2.82E-07	1.98E-07 U	1.38E-07 U	1.75E-07 U	5.05E-07
PCB 29	1.79E-03	4.48E-04	8.67E-05	1.20E-04	6.67E-05 J	3.59E-05 U	3.59E-05 U	4.67E-05	3.68E-05 J	4.06E-05 U	4.06E-05 U	7.18E-05 U	1.48E-04
PCB 44	9.94E-05 U	4.38E-05 U	2.73E-05 U	5.47E-05 U	9.12E-05 U	4.21E-05 U	4.21E-05 U	2.73E-05 U	3.77E-05 U	4.76E-05 U	4.76E-05 U	8.41E-05 U	4.05E-05 U
PCB 50	6.68E-04 J	1.78E-04 J	1.34E-04 J	6.68E-05	4.64E-05 U	6.85E-05 J	4.28E-05 J	6.68E-05 J	8.44E-05 J	3.87E-05 J	4.84E-05 J	3.42E-05 J	9.07E-05
PCB 52	6.64E-05 U	2.92E-05 U	1.83E-05 U	3.65E-05 U	6.08E-05 U	2.81E-05 U	2.81E-05 U	1.83E-05 U	2.52E-05 U	3.17E-05 U	3.17E-05 U	5.62E-05 U	2.70E-05 U
PCB 66/95	5.61E-04 J	2.32E-04 J	1.32E-04 J	9.99E-05	5.30E-05 U	2.79E-05 U	2.44E-05 U	5.45E-05 J	2.82E-05 UJ	2.76E-05 U	3.55E-05 U	4.89E-05 U	9.41E-05
PCB 8	4.75E-04	1.61E-04	9.24E-05	8.84E-05	3.01E-05 U	5.26E-05	4.02E-05	7.84E-05	6.37E-05	4.89E-05	5.59E-05	3.09E-05 U	8.04E-05
PCB 87	7.54E-04	6.22E-04	2.33E-04	1.30E-04 U	1.30E-04 U	2.39E-04	5.98E-05 U	2.07E-04	3.04E-03	6.77E-05 U	6.77E-05 U	1.20E-04 U	1.15E-04 U
trans-Nonachlor	4.77E-05 J	4.20E-05 J	4.10E-05 J	9.83E-06 U	1.64E-05 U	1.77E-05 J	1.51E-05 J	2.62E-05 J	1.13E-05 J	8.55E-06 UJ	1.71E-05 J	1.51E-05 UJ	2.67E-05
Sum of PCB Congeners	6.41E-06 U	4.23E-06 J	4.41E-06 J	3.53E-06 J	2.94E-06 J	2.71E-06 U	2.71E-06 U	4.41E-06 J	4.26E-06 J	3.07E-06 U	3.07E-06 U	5.43E-06 U	7.84E-06
Sum of PCB Congeners X 2	7.02E-03	2.75E-03	1.19E-03	1.18E-03	8.19E-04	7.35E-04	4.97E-04	8.40E-04	3.74E-03	5.60E-04	5.79E-04	7.17E-04	9.61E-04
	1.40E-02	5.50E-03	2.38E-03	2.37E-03	1.64E-03	1.47E-03	9.94E-04	1.68E-03	7.49E-03	1.12E-03	1.16E-03	1.43E-03	1.92E-03
Metals (ug/L)													
Aluminum	53.8	54.2	47.3	52.7	59.6	49.2	58.7	63.4	51.3	49.8	65.1	49.2	59.7
Arsenic	2	2.6	2.7	2.8	3.4	2.9	3.9	1.5	3	2.4	3	2.6	1.8
Barium	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cadmium	0.4	0.7	0.8	0.7	0.6	0.9	0.6	0.7	0.8	0.9	0.4	0.9	0.4
Chromium	20.8	14.7	19.6	18.6	21.3	23.8	17.3	19.5	17.4	18.5	25.6	17.2	19.7
Copper	31	17	21	18	26	19	24	28	20	21	18	18	11
Iron	470	210	230	160	230	340	180	270	290	110	530	250	390
Lead	13.24	21.4	18.5	19.9	14.3	12	18.1	12.5	11.7	15.9	11.3	17.14	27.9
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	R	R	R	R	R	R	R	R	R	R	R	R	R
Nickel	0.9	1.3	1.7	2.1	2.5	1.5	1	1.9	1.3	1.4	1.3	1.5	1.6
Silver	1.4	1.3	1.9	1.4	1.2	1.6	1.2	1.8	1.5	1.6	1.4	1.2	1.8
Zinc	260	140	160	110	190	210	240	180	150	150	220	200	160
Total Organic Carbon (percent)													
Total Organic Carbon	1.1	2.5	4	2	1.2	2.6	2.6	4	2.9	2.3	2.3	1.3	2.7

Notes:
1/2 of the detection limit was used for all non-detected results
The pore water concentrations for the organic constituents is calculated using the following equation: [PW] = [SD]/(Koc*foc)
Where: [PW] = Pore water concentration
[SD] = Sediment concentration
Koc = Organic carbon partitioning coefficient
foc = Fraction of organic carbon = Total Organic Carbon/100
The pore water concentrations for the metals were measured

Footnotes:
1 - Sources of LogKow values are Karickhoff and Long, 1995 or Karickhoff et al., 1989
2 - LogKoc value is calculated using the following equantion from Karickhoff et al., 1989: $Log_{10}(koc) = 0.00028 + 0.983*log_{10}(Kow)$
3 - The pore water concentrations for HMW PAHs were calculated by summing the pore water concentrations for the following individual PAHs: [benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, and pyrene]
4 - The pore water concentrations for LMW PAHs were calculated by summing the pore water concentrations for the following individual PAHs: (2-methylnaphthalene, acenaphthalene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene)
5 - The pore water concentrations for total PAHs were calculated by summing the pore water concentrations for HMW and LMW PAHs

TABLE 3.4
SUMMARY OF TOXIC AND NON-TOXIC PORE WATER AND SEDIMENT SAMPLES
ECOLOGICAL PRG DEVELOPMENT STEP 3
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

	Sea Urchin Development Test with Pore Water Samples					Amphipod Test with Sediment Samples	
	Mean Number of Normal Larvae				Toxic	Mean	Toxic
Station	100%[1]	50%[1]	10%[1]	EC50[2]	Samples[3]	Survival	Samples[3]
Site Stations							
OF-1	0	7	84	30	Toxic	95	
OF-2	0	13	88	33	Toxic	87	
OF-3	4	73	88	71		92	
OF-4	85	83	90	>100		90	
OF-5	0	1	19	6	Toxic	72	Toxic
OF-6	6	79	85	74		94	
OF-7	1	81	88	73		94	
OF-8	0	71	80	72		100	
OF-9	3	0	74	29	Toxic	95	
OF-10	0	74	91	69		100	
OF-11	9	95	94	78		98	
OF-12	0	1	93	30	Toxic	100	
OF-13	0	0	93	30	Toxic	99	
OF-14	54	81	79	>100		99	
OF-15	0	41	87	49	Toxic	98	
OF-16	0	93	90	75		97	
OF-17	17	94	94	81		98	
OF-18	1	0	94	30	Toxic	96	
OF-19	0	33	85	43	Toxic	98	
OF-20	2	89	93	75		100	
OF-21	7	88	91	76		98	
Reference Stations							
OF-22	2	82	91	73		90	
OF-23	0	0	89	30	Toxic	95	

Notes:
1 - Value is the percentage of pore water used in the toxicity test.
2 - The EC50 value is the percentage of pore water that causes 50% of the larvae to development abnormally.
3 - Samples with EC50 values of greater than ~70% are considered non-toxic.

NA - Not Applicable because the sample is a control sample
Source of data is Technical Support Document for the Marine Ecological Risk Assessment for OFFTA (TtNUS, 1998)

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Non-Toxic Sea Urchin Samples[1]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution	Statistic Selected[5]	Selected Pore Water Concentration
Metals (ug/L)						
Aluminum	12 / 12	6.51E+01	OFF-21-PW	Lognormal	95% UL-T	6.60E+01
Arsenic	12 / 12	3.90E+00	OFF-17-PW	Lognormal	95% UL-T	3.87E+00
Cadmium	12 / 12	9.00E-01	OFF-16-PW, OFF-20-PW, OFF-4-PW	Normal	95% UL-N	1.01E+00
Chromium	12 / 12	2.56E+01	OFF-21-PW	Lognormal	95% UL-T	2.59E+01
Copper	12 / 12	3.10E+01	OFF-11-PW	Lognormal	95% UL-T	3.26E+01
Iron	12 / 12	5.30E+02	OFF-21-PW	Lognormal	95% UL-T	5.91E+02
Lead	12 / 12	1.99E+01	OFF-14-PW	Normal	95% UL-N	2.03E+01
Nickel	11 / 12	3.10E+00	OFF-10-PW	Normal	95% UL-N	2.92E+00
Silver	11 / 12	1.70E+00	OFF-4-PW, OFF-7-PW	Undefined	95% UL-T	6.71E+00
Zinc	12 / 12	4.20E+02	OFF-6-PW	Lognormal	95% UL-T	3.99E+02
SEM and AVS (umol/g)						
SEM-AVS	11 / 12	4.89E-01 J	OFF-3-PW	Undefined	95% UL-T	4.89E-01
PAHs (ug/L)						
1-Methylnaphthalene	12 / 12	9.17E-01 J	OFF-6-PW	Lognormal	95% UL-T	1.21E+00
1-Methylphenanthrene	12 / 12	6.07E-01	OFF-3-PW	Lognormal	95% UL-T	6.99E-01
2,6-Dimethylnaphthalene	12 / 12	2.42E-01 J	OFF-6-PW	Lognormal	95% UL-T	3.00E-01
2-Methylnaphthalene	12 / 12	1.24E+00 J	OFF-3-PW	Lognormal	95% UL-T	1.49E+00
Acenaphthene	12 / 12	5.77E+00	OFF-3-PW	Lognormal	95% UL-T	5.61E+00
Acenaphthylene	12 / 12	4.92E+00	OFF-4-PW	Lognormal	95% UL-T	5.26E+00
Anthracene	12 / 12	5.46E+00 J	OFF-3-PW	Lognormal	95% UL-T	5.91E+00
Benzo(a)anthracene	12 / 12	1.58E+00	OFF-3-PW	Lognormal	95% UL-T	1.42E+00
Benzo(a)pyrene	12 / 12	3.78E-01 J	OFF-3-PW	Lognormal	95% UL-T	3.57E-01
Benzo(b,j,k)fluoranthene	12 / 12	1.54E+00 J	OFF-3-PW	Undefined	95% UL-T	1.02E+00
Benzo(e)pyrene	12 / 12	5.75E-01 J	OFF-3-PW	Undefined	95% UL-T	4.02E-01
Benzo(g,h,i)Perylene	12 / 12	1.55E-01 J	OFF-3-PW	Undefined	95% UL-T	1.03E-01
Biphenyl	10 / 12	5.49E-01	OFF-3-PW	Lognormal	95% UL-T	4.50E-01
Chrysene/triphenylene	12 / 12	1.26E+00	OFF-3-PW	Lognormal	95% UL-T	1.04E+00
Dibenzo(a,h)Anthracene	12 / 12	8.28E-02 J	OFF-3-PW	Undefined	95% UL-T	4.71E-02
Fluoranthene	12 / 12	1.50E+01	OFF-3-PW	Lognormal	95% UL-T	1.33E+01
Fluorene	12 / 12	4.83E+00 J	OFF-3-PW	Lognormal	95% UL-T	4.74E+00
Indeno(1,2,3-cd)pyrene	12 / 12	2.12E-01 J	OFF-3-PW	Undefined	95% UL-T	1.28E-01
Naphthalene	12 / 12	8.24E+00	OFF-3-PW	Lognormal	95% UL-T	1.05E+01
Perylene	12 / 12	1.87E-01 J	OFF-3-PW	Lognormal	95% UL-T	1.48E-01
Phenanthrene	12 / 12	4.00E+01	OFF-3-PW	Lognormal	95% UL-T	3.86E+01
Pyrene	12 / 12	1.13E+01	OFF-3-PW	Undefined	95% UL-T	1.07E+01
Sum PAHs (6 High Molecular Weight)	12 / 12	2.96E+01	OFF-3-PW	Lognormal	95% UL-T	2.68E+01
Sum PAHs (7 Low Molecular Weight)	12 / 12	6.96E+01	OFF-3-PW	Lognormal	95% UL-T	6.99E+01
Sum PAHs (NOAA Status &Trends)	12 / 12	9.92E+01	OFF-3-PW	Lognormal	95% UL-T	9.66E+01
Pesticides (ug/L)						
2,4'-DDE	0 / 12	0.00E+00	None	Lognormal	NA	0.00E+00
2,4'-DDT	5 / 12	6.54E-05	OFF-4-PW	Undefined	95% UL-T	3.82E-05
4,4'-DDD	10 / 12	5.00E-04 J	OFF-17-PW	Lognormal	95% UL-T	5.11E-04
4,4'-DDE	4 / 12	4.78E-05	OFF-6-PW	Lognormal	95% UL-T	4.85E-05
4,4'-DDT	12 / 12	2.89E-04	OFF-4-PW	Undefined	95% UL-T	2.03E-04
Aldrin	1 / 12	3.14E-06 J	OFF-8-PW	Lognormal	95% UL-T	1.96E-05
Alpha-Chlordane	7 / 12	5.43E-05	OFF-4-PW	Lognormal	95% UL-T	4.95E-05
Gamma-BHC	3 / 12	7.99E-03 J	OFF-6-PW	Lognormal	95% UL-T	8.79E-03
Heptachlor	2 / 12	6.44E-06 J	OFF-7-PW	Undefined	95% UL-T	2.08E-05

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Non-Toxic Sea Urchin Samples[1]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution	Statistic Selected[5]	Selected Pore Water Concentration
Heptachlor Epoxide	2 / 12	1.04E-04 J	OFF-11-PW	Undefined	95% UL-T	4.83E-05
Hexachlorobenzene	0 / 12	0.00E+00	None	Lognormal	NA	0.00E+00
Mirex	3 / 12	4.68E-06 J	OFF-6-PW	Normal	95% UL-N	6.18E-06
PCBs (ug/L)						
PCB 101/90	3 / 12	1.72E-04	OFF-4-PW	Lognormal	95% UL-T	1.38E-04
PCB 105	0 / 12	0.00E+00	None	Lognormal	95% UL-T	0.00E+00
PCB 118	12 / 12	4.74E-05	OFF-3-PW	Lognormal	95% UL-T	4.79E-05
PCB 126	8 / 12	3.18E-05 J	OFF-4-PW	Lognormal	95% UL-T	3.04E-05
PCB 128	9 / 12	5.52E-05	OFF-4-PW	Lognormal	95% UL-T	4.04E-05
PCB 138/163/164	12 / 12	2.45E-04	OFF-4-PW	Undefined	95% UL-T	2.09E-04
PCB 153	12 / 12	4.73E-05	OFF-11-PW	Lognormal	95% UL-T	4.78E-05
PCB 170	5 / 12	1.43E-05	OFF-4-PW	Lognormal	95% UL-T	1.30E-05
PCB 18	6 / 12	2.25E-03	OFF-11-PW	Lognormal	95% UL-T	2.13E-03
PCB 180	12 / 12	1.69E-05	OFF-11-PW	Lognormal	95% UL-T	1.87E-05
PCB 187/182/159	11 / 12	2.78E-05	OFF-4-PW	Lognormal	95% UL-T	2.11E-05
PCB 188	9 / 12	2.85E-05	OFF-6-PW	Lognormal	95% UL-T	2.42E-05
PCB 195	2 / 12	4.93E-06	OFF-4-PW	Undefined	95% UL-T	3.27E-06
PCB 200	11 / 12	1.43E-05	OFF-4-PW	Lognormal	95% UL-T	1.15E-05
PCB 206	3 / 12	6.86E-07	OFF-8-PW	Lognormal	95% UL-T	1.38E-06
PCB 209	5 / 12	2.07E-06 J	OFF-6-PW	Lognormal	95% UL-T	1.29E-06
PCB 28/50	6 / 12	1.79E-03	OFF-11-PW	Lognormal	95% UL-T	8.73E-04
PCB 44	11 / 12	6.68E-04 J	OFF-11-PW	Undefined	95% UL-T	6.98E-04
PCB 52	5 / 12	5.61E-04 J	OFF-11-PW	Lognormal	95% UL-T	5.42E-04
PCB 66/95	12 / 12	4.75E-04	OFF-11-PW	Lognormal	95% UL-T	3.58E-04
PCB 8	4 / 12	1.04E-03 J	OFF-3-PW	Lognormal	95% UL-T	9.25E-04
PCB 87	8 / 12	5.83E-05 J	OFF-3-PW, OFF-6-PW	Lognormal	95% UL-T	8.32E-05
Sum of PCB Congeners	12 / 12	7.02E-03	OFF-11-PW	Lognormal	95% UL-T	6.09E-03
Sum of PCB Congeners X 2	12 / 12	1.40E-02	OFF-11-PW	Lognormal	95% UL-T	1.22E-02
Trans-Nonachlor	4 / 12	1.37E-05 J	OFF-3-PW	Lognormal	95% UL-T	1.22E-05

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Toxic Sea Urchin Samples[2]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution[6]	Statistic Selected	Selected Pore Water Concentration
Metals (ug/L)						
Aluminum	8 / 8	6.93E+01	OFF-9-PW	< 11 Samples	Max	6.93E+01
Arsenic	9 / 9	5.50E+00	OFF-2-PW	< 11 Samples	Max	5.50E+00
Cadmium	9 / 9	8.00E-01	OFF-13-PW, OFF-19-PW, OFF-9-PW	< 11 Samples	Max	8.00E-01
Chromium	9 / 9	2.86E+01	OFF-1-PW	< 11 Samples	Max	2.86E+01
Copper	9 / 9	8.40E+01	OFF-5-PW	< 11 Samples	Max	8.40E+01
Iron	9 / 9	6.10E+02	OFF-1-PW	< 11 Samples	Max	6.10E+02
Lead	9 / 9	2.14E+01	OFF-12-PW	< 11 Samples	Max	2.14E+01
Nickel	8 / 9	2.50E+00	OFF-15-PW	< 11 Samples	Max	2.50E+00
Silver	9 / 9	1.90E+00	OFF-13-PW	< 11 Samples	Max	1.90E+00
Zinc	9 / 9	2.60E+02	OFF-5-PW	< 11 Samples	Max	2.60E+02
SEM and AVS (umol/g)						
SEM-AVS	7 / 7	-3.65E+00 J	OFF-15-PW	< 11 Samples	Max	-3.65E+00
PAHs (ug/L)						
1-Methylnaphthalene	9 / 9	3.48E+00 J	OFF-5-PW	< 11 Samples	Max	3.48E+00
1-Methylphenanthrene	9 / 9	1.48E+00	OFF-5-PW	< 11 Samples	Max	1.48E+00
2,6-Dimethylnaphthalene	9 / 9	1.40E+00 J	OFF-5-PW	< 11 Samples	Max	1.40E+00
2-Methylnaphthalene	9 / 9	4.13E+00 J	OFF-5-PW	< 11 Samples	Max	4.13E+00
Acenaphthene	9 / 9	1.35E+01	OFF-5-PW	< 11 Samples	Max	1.35E+01
Acenaphthylene	9 / 9	5.31E+00	OFF-5-PW	< 11 Samples	Max	5.31E+00
Anthracene	9 / 9	9.46E+00 J	OFF-5-PW	< 11 Samples	Max	9.46E+00
Benzo(a)anthracene	9 / 9	2.32E+00	OFF-5-PW	< 11 Samples	Max	2.32E+00
Benzo(a)pyrene	9 / 9	4.76E-01	OFF-5-PW	< 11 Samples	Max	4.76E-01
Benzo(b,j,k)fluoranthene	9 / 9	2.01E+00	OFF-5-PW	< 11 Samples	Max	2.01E+00
Benzo(e)pyrene	9 / 9	7.48E-01 J	OFF-5-PW	< 11 Samples	Max	7.48E-01
Benzo(g,h,i)Perylene	9 / 9	1.55E-01 J	OFF-5-PW	< 11 Samples	Max	1.55E-01
Biphenyl	7 / 9	1.93E+00	OFF-5-PW	< 11 Samples	Max	1.93E+00
Chrysene/triphenylene	9 / 9	1.82E+00	OFF-5-PW	< 11 Samples	Max	1.82E+00
Dibenzo(a,h)Anthracene	8 / 9	9.04E-02 J	OFF-5-PW	< 11 Samples	Max	9.04E-02
Fluoranthene	9 / 9	1.78E+01	OFF-5-PW	< 11 Samples	Max	1.78E+01
Fluorene	9 / 9	9.88E+00 J	OFF-5-PW	< 11 Samples	Max	9.88E+00
Indeno(1,2,3-cd)pyrene	9 / 9	2.14E-01	OFF-5-PW	< 11 Samples	Max	2.14E-01
Naphthalene	9 / 9	1.28E+01	OFF-5-PW	< 11 Samples	Max	1.28E+01
Perylene	9 / 9	1.65E-01	OFF-5-PW	< 11 Samples	Max	1.65E-01
Phenanthrene	9 / 9	4.91E+01	OFF-5-PW	< 11 Samples	Max	4.91E+01
Pyrene	9 / 9	1.60E+01	OFF-5-PW	< 11 Samples	Max	1.60E+01
Sum PAHs (6 High Molecular Weight)	9 / 9	3.85E+01	OFF-5-PW	< 11 Samples	Max	3.85E+01
Sum PAHs (7 Low Molecular Weight)	9 / 9	1.04E+02	OFF-5-PW	< 11 Samples	Max	1.04E+02
Sum PAHs (NOAA Status &Trends)	9 / 9	1.43E+02	OFF-5-PW	< 11 Samples	Max	1.43E+02
Pesticides (ug/L)						
2,4'-DDE	1 / 9	8.15E-06	OFF-12-PW	< 11 Samples	Max	8.15E-06
2,4'-DDT	6 / 9	3.85E-05	OFF-5-PW	< 11 Samples	Max	3.85E-05
4,4'-DDD	8 / 9	4.96E-04 J	OFF-13-PW	< 11 Samples	Max	4.96E-04
4,4'-DDE	5 / 9	6.11E-05	OFF-13-PW	< 11 Samples	Max	6.11E-05
4,4'-DDT	9 / 9	2.56E-04	OFF-5-PW	< 11 Samples	Max	2.56E-04
Aldrin	1 / 9	2.81E-06 J	OFF-19-PW	< 11 Samples	Max	2.81E-06
Alpha-Chlordane	9 / 9	5.71E-05	OFF-5-PW	< 11 Samples	Max	5.71E-05
Gamma-BHC	3 / 9	7.49E-03 J	OFF-15-PW	< 11 Samples	Max	7.49E-03
Heptachlor	1 / 9	3.40E-06 J	OFF-15-PW	< 11 Samples	Max	3.40E-06

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Toxic Sea Urchin Samples[2]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution[6]	Statistic Selected	Selected Pore Water Concentration
Heptachlor Epoxide	3 / 9	3.91E-05 J	OFF-12-PW	< 11 Samples	Max	3.91E-05
Hexachlorobenzene	1 / 9	5.03E-05	OFF-19-PW	< 11 Samples	Max	5.03E-05
Mirex	3 / 9	1.01E-05	OFF-5-PW	< 11 Samples	Max	1.01E-05
PCBs (ug/L)						
PCB 101/90	4 / 9	8.77E-05	OFF-12-PW	< 11 Samples	Max	8.77E-05
PCB 105	4 / 9	4.93E-05 J	OFF-5-PW	< 11 Samples	Max	4.93E-05
PCB 118	9 / 9	4.52E-05	OFF-2-PW	< 11 Samples	Max	4.52E-05
PCB 126	5 / 9	4.21E-05 J	OFF-5-PW	< 11 Samples	Max	4.21E-05
PCB 128	6 / 9	2.37E-05	OFF-13-PW	< 11 Samples	Max	2.37E-05
PCB 138/163/164	9 / 9	3.13E-04 J	OFF-5-PW	< 11 Samples	Max	3.13E-04
PCB 153	9 / 9	6.30E-05	OFF-5-PW	< 11 Samples	Max	6.30E-05
PCB 170	4 / 9	1.28E-05	OFF-5-PW	< 11 Samples	Max	1.28E-05
PCB 18	5 / 9	9.88E-04	OFF-5-PW	< 11 Samples	Max	9.88E-04
PCB 180	9 / 9	2.27E-05	OFF-5-PW	< 11 Samples	Max	2.27E-05
PCB 187/182/159	7 / 9	1.43E-05	OFF-5-PW	< 11 Samples	Max	1.43E-05
PCB 188	5 / 9	2.57E-05	OFF-5-PW	< 11 Samples	Max	2.57E-05
PCB 195	3 / 9	1.30E-05	OFF-5-PW	< 11 Samples	Max	1.30E-05
PCB 200	8 / 9	1.43E-05	OFF-5-PW	< 11 Samples	Max	1.43E-05
PCB 206	4 / 9	1.11E-06	OFF-13-PW	< 11 Samples	Max	1.11E-06
PCB 209	6 / 9	8.00E-07	OFF-12-PW	< 11 Samples	Max	8.00E-07
PCB 28/50	8 / 9	4.80E-04	OFF-5-PW	< 11 Samples	Max	4.80E-04
PCB 44	7 / 9	3.12E-04 J	OFF-5-PW	< 11 Samples	Max	3.12E-04
PCB 52	4 / 9	3.27E-04 J	OFF-5-PW	< 11 Samples	Max	3.27E-04
PCB 66/95	7 / 9	3.13E-04	OFF-5-PW	< 11 Samples	Max	3.13E-04
PCB 8	5 / 9	4.90E-03 J	OFF-1-PW	< 11 Samples	Max	4.90E-03
PCB 87	6 / 9	5.36E-05 J	OFF-2-PW	< 11 Samples	Max	5.36E-05
Sum of PCB Congeners	9 / 9	5.88E-03	OFF-1-PW	< 11 Samples	Max	5.88E-03
Sum of PCB Congeners X 2	9 / 9	1.18E-02	OFF-1-PW	< 11 Samples	Max	1.18E-02
Trans-Nonachlor	8 / 9	2.29E-05	OFF-5-PW	< 11 Samples	Max	2.29E-05

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Non-Toxic Amphipod Samples[3,4]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution	Statistic Selected	Selected Pore Water Concentration
Metals (ug/L)						
Aluminum	19 / 19	6.93E+01	OFF-9-PW	Lognormal	95% UL-T	6.93E+01
Arsenic	20 / 20	5.50E+00	OFF-2-PW	Lognormal	95% UL-T	4.78E+00
Cadmium	20 / 20	9.00E-01	OFF-16-PW, OFF-20-PW, OFF-4-PW	Normal	95% UL-N	1.00E+00
Chromium	20 / 20	2.86E+01	OFF-1-PW	Lognormal	95% UL-T	2.66E+01
Copper	20 / 20	3.10E+01	OFF-11-PW, OFF-9-PW	Lognormal	95% UL-T	3.23E+01
Iron	20 / 20	6.10E+02	OFF-1-PW	Lognormal	95% UL-T	5.84E+02
Lead	20 / 20	2.14E+01	OFF-12-PW	Normal	95% UL-N	2.07E+01
Nickel	18 / 20	3.10E+00	OFF-10-PW	Normal	95% UL-N	2.77E+00
Silver	19 / 20	1.90E+00	OFF-13-PW	Undefined	95% UL-T	4.90E+00
Zinc	20 / 20	4.20E+02	OFF-6-PW	Lognormal	95% UL-T	3.18E+02
SEM and AVS (umol/g)						
SEM-AVS	17 / 20	4.89E-01 J	OFF-3-PW	Undefined	95% UL-T	4.89E-01
PAHs (ug/L)						
1-Methylnaphthalene	20 / 20	9.17E-01 J	OFF-6-PW	Lognormal	95% UL-T	9.11E-01
1-Methylphenanthrene	20 / 20	6.07E-01	OFF-3-PW	Lognormal	95% UL-T	4.87E-01
2,6-Dimethylnaphthalene	20 / 20	2.75E-01 J	OFF-2-PW	Lognormal	95% UL-T	2.46E-01
2-Methylnaphthalene	20 / 20	1.24E+00 J	OFF-3-PW	Lognormal	95% UL-T	1.20E+00
Acenaphthene	20 / 20	5.77E+00	OFF-3-PW	Lognormal	95% UL-T	3.52E+00
Acenaphthylene	20 / 20	4.92E+00	OFF-4-PW	Undefined	95% UL-T	3.77E+00
Anthracene	20 / 20	5.46E+00 J	OFF-3-PW	Lognormal	95% UL-T	4.15E+00
Benzo(a)anthracene	20 / 20	1.58E+00	OFF-3-PW	Undefined	95% UL-T	8.56E-01
Benzo(a)pyrene	20 / 20	3.78E-01 J	OFF-3-PW	Lognormal	95% UL-T	2.45E-01
Benzo(b,j,k)fluoranthene	20 / 20	1.54E+00 J	OFF-3-PW	Undefined	95% UL-T	6.67E-01
Benzo(e)pyrene	20 / 20	5.75E-01 J	OFF-3-PW	Undefined	95% UL-T	2.67E-01
Benzo(g,h,i)Perylene	20 / 20	1.55E-01 J	OFF-3-PW	Undefined	95% UL-T	6.77E-02
Biphenyl	16 / 20	5.49E-01	OFF-3-PW	Lognormal	95% UL-T	3.34E-01
Chrysene/triphenylene	20 / 20	1.26E+00	OFF-3-PW	Undefined	95% UL-T	6.50E-01
Dibenzo(a,h)Anthracene	19 / 20	8.28E-02 J	OFF-3-PW	Lognormal	95% UL-T	3.35E-02
Fluoranthene	20 / 20	1.50E+01	OFF-3-PW	Undefined	95% UL-T	8.40E+00
Fluorene	20 / 20	4.83E+00 J	OFF-3-PW	Lognormal	95% UL-T	2.96E+00
Indeno(1,2,3-cd)pyrene	20 / 20	2.12E-01 J	OFF-3-PW	Undefined	95% UL-T	8.48E-02
Naphthalene	20 / 20	8.24E+00	OFF-3-PW	Lognormal	95% UL-T	7.94E+00
Perylene	20 / 20	1.87E-01 J	OFF-3-PW	Undefined	95% UL-T	9.29E-02
Phenanthrene	20 / 20	4.00E+01	OFF-3-PW	Lognormal	95% UL-T	2.32E+01
Pyrene	20 / 20	1.13E+01	OFF-3-PW	Undefined	95% UL-T	7.05E+00
Sum PAHs (6 High Molecular Weight)	20 / 20	2.96E+01	OFF-3-PW	Undefined	95% UL-T	1.72E+01
Sum PAHs (7 Low Molecular Weight)	20 / 20	6.96E+01	OFF-3-PW	Lognormal	95% UL-T	4.60E+01
Sum PAHs (NOAA Status &Trends)	20 / 20	9.92E+01	OFF-3-PW	Lognormal	95% UL-T	6.30E+01
Pesticides (ug/L)						
2,4'-DDE	1 / 20	8.15E-06	OFF-12-PW	Lognormal	95% UL-T	1.20E-05
2,4'-DDT	10 / 20	6.54E-05	OFF-4-PW	Undefined	95% UL-T	3.28E-05
4,4'-DDD	17 / 20	5.00E-04 J	OFF-17-PW	Lognormal	95% UL-T	6.14E-04
4,4'-DDE	9 / 20	6.11E-05	OFF-13-PW	Undefined	95% UL-T	6.56E-05
4,4'-DDT	20 / 20	2.89E-04	OFF-4-PW	Undefined	95% UL-T	1.83E-04
Aldrin	2 / 20	3.14E-06 J	OFF-8-PW	Lognormal	95% UL-T	1.88E-05
Alpha-Chlordane	15 / 20	5.43E-05	OFF-4-PW	Lognormal	95% UL-T	4.28E-05
Gamma-BHC	6 / 20	7.99E-03 J	OFF-6-PW	Lognormal	95% UL-T	8.72E-03
Heptachlor	3 / 20	6.44E-06 J	OFF-7-PW	Undefined	95% UL-T	1.62E-05

TABLE 3.5
PORE WATER SUMMARY STATISTICS
ECOLOGICAL PRG DEVELOPMENT STEP 4
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	Non-Toxic Amphipod Samples[3,4]					
	Frequency of Detection	Maximum Detection	Location of Maximum Detection	Data Distribution	Statistic Selected	Selected Pore Water Concentration
Heptachlor Epoxide	5 / 20	1.04E-04 J	OFF-11-PW	Undefined	95% UL-T	3.82E-05
Hexachlorobenzene	1 / 20	5.03E-05	OFF-19-PW	Lognormal	95% UL-T	4.94E-05
Mirex	5 / 20	5.62E-06 J	OFF-15-PW	Normal	95% UL-T	5.99E-06
PCBs (ug/L)						
PCB 101/90	7 / 20	1.72E-04	OFF-4-PW	Lognormal	95% UL-T	1.25E-04
PCB 105	3 / 20	2.54E-05 J	OFF-13-PW	Lognormal	95% UL-T	2.56E-05
PCB 118	20 / 20	4.74E-05	OFF-3-PW	Lognormal	95% UL-T	5.35E-05
PCB 126	12 / 20	3.18E-05 J	OFF-4-PW	Lognormal	95% UL-T	2.73E-05
PCB 128	14 / 20	5.52E-05	OFF-4-PW	Lognormal	95% UL-T	3.71E-05
PCB 138/163/164	20 / 20	2.45E-04	OFF-4-PW	Undefined	95% UL-T	1.80E-04
PCB 153	20 / 20	4.73E-05	OFF-11-PW	Lognormal	95% UL-T	4.82E-05
PCB 170	8 / 20	1.43E-05	OFF-4-PW	Undefined	95% UL-T	1.27E-05
PCB 18	10 / 20	2.25E-03	OFF-11-PW	Lognormal	95% UL-T	1.42E-03
PCB 180	20 / 20	1.69E-05	OFF-11-PW	Undefined	95% UL-T	1.74E-05
PCB 187/182/159	17 / 20	2.78E-05	OFF-4-PW	Lognormal	95% UL-T	1.93E-05
PCB 188	13 / 20	2.85E-05	OFF-6-PW	Lognormal	95% UL-T	1.74E-05
PCB 195	4 / 20	4.93E-06	OFF-4-PW	Lognormal	95% UL-T	2.99E-06
PCB 200	18 / 20	1.43E-05	OFF-4-PW	Lognormal	95% UL-T	9.56E-06
PCB 206	7 / 20	1.11E-06	OFF-13-PW	Lognormal	95% UL-T	1.18E-06
PCB 209	11 / 20	2.07E-06 J	OFF-6-PW	Lognormal	95% UL-T	1.14E-06
PCB 28/50	13 / 20	1.79E-03	OFF-11-PW	Undefined	95% UL-T	5.63E-04
PCB 44	17 / 20	6.68E-04 J	OFF-11-PW	Undefined	95% UL-T	4.18E-04
PCB 52	8 / 20	5.61E-04 J	OFF-11-PW	Lognormal	95% UL-T	3.55E-04
PCB 66/95	18 / 20	4.75E-04	OFF-11-PW	Lognormal	95% UL-T	2.87E-04
PCB 8	9 / 20	4.90E-03 J	OFF-1-PW	Undefined	95% UL-T	2.06E-03
PCB 87	13 / 20	5.83E-05 J	OFF-3-PW, OFF-6-PW	Undefined	95% UL-T	7.22E-05
Sum of PCB Congeners	20 / 20	7.02E-03	OFF-11-PW	Lognormal	95% UL-T	5.79E-03
Sum of PCB Congeners X 2	20 / 20	1.40E-02	OFF-11-PW	Lognormal	95% UL-T	1.16E-02
Trans-Nonachlor	11 / 20	1.37E-05 J	OFF-3-PW	Lognormal	95% UL-T	1.03E-05

Footnotes:

1 - Samples were considered non-toxic for the sea urchin toxicity test (see Table 4)
2 - Samples were considered toxic for the sea urchin toxicity test (see Table 4)
3 - Samples were considered non-toxic for the amphipod toxicity test (see Table 4)
4 - The summary statistics for the toxic sediment samples are not presented because only one sediment sample (OFF-5) was toxic
5 - The selected statistic is based on the data distribution.
- The Maximum (Max) value was selected when the 95% Upper Limit (UL) exceeded the maximum detection
- The Log-normal 95% UL (95% UL-T) was selected when the data was lognormally distributed
- The Normal 95% UL (95% UL-N) was selected when the data was normally distributed
6 - There were not enough samples to accurately calculate a 95% UL

TABLE 3.6
CALCULATION OF NO OBSERVED EFFECTS CONCENTRATION
ECOLOGICAL PRG DEVELOPMENT STEP 5
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	WQSV[1]	Sea Urchin Samples		NOEC[4]	Amphipod Samples		NOEC[4]	Aquatic NOEC[5]
		Non-Toxic Concentration[2]	Toxic Concentration[3]		Non-Toxic Concentration[2]	Toxic Concentration[3]		
Metals (ug/L)								
Aluminum	87	66	69		69	64		
Arsenic	36	4	5.5		5	1.0		
Cadmium	9.4	1	0.8		1	0.5		
Chromium	50	26	29		27	22		
Copper	3.7	33	84	33	32	84	32	32
Iron	1000	591	610		584	170		
Lead	8.5	20	21	20	21	18		20
Nickel	8.3	3	2.5		3	1.1		
Silver	0.92	7	1.9		5	1.3		
Zinc	86	399	260		318	260		
SEM and AVS (umol/g)								
SEM-AVS	5	0.49	0.21		0.5	-22.2		
PAHs (ug/L)								
2-Methylnaphthalene	0.88	1.5	4.1	1.5	1.2	4.1	1.2	1.20
Acenaphthene	710	5.6	14		3.5	14		
Acenaphthylene	0.46	5.3	5.3	5.3	3.8	5.3	3.8	3.8
Anthracene	0.29	5.9	9.5	5.9	4.2	9.5	4.2	4.2
Benzo(a)anthracene	0.065	1.4	2.3	1.4	0.86	2.3	0.86	0.86
Benzo(a)pyrene	0.042	0.36	0.48	0.36	0.24	0.48	0.24	0.24
Benzo(b,j,k)fluoranthene	0.14	1.0	2.0	1.0	0.67	2.0	0.67	0.67
Benzo(g,h,i)Perylene	0.02	0.10	0.16	0.10	0.07	0.16	0.068	0.068
Biphenyl	14	0.45	1.9		0.33	1.93		
Chrysene/triphenylene	0.10	1.0	1.8	1.0	0.65	1.8	0.65	0.65
Dibenzo(a,h)Anthracene	0.0017	0.047	0.090	0.047	0.033	0.09	0.033	0.033
Fluoranthene	16	13	18	16	8.4	18	16	16
Fluorene	0.14	4.7	10	4.7	3.0	10	3.0	3.0
Indeno(1,2,3-cd)pyrene	0.020	0.13	0.21	0.128	0.085	0.21	0.085	0.085
Naphthalene	633	11	13		7.9	13		
Phenanthrene	4.6	39	49	39	23	49	23	23
Pyrene	0.63	11	16	11	7.0	16	7.0	7.0
Sum PAHs (6 High Molecular Weight)	0.17	27	39	27	17	39	17	17

TABLE 3.6
CALCULATION OF NO OBSERVED EFFECTS CONCENTRATION
ECOLOGICAL PRG DEVELOPMENT STEP 5
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND

PARAMETER	WQSV[1]	Sea Urchin Samples		NOEC[4]	Amphipod Samples		NOEC[4]	Aquatic NOEC[5]
		Non-Toxic Concentration[2]	Toxic Concentration[3]		Non-Toxic Concentration[2]	Toxic Concentration[3]		
Sum PAHs (7 Low Molecular Weight)	4.8	70	104	70	46	104	46	46
Sum PAHs (NOAA Status &Trends)	3.7	97	143	97	63	143	63	63
Pesticides (ug/L)								
2,4'-DDE	1.00E-03	0.00E+00	8.15E-06		1.20E-05	9.05E-06		
2,4'-DDT	1.00E-03	3.82E-05	3.85E-05		3.28E-05	3.85E-05		
4,4'-DDD	1.00E-03	5.11E-04	4.96E-04		6.14E-04	2.02E-04		
4,4'-DDE	1.00E-03	4.85E-05	6.11E-05		6.56E-05	3.39E-05		
4,4'-DDT	1.00E-03	2.03E-04	2.56E-04		1.83E-04	2.56E-04		
Aldrin	1.63E-01	1.96E-05	2.81E-06		1.88E-05	1.43E-05		
Alpha-Chlordane	4.00E-03	4.95E-05	5.71E-05		4.28E-05	5.71E-05		
Gamma-BHC	1.60E-01	8.79E-03	7.49E-03		8.72E-03	5.39E-03		
Heptachlor	3.60E-03	2.08E-05	3.40E-06		1.62E-05	1.02E-05		
Heptachlor Epoxide	3.60E-03	4.83E-05	3.91E-05		3.82E-05	1.02E-05		
Hexachlorobenzene	3.57E-03	0.00E+00	5.03E-05		4.94E-05	4.05E-05		
Mirex	1.00E-03	6.18E-06	1.01E-05		5.99E-06	1.01E-05		
PCBs (ug/L)								
Sum of PCB Congeners X 2	3.00E-02	1.22E-02	1.18E-02		1.16E-02	6.98E-03		

Notes:
WQSV - Water Quality Screening Value
NOEC - No Observed Effects Concentration
This table only includes constituents that have WQSVs

Footnotes:
1 - The sources of the Water Quality Screening Values (WQSVs) are presented in Table 1
2 - The cells in this column are shaded if the chemical concentrations exceed the WQSV
3 - The cells in this column are shaded if the chemical concentrations in the toxic samples exceed the chemical concentrations in the non-toxic samples **and** the WQSV
4 - This column only lists chemicals if the concentration in the toxic sample exceeds the WQSV **and** the chemical concentration in the toxic samples exceeds the chemical concentration in the non-toxic samples
The chemical concentration in this column is the higher of the WQSV or the non-toxic concentration
5 - The concentration in this column is the lower of the two NOEC values and is named the Aquatic NOEC

TABLE 3.7
SEM-AVS RESULTS
ECOLOGICAL PRG DEVELOPMENT STEP 5
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	Bulk Chemistry Sediment Results						SEM-AVS	TOC	TOC Normalized SEM-AVS[2]
	Cadmium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Silver (mg/kg)	Zinc (mg/kg)			
OFF-1	0.31	58	131	34	0.46 J	156	1.23[1]	1.8	68
OFF-2	0.14	24	90	26	0.065 UJ	315	0.79[1]	1.1	72
OFF-3	0.18	12	60	22	0.065 UJ	50 U	0.49	0.9	54
OFF-4	0.06	31	96	20	0.065 UJ	106	1.51[1]	0.9	168
OFF-5	0.23	17	139	19	0.065 UJ	40 U	-22	1	-2222
OFF-6	0.15	11	47	19	0.065 UJ	53 U	-25	1.8	-1387
OFF-7	0.29	33	294	28	0.18 J	156	-37	1.9	-1969
OFF-8	0.19	11	38	16	0.17 J	47 U	-4.7	1.3	-360
OFF-9	0.11	6.9	25	18	0.065 UJ	40 U	-3.6	1.2	-304
OFF-10	0.15	10	27	13	0.065 UJ	27 U	-6.4	1.1	-581
OFF-11	0.22	9.1	39	5.5 U	0.17 J	28 U	-12	1.1	-1104
OFF-12	0.53	37	114	21	0.48 J	147	-23	2.5	-923
OFF-13	0.80	81	202	30	1.06 J	263	-47	4	-1168
OFF-14	0.12	19	45	16	0.23 J	48 U	-8.4	2	-420
OFF-15	0.18	12	33	14	0.19 J	37 U	-5.6	1.2	-466
OFF-16	0.36	24	61	18	0.44 J	51 U	-22	2.6	-849
OFF-17	0.38	26	71	19	0.4 J	126	-13	2.6	-490
OFF-18	0.69	84	190	28	1.08 J	248	-36	4	-904
OFF-19	0.21	30	56	24	0.18 J	166	-16	2.9	-546
OFF-20	0.25	19	41	21	0.19 J	109	-28	2.3	-1213
OFF-21	0.39	23	46	27	0.16 J	144	-12	2.3	-504
OFF-22	0.19	18	22	21	0.065 UJ	39 U	-1.4	1.3	-110
OFF-23	0.43	45	74	43	0.27 J	306	-31	2.7	-1142

Notes:
SEM - Simultaneous Extracted Metals
AVS - Acid Volatile Sulfide
TOC - Total Organic Carbon
1 - AVS was not detected in these samples
2 - This value is calculated using the following equation: TOC Normalized SEM-AVS = (SEM-AVS)/(TOC/100)

TABLE 3.8
TOXICITY EFFECTS LEVEL CALCULATION
ECOLOGICAL PRG DEVELOPMENT STEP 6
OLD FIRE FIGHTING TRAINING CENTER, NETC
NEWPORT, RHODE ISLAND
PAGE 1 OF 1

PARAMETER	Aquatic NOEC[1]	Reference Stations		Toxicity Effects Level[2]
		OFF-22	OFF-23	
2-Methylnaphthalene	1.2	0.030	0.20	1.2
Acenaphthylene	3.8	0.035	0.30	3.8
Anthracene	4.2	0.025	0.43	4.2
Benzo(a)anthracene	0.86	0.0068	0.057	0.86
Benzo(a)pyrene	0.24	0.0029	0.028	0.24
Benzo(b,j,k)fluoranthene	0.67	0.0049	0.046	0.67
Benzo(g,h,i)Perylene	0.068	0.0012	0.0067	0.068
Chrysene/triphenylene	0.65	0.005	0.05	0.65
Dibenzo(a,h)Anthracene	0.033	0.00025	0.0018	0.033
Fluoranthene	16	0.047	0.54	16
Fluorene	3.0	0.013	0.29	3.0
Indeno(1,2,3-cd)pyrene	0.085	0.00076	0.0055	0.085
Phenanthrene	23	0.061	0.96	23
Pyrene	7.0	0.050	0.50	7.0
Sum PAHs (6 High Molecular Weight)	17	0.11	1.2	17
Sum PAHs (7 Low Molecular Weight)	46	0.31	3.4	46
Sum PAHs (NOAA Status &Trends)	63	0.42	4.6	63

Notes:
NOEC - No Observed Effects Concentration
This table only includes constituents that were retained as Aquatic NOECs
Footnotes:
1 - The Aquatic NOEC was obtained from Table 6
2 - The TEV is the higher of the reference concentration or the Aquatic NOEC

TABLE 3.9
LIMITING COCS CALCULATION
ECOLOGICAL PRG DEVELOPMENT STEP 7
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location		OFF-1	OFF-2	OFF-3	OFF-4	OFF-5	OFF-6	OFF-7	OFF-8	OFF-9	OFF-10	OFF-11
Sample Depth Interval		0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	TEV[1]	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	4/7/98	4/7/98	4/3/98	4/3/98
Polyaromatic Hydrocarbons												
2-Methylnaphthalene	1.2	1.50E-01 J	7.34E-01 J	1.03E+00 J	4.40E-01 J	3.43E+00 J	9.82E-01 J	3.01E-01	1.15E-01	2.69E-02	2.93E-02 J	1.65E-01 J
Acenaphthylene	3.8	1.43E-01	1.23E+00	1.08E+00	1.30E+00	1.41E+00	3.00E-01	2.46E-01	3.94E-02	1.31E-02	1.03E-02 J	2.26E-02
Anthracene	4.2	1.15E-01 J	8.10E-01 J	1.31E+00 J	6.97E-01 J	2.28E+00 J	5.27E-01 J	1.68E-01	4.37E-02	7.63E-03	7.22E-03 J	4.71E-02 J
Benzo(a)anthracene	0.86	1.62E-02	9.53E-01	1.84E+00	7.38E-01	2.71E+00	6.88E-01	1.78E-01	4.79E-02	1.39E-02	9.32E-03	4.45E-02
Benzo(a)pyrene	0.24	1.33E-01	8.82E-01	1.54E+00 J	9.35E-01	1.95E+00	4.45E-01	2.82E-01	6.75E-02	2.55E-02	1.65E-02	5.42E-02
Benzo(b,j,k)fluoranthene	0.67	1.86E-01	8.45E-01	2.32E+00 J	4.69E-01	3.01E+00	6.29E-01	1.81E-01	3.81E-02	1.53E-02	1.04E-02	3.11E-02
Benzo(g,h,i)Perylene	0.068	1.86E-01 J	8.77E-01 J	2.28E+00 J	5.49E-01 J	2.29E+00 J	5.59E-01 J	2.06E-01	4.15E-02	1.68E-02	1.41E-02 J	3.31E-02 J
Chrysene/triphenylene	0.65	1.68E-01	8.15E-01	1.94E+00	7.88E-01	2.80E+00	7.13E-01	1.05E-01 J	5.78E-02	1.90E-02	1.11E-02	4.08E-02
Dibenzo(a,h)Anthracene	0.033	1.94E-01 J	9.29E-01 J	2.47E+00 J	3.10E-01 J	2.70E+00 J	6.12E-01 J	1.22E-01	2.53E-02	4.49E-03 U	6.19E-03 J	1.72E-02 J
Fluoranthene	16	6.27E-02	4.39E-01	9.39E-01	3.59E-01	1.11E+00	3.60E-01	6.67E-02	2.03E-02	5.64E-03	4.54E-03	2.04E-02
Fluorene	3.0	5.50E-02 J	6.77E-01 J	1.63E+00 J	4.83E-01 J	3.34E+00 J	5.35E-01 J	2.07E-01	6.56E-02	1.09E-02 J	6.26E-03 J	5.61E-02 J
Indeno(1,2,3-cd)pyrene	0.08	1.92E-01	9.56E-01	2.50E+00 J	4.57E-01	2.53E+00	5.76E-01	1.74E-01	3.58E-02	1.37E-02	1.10E-02	2.69E-02
Phenanthrene	23	8.55E-02	7.40E-01	1.73E+00	4.89E-01	2.12E+00	7.63E-01	1.01E-01	2.91E-02	5.60E-03	4.13E-03	3.14E-02
Pyrene	7.0	1.33E-01	8.25E-01	1.60E+00	7.19E-01	2.27E+00	7.30E-01	1.50E-01	4.15E-02	1.14E-02	1.07E-02	4.12E-02
Sum PAHs (6 High Molecular Weight)	17	1.23E-01	8.42E-01	1.72E+00	7.11E-01	2.24E+00	7.05E-01	1.41E-01	4.15E-02	1.17E-02	9.76E-03	4.05E-02
Sum PAHs (7 Low Molecular Weight)	46	9.58E-02	8.03E-01	1.51E+00	6.41E-01	2.27E+00	6.73E-01	1.67E-01	5.61E-02	1.09E-02	9.38E-03	4.73E-02
Sum PAHs (NOAA Status &Trends)	63	1.03E-01	8.15E-01	1.57E+00	6.61E-01	2.27E+00	6.83E-01	1.60E-01	5.22E-02	1.12E-02	9.50E-03	4.55E-02
SUM TEV_{HQ}[2]		1.82E+00	1.17E+01	2.42E+01	8.73E+00	3.40E+01	8.42E+00	2.49E+00	6.69E-01	1.90E-01	1.51E-01	6.32E-01
MAX TEV_{HQ}		1.94E-01	1.23E+00	2.50E+00	1.30E+00	3.43E+00	9.82E-01	3.01E-01	1.15E-01	2.69E-02	2.93E-02	1.65E-01
Limiting COC[3]		Dibenzo(a,h)Anthracene	Acenaphthylene	Indeno(1,2,3-cd)pyrene	Acenaphthylene	2-Methylnaphthalene	2-Methylnaphthalene	2-Methylnaphthalene	NA	NA	NA	NA

TABLE 3.9
LIMITING COCS CALCULATION
ECOLOGICAL PRG DEVELOPMENT STEP 7
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-12	OFF-13	OFF-14	OFF-15	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	4/3/98	4/3/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98
Polyaromatic Hydrocarbons										
2-Methylnaphthalene	4.87E-01 J	1.71E-01 J	8.06E-02	8.23E-02	9.56E-02 J	7.88E-02 J	1.66E-01	1.13E-01	1.83E-01 J	5.92E-02 J
Acenaphthylene	6.45E-02	1.08E-01 J	3.48E-02	2.74E-02	3.81E-02 J	4.37E-02	9.75E-02	3.87E-02	1.78E-02	2.20E-02
Anthracene	1.85E-01 J	9.76E-02 J	2.10E-02	2.36E-02	2.74E-02 J	3.74E-02 J	6.89E-02 J	2.91E-02	7.64E-02 J	1.69E-02 J
Benzo(a)anthracene	1.40E-01	8.45E-02 J	3.15E-02	2.57E-02	2.18E-02 J	2.81E-02	5.31E-02	3.17E-02	4.05E-02	1.91E-02
Benzo(a)pyrene	2.29E-01	1.16E-01 J	5.14E-02	3.46E-02	3.41E-02 J	5.16E-02	9.71E-02	4.47E-02	4.50E-02	3.08E-02
Benzo(b,j,k)fluoranthene	1.32E-01	7.32E-02 J	2.75E-02	3.68E-02	2.02E-02 J	3.03E-02	6.90E-02	2.57E-02	3.08E-02	1.96E-02
Benzo(g,h,i)Perylene	1.25E-01 J	7.12E-02 J	3.73E-02	3.19E-02	2.67E-02 J	3.98E-02 J	8.61E-02 J	2.65E-02	2.18E-02 J	2.21E-02 J
Chrysene/triphenylene	1.53E-01	7.42E-02 J	3.64E-02	2.79E-02	2.23E-02 J	2.99E-02 J	6.05E-02	3.66E-02	4.93E-02	2.52E-02
Dibenzo(a,h)Anthracene	8.87E-02 J	4.22E-02 J	2.07E-02	2.90E-02	1.51E-02 J	2.32E-02 J	5.41E-02 J	1.57E-02	1.73E-02 J	1.39E-02 J
Fluoranthene	7.23E-02	3.76E-02 J	8.92E-03	8.93E-03	9.89E-03 J	1.18E-02 J	2.72E-02	1.08E-02	2.22E-02	7.32E-03
Fluorene	2.66E-01 J	7.56E-02 J	2.11E-02	1.56E-02	3.22E-02 J	2.92E-02 J	4.60E-02 J	4.35E-02	9.89E-02 J	1.21E-02 J
Indeno(1,2,3-cd)pyrene	1.06E-01	5.53E-02 J	2.94E-02	3.31E-02	2.05E-02 J	3.12E-02	6.72E-02	2.30E-02	2.23E-02	1.88E-02
Phenanthrene	1.46E-01	5.22E-02 J	9.43E-03	1.06E-02	1.85E-02 J	1.51E-02	3.33E-02	1.47E-02	5.22E-02	7.95E-03
Pyrene	1.62E-01	8.50E-02 J	2.31E-02	2.10E-02	2.65E-02 J	2.81E-02 J	6.08E-02	2.42E-02	4.39E-02	1.95E-02
Sum PAHs (6 High Molecular Weight)	1.50E-01	7.88E-02	2.15E-02	1.98E-02	2.26E-02	2.58E-02	5.68E-02	2.37E-02	4.33E-02	1.72E-02
Sum PAHs (7 Low Molecular Weight)	2.20E-01	7.83E-02	2.59E-02	2.44E-02	3.22E-02	3.19E-02	6.13E-02	4.35E-02	7.47E-02	1.50E-02
Sum PAHs (NOAA Status &Trends)	2.01E-01	7.86E-02	2.47E-02	2.32E-02	2.96E-02	3.03E-02	6.02E-02	3.82E-02	6.63E-02	1.56E-02
SUM TEV_{HQ} (2)	2.36E+00	1.14E+00	4.33E-01	4.08E-01	4.09E-01	4.78E-01	9.87E-01	4.78E-01	7.21E-01	2.95E-01
MAX TEV_{HQ}	4.87E-01	1.71E-01	8.06E-02	8.23E-02	9.56E-02	7.88E-02	1.66E-01	1.13E-01	1.83E-01	5.92E-02
Limiting COC (3)	2-Methylnaphthalene	2-Methylnaphthalene	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

1 - Source of TEV is presented in Table 8

2 - The SUM TEV_{HQs} does not include the Sum PAHs because they are already counted as individual PAHs

3 - Limiting COCs are the cells with the maximim TEV_{HQs} at each station (shaded cells)

The values in this table are calculated using the following equation: TEV_{HQ} = [PW]/TEV

Where: TEV_{HQ} = Toxicity Effects Value Hazard Quotient

[PW] = Pore Water Concentration (ug/L) (from Table 3)

TEV = Toxicity Effects Level (ug/L) (from Table 8)

TABLE 3.10
PRG CALCULATION
ECOLOGICAL PRG CALCULATION STEP 8
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-1	OFF-2	OFF-3	OFF-4	OFF-5	OFF-6	OFF-7	OFF-8	OFF-9	OFF-10	OFF-11	OFF-12
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
Date Sampled	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	3/27/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98
Filtering	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
Polyaromatic Hydrocarbons (ug/kg)												
2-Methylnaphthalene	1.73E+02	1.06E+02	8.65E+01	8.65E+01	9.61E+01	1.73E+02	1.83E+02	1.25E+02	1.15E+02	1.06E+02	1.06E+02	2.40E+02
Acenaphthylene	6.51E+02	3.98E+02	3.25E+02	3.25E+02	3.62E+02	6.51E+02	6.87E+02	4.70E+02	4.34E+02	3.98E+02	3.98E+02	9.04E+02
Dibenzo(a,h)Anthracene	2.27E+03	1.39E+03	1.14E+03	1.14E+03	1.26E+03	2.27E+03	2.40E+03	1.64E+03	1.51E+03	1.39E+03	1.39E+03	3.16E+03
Indeno(1,2,3-cd)pyrene	5.26E+03	3.21E+03	2.63E+03	2.63E+03	2.92E+03	5.26E+03	5.55E+03	3.80E+03	3.50E+03	3.21E+03	3.21E+03	7.30E+03

TABLE 3.10
PRG CALCULATION
ECOLOGICAL PRG CALCULATION STEP 8
OLD FIRE FIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT RHODE ISLAND

Sample Location	OFF-13	OFF-14	OFF-15	OFF-16	OFF-17	OFF-18	OFF-19	OFF-20	OFF-21	
Sample Depth Interval	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	
Date Sampled	4/3/98	4/7/98	4/7/98	4/3/98	4/3/98	4/3/98	4/7/98	4/3/98	4/3/98	Average
Filtering	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	PRG(1)
Polyaromatic Hydrocarbons (ug/kg)										
2-Methylnaphthalene	3.85E+02	1.92E+02	1.15E+02	2.50E+02	2.50E+02	3.85E+02	2.79E+02	2.21E+02	2.21E+02	185
Acenaphthylene	1.45E+03	7.23E+02	4.34E+02	9.40E+02	9.40E+02	1.45E+03	1.05E+03	8.32E+02	8.32E+02	697
Dibenzo(a,h)Anthracene	5.05E+03	2.52E+03	1.51E+03	3.28E+03	3.28E+03	5.05E+03	3.66E+03	2.90E+03	2.90E+03	2434
Indeno(1,2,3-cd)pyrene	1.17E+04	5.84E+03	3.50E+03	7.59E+03	7.59E+03	1.17E+04	8.47E+03	6.72E+03	6.72E+03	5633

Notes:

The values in this table are calculated using the following equation: PRG = [SD]/TEV_{HQ}

Where: PRG = Preliminary Remediation Goal

[SD] = Sediment Concentration (ug/kg or mg/kg) (from Table 2)

TEV_{HQ} = Toxicity Effects Level Hazard Quotient (unitless) (from Table 9)

1 - Average PRG is the arithmetic average of all the PRGs across each station

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-5E-SD-2025		OFF-5E-SD-5560		OFF-SD-411-0006		OFF-SD-412-0006		OFF-SD-413-0006	
Sample Location		OFF-5E		OFF-5E		SD-411		SD-412		SD-413	
Date Sampled		4/27/1998		4/27/1998		11/13/2001		11/13/2001		11/13/2001	
Interval		0.7-0.8		1.8-2.0		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Recreational Sediment PRG	None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)											
2-Methylnaphthalene		18.7		3.6	U	66	U	28	J	58	U
Acenaphthylene		11		0.2	J	100		580		81	J
Benzo(a)anthracene	1338	829		8	U	840		1400		430	J
Benzo(a)pyrene	134	648		3	U	680	J	1000		320	J
Benzo(b)fluoranthene	1338		NA		NA	990	J	1200		470	J
Dibenzo(a,h)anthracene	134	115		1	J	66	UJ	120		58	UJ
Indeno(1,2,3-cd)pyrene		302		1.5	J	200	J	400		86	J
Pesticide/PCB Analysis (UG/KG)											
Sum of PCB Congeners		4.3		0.50			NA		NA		NA
TAL Metal Analysis (MG/KG)											
Arsenic	6.2**	7.3	J	4.6	J	4.4	J	5.4	J	4.7	J
Cadmium		0.11		0.10		0.024	UJ	0.023	UJ	0.022	UJ
Chromium		19.7		23.2		11.2		17.5		10.7	
Mercury		0.062		0.050	U	0.058		0.019	J	0.017	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-414-0006		OFF-SD-417-0006		OFF-SD-424-0006		OFF-SD-425-0006		OFF-SD-432-0006	
Sample Location		SD-414		SD-417		SD-424		SD-425		SD-432	
Date Sampled		11/9/2001		11/13/2001		11/13/2001		11/13/2001		11/13/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Recreational Sediment PRG	None		None		None		None		Field Dup. OFF-SD-432-0006	
Semivolatile Organic Analysis (UG/KG)											
2-Methylnaphthalene		100	J	68	U	58	U	44	J	55	U
Acenaphthylene		1500	J	250		38	J	52	J	84	
Benzo(a)anthracene	1338	4900	J	1100		300		830		340	
Benzo(a)pyrene	134	3900	J	810		230	J	640	J	240	
Benzo(b)fluoranthene	1338	5100	J	1000		320	J	900	J	300	
Dibenzo(a,h)anthracene	134	480	J	94		58	UJ	54	UJ	55	U
Indeno(1,2,3-cd)pyrene		1600	J	310		85	J	200	J	120	
Pesticide/PCB Analysis (UG/KG)											
Sum of PCB Congeners			NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)											
Arsenic	6.2**	6.7	J	5.2	J	5.8	J	10.6	J	4.7	J
Cadmium		0.87	J	1.5	J	0.13	J	2.8	J	0.020	UJ
Chromium		21.3	J	12.1		26.1		18.6		11.5	
Mercury		0.018	U	0.066		0.035		0.056		0.019	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-432-0006-D		OFF-SD-432-1824		OFF-SD-439-0006		OFF-SD-439-0006-D		OFF-SD-439-0612	
Sample Location		SD-432		SD-432		SD-439		SD-439		SD-439	
Date Sampled		11/13/2001		11/13/2001		10/29/2001		10/29/2001		10/29/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		0.0-0.5		0.5-1.0	
QC Identifier	Recreational Sediment PRG	Field Dup. OFF-SD-432-0006		None		Field Dup. OFF-SD-439-0006		Field Dup. OFF-SD-439-0006		None	
Semivolatile Organic Analysis (UG/KG)											
2-Methylnaphthalene		58	U	60	J	370	U	370	U	47	J
Acenaphthylene		100		760		370	U	57	J	160	J
Benzo(a)anthracene	1338	520		2800		540		490		1400	
Benzo(a)pyrene	134	370		2000		550		500		710	
Benzo(b)fluoranthene	1338	500		2600		680		680		1400	
Dibenzo(a,h)anthracene	134	58	U	240		74	J	68	J	85	J
Indeno(1,2,3-cd)pyrene		140		810		240	J	200	J	240	J
Pesticide/PCB Analysis (UG/KG)											
Sum of PCB Congeners			NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)											
Arsenic	6.2**	6.1	J	4.6	J	2.4		1.5		14.9	
Cadmium		2.2	J	2.3	J	0.60	J	1.4	J	1.2	J
Chromium		12.7		12.1		9.5	J	21.3	J	17.5	J
Mercury		0.019	U	0.019	J	0.016	U	0.032	J	0.061	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-439-1824		OFF-SD-442-0006		OFF-SD-442-1824		OFF-SD-445-0006		OFF-SD-445-1824	
Sample Location		SD-439		SD-442		SD-442		SD-445		SD-445	
Date Sampled		11/13/2001		11/9/2001		11/13/2001		11/13/2001		11/13/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Recreational Sediment PRG	None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)											
2-Methylnaphthalene		44	J	58	J	61	U	67	U	46	J
Acenaphthylene		41	J	870		56	J	76		66	J
Benzo(a)anthracene	1338	430		2900		360		570		450	
Benzo(a)pyrene	134	440	J	2400	J	290	J	500		470	J
Benzo(b)fluoranthene	1338	530	J	3200	J	400	J	670		640	J
Dibenzo(a,h)anthracene	134	59	UJ	280	J	61	UJ	67	U	66	UJ
Indeno(1,2,3-cd)pyrene		150	J	990	J	81	J	160		160	J
Pesticide/PCB Analysis (UG/KG)											
Sum of PCB Congeners			NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)											
Arsenic	6.2**	6.1	J	7.2	J	9.1	J	2.6	J	7.2	J
Cadmium		2.2	J	0.62	J	0.63	J	0.82	J	2.1	J
Chromium		20.1		10.2		18.7		6.2	J	30.3	
Mercury		0.068		0.020	J	0.035		0.058		0.18	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SSD-333-00005		OFF-SSD-333-00005-MAX		OFF-SSD-334-00005		OFF-SSD-335-00005		OFF-SSD-336-00005	
Sample Location		OFF-SSD-333		OFF-SSD-333		OFF-SSD-334		OFF-SSD-335		OFF-SSD-336	
Date Sampled		11/19/1998		11/19/1998		11/19/1998		11/19/1998		11/19/1998	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Recreational Sediment PRG	Field Dup. OFF-SSD-333-00005		Field Dup. OFF-SSD-333-00005		None		None		None	
Semivolatile Organic Analysis (UG/KG)											
2-Methylnaphthalene		1800	U	1800	U	2300	U	2100	U	4000	U
Acenaphthylene		1800	U	1800	U	230	J	2100	U	4000	U
Benzo(a)anthracene	1338	850	J	1100		1900	J	1800	J	620	J
Benzo(a)pyrene	134	770	J	910		1400	J	1300	J	520	J
Benzo(b)fluoranthene	1338	940	J	1100		2300	U	1700	J	610	J
Dibenzo(a,h)anthracene	134	1800	U	1800	U	290	J	2100	U	4000	U
Indeno(1,2,3-cd)pyrene		430	J	550		1000	J	950	J	4000	U
Pesticide/PCB Analysis (UG/KG)											
Sum of PCB Congeners			NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)											
Arsenic	6.2**	3.1	J	4.3		5.3	J	4.2	J	4.8	
Cadmium		0.080	U	0.080	U	0.10	U	0.10	U	0.090	UJ
Chromium		12.3		13.0		13.3		11.8		10.9	
Mercury		0.050	U	0.050	U	0.060	U	0.060	U	0.060	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1A
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL EXPOSURE TO SEDIMENT
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SSD-337-00005	
Sample Location		OFF-SSD-337	
Date Sampled		11/19/1998	
Interval		0.0-0.5	
QC Identifier	Recreational Sediment PRG	None	
Semivolatile Organic Analysis (UG/KG)			
2-Methylnaphthalene		4000	U
Acenaphthylene		4000	U
Benzo(a)anthracene	1338	4000	U
Benzo(a)pyrene	134	4000	U
Benzo(b)fluoranthene	1338	4000	U
Dibenzo(a,h)anthracene	134	4000	U
Indeno(1,2,3-cd)pyrene		4000	U
Pesticide/PCB Analysis (UG/KG)			
Sum of PCB Congeners			NA
TAL Metal Analysis (MG/KG)			
Arsenic	6.2**	7.1	
Cadmium		0.090	UJ
Chromium		15.8	
Mercury		0.050	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed
** - Arsenic PRG for human exposure to sediment is based on HHRA and Background Assessment

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-1-SD-0015		OFF-2-SD-0015		OFF-3-SD-0015		OFF-4-SD-0015		OFF-5-SD-0015		OFF-5-SD-2025		OFF-5-SD-5560		OFF-6-SD-0015	
Sample Location		OFF-1		OFF-2		OFF-3		OFF-4		OFF-5		OFF-5		OFF-5		OFF-6	
Date Sampled		3/27/1998		3/27/1998		3/27/1998		3/27/1998		3/27/1998		4/27/1998		4/27/1998		3/27/1998	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.7-0.8		1.8-2.0		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene		26	J	77.6	J	89.2	J	38.1	J	330	J	42.5		3.6	U	170	J
Acenaphthylene		93		488		350		424		509		144		4.6	U	195	
Benzo(a)anthracene	34270	100		3600		5690		2280		9300		882		8	U	4250	
Benzo(a)pyrene	9360	595		2410		3450	J	2090		4830		973		3	U	1990	
Benzo(b)fluoranthene	51269		NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	6742	441	J	1290	J	2810	J	352	J	3410	J	345		2.8	U	1390	J
Indeno(1,2,3-cd)pyrene	72519	1010		3070		6560	J	1200		7390		524		1.2	J	3030	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners	175	18.9		22.9		29.8		36.1		51.6		37		3.0	-	38.2	
TAL Metal Analysis (MG/KG)																	
Arsenic	5.48	6.3	J	8.0	J	3.6	J	4.3	J	3.6	J	4.9	J	5.3	J	4.1	J
Cadmium	10	0.31		0.14		0.18		0.060		0.23		0.55		1.29		0.15	
Chromium	3708	31.1		36.6		26.5		24.3		27.4		17.6		29.5		23.0	
Mercury	2.3	0.371		0.081		0.050	U	0.050	U	0.050	U	0.071		0.050	U	0.050	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-6-SD-2025		OFF-6-SD-3540		OFF-7-SD-0015		OFF-8-SD-0015		OFF-9-SD-0015		OFF-10-SD-0015		OFF-10-SD-1520		OFF-10-SD-2530	
Sample Location		OFF-6		OFF-6		OFF-7		OFF-8		OFF-9		OFF-10		OFF-10		OFF-10	
Date Sampled		4/27/1998		4/27/1998		3/27/1998		4/7/1998		4/7/1998		4/3/1998		4/7/1998		4/7/1998	
Interval		0.7-0.8		1.1-1.3		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.5-0.7		0.8-1.0	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene		280		9.6		54.9		14.4		3.1	J	3.1	J	3	J	2.6	J
Acenaphthylene		95.8		3.1	J	169		18.5		5.7		4.1	J	3	J	2.1	J
Benzo(a)anthracene	34270	988		118		1160		214		57.3		35.2		23.4		15.5	
Benzo(a)pyrene	9360	1750		116		1330		218		76.1		45.1		31.3		19.8	
Benzo(b)fluoranthene	51269		NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	6742	357		22.3		293		41.5		13.6	U	8.6	J	6.6		4.8	
Indeno(1,2,3-cd)pyrene	72519	1140		72.2		968		136		48.1		35.3		26.9		14.8	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners	175	106.9		2.7		30.5		10.6		4.7		5.5		2.9		0.40	
TAL Metal Analysis (MG/KG)																	
Arsenic	5.48	7.5	J	3.7	J	6.8	J	4.3	J	4.3	J	3.4	J	2.9	J	3.3	J
Cadmium	10	0.68		0.14		0.29		0.19		0.11		0.15		0.18		0.070	
Chromium	3708	35.3		29.7		43.1		42.3		38.6		32.1		30.1		39.2	
Mercury	2.3	0.176		0.050	U	0.119		0.148		0.050	U	0.070		0.070		0.073	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-11-SD-0015		OFF-11-SD-5055		OFF-11-SD-105110		OFF-12-SD-0015		OFF-13-SD-0015		OFF-14-SD-0015		OFF-15-SD-0015		OFF-16-SD-0015	
Sample Location		OFF-11		OFF-11		OFF-11		OFF-12		OFF-13		OFF-14		OFF-15		OFF-16	
Date Sampled		4/3/1998		4/7/1998		4/7/1998		4/3/1998		4/3/1998		4/7/1998		4/7/1998		4/3/1998	
Interval		0.0-0.5		1.6-1.8		3.4-3.6		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene		17.5	J	3.6	U	3.6	U	117	J	65.6	J	15.5		9.5		23.9	J
Acenaphthylene		9		1.1	J	4.6	U	58.3		156	J	25.2		11.9		35.8	J
Benzo(a)anthracene	34270	168		44.7		8	U	1200		1160	J	216		106		195	J
Benzo(a)pyrene	9360	148		37.5		3	U	1420		1150	J	255		103		220	J
Benzo(b)fluoranthene	51269		NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	6742	23.9	J	4.8		0.8	J	280	J	213	J	52.2		44		49.6	J
Indeno(1,2,3-cd)pyrene	72519	86.3		23.1		1.5	J	777		646	J	172		116		156	J
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners	175	44.2		2.0		0.70		65.1		95.5		24.8		7.3		22.7	
TAL Metal Analysis (MG/KG)																	
Arsenic	5.48	2.7	J	5.0	J	4.7	J	5.2	J	6.0	J	8.5	J	3.7	J	5.0	J
Cadmium	10	0.22		0.27		0.20		0.53		0.80		0.12		0.18		0.36	
Chromium	3708	30.2		32.1		231.7		58.6		73.7		44.9		41.0		48.0	
Mercury	2.3	0.125		0.050	U	0.051		0.376		1.355		0.196		0.10		0.208	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-17-SD-0015		OFF-18-SD-0015		OFF-18-SD-5055		OFF-18-SD-105110		OFF-19-SD-0015		OFF-20-SD-0015		OFF-21-SD-0015		OFF-22-SD-0015	
Sample Location		OFF-17		OFF-18		OFF-18		OFF-18		OFF-19		OFF-20		OFF-21		OFF-22	
Date Sampled		4/3/1998		4/3/1998		4/7/1998		4/7/1998		4/7/1998		4/3/1998		4/3/1998		3/27/1998	
Interval		0.0-0.5		0.0-0.5		1.6-1.8		3.4-3.6		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene		19.7	J	63.8	J	210		91.1		31.5		40.4	J	13.1	J	3.1	J
Acenaphthylene		41.1		141		210		80.2		40.6		14.8		18.3		4.4	J
Benzo(a)anthracene	34270	251		730		787		1260		316		320		151		35.6	
Benzo(a)pyrene	9360	333		964		931		1170		322		257		176		38.8	
Benzo(b)fluoranthene	51269		NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	6742	76.1	J	273	J	248		204		57.4		50.3	J	40.4	J	12.2	J
Indeno(1,2,3-cd)pyrene	72519	237		785		821		619		195		150		126		33.9	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners	175	16.6		62.9		46.8		12		28.4		18.9		15.6		2.8	
TAL Metal Analysis (MG/KG)																	
Arsenic	5.48	4.7	J	6.3	J	5.6	J	6.4	J	5.8	J	4.2	J	4.9	J	3.8	J
Cadmium	10	0.38		0.69		1.12		0.50		0.21		0.25		0.39		0.19	
Chromium	3708	44.1		73.6		79.7		76.4		55.6		52.5		52.9		47.8	
Mercury	2.3	0.225		0.562		0.97		1.901		0.299		0.171		0.112		0.111	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-23-SD-0015		OFF-SD-406-0006		OFF-SD-407-0006		OFF-SD-408-0006		OFF-SD-408-0006-D		OFF-SD-409-0006		OFF-SD-409-0006-D	
Sample Location		OFF-23		SD-406		SD-407		SD-408		SD-408		SD-409		SD-409	
Date Sampled		4/3/1998		11/12/2001		11/12/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		Field Dup. OFF-SD-408-0006		Field Dup. OFF-SD-408-0006		Field Dup. OFF-SD-409-0006		Field Dup. OFF-SD-409-0006	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		43.4		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Acenaphthylene		77.5		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Benzo(a)anthracene	34270	616		64	U	66	U	85		110	J	58	J	110	J
Benzo(a)pyrene	9360	758		64	U	66	U	90		130	J	69		120	J
Benzo(b)fluoranthene	51269		NA	64	U	66	U	120		170	J	78		160	J
Dibenzo(a,h)anthracene	6742	179		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Indeno(1,2,3-cd)pyrene	72519	511		64	U	66	U	74		100	J	61	U	77	UJ
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175	44.6			NA		NA		NA		NA	NA		-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	4.8	J	2.4		2.1		3.1	J	3.0	J	6.4	J	4.9	J
Cadmium	10	0.43		0.025	U	0.022	U	0.021	U	0.025	U	0.022	U	0.031	U
Chromium	3708	53.2		10.8		11.4		11.3		13.6		11.2		15.4	
Mercury	2.3	0.387		0.032	J	0.038	J	0.029	J	0.035	J	0.030	J	0.073	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-410-0006		OFF-SD-415-0006		OFF-SD-416-0006		OFF-SD-418-0006		OFF-SD-419-0006		OFF-SD-419-0006-D		OFF-SD-420-0006	
Sample Location		SD-410		SD-415		SD-416		SD-418		SD-419		SD-419		SD-420	
Date Sampled		11/14/2001		11/12/2001		11/14/2001		11/8/2001		11/8/2001		11/8/2001		11/8/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		Field Dup. OFF-SD-419-0006		Field Dup. OFF-SD-419-0006		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		470		62	U	61	U	120	U	130	U	140	U	280	U
Acenaphthylene		400		24	J	280		120	U	91	J	130	J	120	J
Benzo(a)anthracene	34270	9200		120	J	1200		180		580		530		860	
Benzo(a)pyrene	9360	9500		140	J	1400		160		470		540		850	
Benzo(b)fluoranthene	51269	12000		160		1600		180		600		700		1000	
Dibenzo(a,h)anthracene	6742	1500		62	U	220		120	U	130	U	140	U	280	U
Indeno(1,2,3-cd)pyrene	72519	5200		91		860		80	J	200		200	J	310	J
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	4.4	J	2.2		3.3	J	3.2	J	2.7	J	2.9	J	3.4	J
Cadmium	10	0.025	U	0.023	U	0.021	U	0.47	J	0.44	J	0.45	J	0.52	J
Chromium	3708	17.5		10.6		10.8		11.3		11.8		12.4		14.6	
Mercury	2.3	0.060		0.049		0.037	J	0.053		0.057		0.061		0.085	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-421-0006		OFF-SD-422-0006		OFF-SD-423-0006		OFF-SD-426-0006		OFF-SD-427-1824		OFF-SD-427-1824-D		OFF-SD-427-0006	
Sample Location		SD-421		SD-422		SD-423		SD-426		SD-427		SD-427		SD-427	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/14/2001		11/12/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		1.5-2.0		1.5-2.0		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		Field Dup. OFF-SD-427-1824		Field Dup. OFF-SD-427-1824		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		260	U	290	U	380	U	63	U	60	U	58	U	82	U
Acenaphthylene		260	U	210	J	380	U	63	U	60	U	58	U	82	U
Benzo(a)anthracene	34270	320		1300		1600		63	U	60	U	58	U	82	U
Benzo(a)pyrene	9360	340		1000		1600		63	U	60	U	58	U	82	U
Benzo(b)fluoranthene	51269	420		1200		2100		63	U	60	U	58	U	82	U
Dibenzo(a,h)anthracene	6742	260	U	290	U	380	U	63	U	60	U	58	U	82	U
Indeno(1,2,3-cd)pyrene	72519	150	J	500		560	J	63	U	60	U	58	U	82	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	2.6	J	3.5	J	6.9	J	2.8	J	2.4	J	2.0		2.6	
Cadmium	10	0.42	J	0.57	J	1.1	J	0.024	UJ	0.022	U	0.021	U	0.029	U
Chromium	3708	12.7		15.9		27.5		10.2		13.5		13.7		14.0	
Mercury	2.3	0.078		0.096		0.23		0.025	J	0.026	J	0.027		0.041	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-428-0006		OFF-SD-428-1824		OFF-SD-429-0006		OFF-SD-430-0006		OFF-SD-430-1824		OFF-SD-431-0006		OFF-SD-431-1824	
Sample Location		SD-428		SD-428		SD-429		SD-430		SD-430		SD-431		SD-431	
Date Sampled		11/14/2001		11/14/2001		11/12/2001		11/12/2001		11/12/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		73	U	60	U	65	U	63	U	61	U	62	U	58	U
Acenaphthylene		64	J	47	J	65	U	63	U	61	U	62	U	58	U
Benzo(a)anthracene	34270	580		370		65	U	63	U	61	U	62	U	58	U
Benzo(a)pyrene	9360	530	J	320	J	65	U	63	U	61	U	62	U	58	U
Benzo(b)fluoranthene	51269	740	J	420	J	65	U	63	U	61	U	62	U	58	U
Dibenzo(a,h)anthracene	6742	73	UJ	60	UJ	65	U	63	U	61	U	62	U	58	U
Indeno(1,2,3-cd)pyrene	72519	200	J	120	J	65	U	63	U	61	U	62	U	58	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	4.5	J	3.1	J	4.7	J	2.6	J	4.5	J	1.4	J	3.2	J
Cadmium	10	0.030	UJ	0.023	UJ	0.024	U	0.026	U	0.022	U	0.024	U	0.023	U
Chromium	3708	15.6		11.8		17.6		11.6		14.8		12.3		14.8	
Mercury	2.3	0.059		0.096		0.070		0.061		0.032	J	0.040	J	0.033	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-433-0006		OFF-SD-433-1824		OFF-SD-434-0006		OFF-SD-434-0006-D		OFF-SD-434-1824		OFF-SD-435-0006		OFF-SD-435-1824	
Sample Location		SD-433		SD-433		SD-434		SD-434		SD-434		SD-435		SD-435	
Date Sampled		11/12/2001		11/12/2001		11/14/2001		11/14/2001		11/14/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Lobster Ingestion PRG	None		None		Field Dup. OFF-SD-434-0006		Field Dup. OFF-SD-434-0006		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		68	U	61	U	65	U	67	U	62	U	72	U	60	U
Acenaphthylene		68	U	61	U	93		51	J	94		72	U	60	U
Benzo(a)anthracene	34270	68	U	61	U	400		330		540		72	U	60	U
Benzo(a)pyrene	9360	68	U	61	U	340	J	280	J	460		32	J	60	U
Benzo(b)fluoranthene	51269	37	J	61	U	440	J	360	J	570		48	J	60	U
Dibenzo(a,h)anthracene	6742	68	U	61	U	65	UJ	67	UJ	60	J	72	U	60	U
Indeno(1,2,3-cd)pyrene	72519	68	U	61	U	120	J	94	J	190		27	J	60	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	2.2	J	5.4	J	3.6	J	3.4	J	3.3	J	2.5	J	2.3	J
Cadmium	10	0.025	U	0.022	U	0.026	UJ	0.026	UJ	0.023	UJ	0.027	U	0.020	U
Chromium	3708	11.9		12.2		11.8		12.1		11.1		14.1		11.1	
Mercury	2.3	0.053		0.019	U	0.030	J	0.036	J	0.033	J	0.050		0.018	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-436-0006		OFF-SD-436-0006-D		OFF-SD-436-1824		OFF-SD-437-0006		OFF-SD-437-1824		OFF-SD-438-0006		OFF-SD-438-1824	
Sample Location		SD-436		SD-436		SD-436		SD-437		SD-437		SD-438		SD-438	
Date Sampled		11/12/2001		11/12/2001		11/12/2001		11/8/2001		11/8/2001		11/8/2001		11/8/2001	
Interval		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Lobster Ingestion PRG	Field Dup. OFF-SD-436-0006		Field Dup. OFF-SD-436-0006		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		64	U	65	U	26	J	140	U	120	U	130	U	120	U
Acenaphthylene		210		210		280		140	U	120	U	150		120	U
Benzo(a)anthracene	34270	980		1200		1200		140		120	U	770		120	U
Benzo(a)pyrene	9360	850		1000		1100		130	J	120	U	740		120	U
Benzo(b)fluoranthene	51269	1000		1300		1300		160		120	U	880		120	U
Dibenzo(a,h)anthracene	6742	140		170		160		140	U	120	U	130	U	120	U
Indeno(1,2,3-cd)pyrene	72519	540		610		680		62	J	120	U	280	J	120	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	6.0	J	3.9		5.5	J	3.4	J	2.3	J	4.1	J	1.9	J
Cadmium	10	0.022	U	0.025	U	0.024	U	0.40	J	0.34	J	0.43	J	0.27	J
Chromium	3708	11.8		10.8		14.9		11.6		9.4		11.7		11.4	
Mercury	2.3	0.023	J	0.027		0.047		0.057		0.019	U	0.045		0.019	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-440-0006		OFF-SD-440-1824		OFF-SD-441-0006		OFF-SD-441-1824		OFF-SD-443-0006		OFF-SD-443-1824		OFF-SD-444-0006	
Sample Location		SD-440		SD-440		SD-441		SD-441		SD-443		SD-443		SD-444	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/8/2001		11/13/2001		11/13/2001		11/8/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		120	U	120	U	630	U	160	U	67	U	67	U	130	U
Acenaphthylene		140		120	U	630	U	160	U	110		67	U	100	J
Benzo(a)anthracene	34270	580		120	U	600	J	180		670		58	J	530	
Benzo(a)pyrene	9360	580		120	U	570	J	170		550		43	J	540	
Benzo(b)fluoranthene	51269	660		120	U	670		180		690		53	J	680	
Dibenzo(a,h)anthracene	6742	120	U	120	U	630	U	160	U	67	U	67	U	130	U
Indeno(1,2,3-cd)pyrene	72519	270		120	U	310	J	85	J	180		67	U	220	J
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175	NA			NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	2.6	J	1.8	J	1.7	J	4.5	J	3.1	J	3.4	J	2.1	J
Cadmium	10	0.41	J	0.25	J	0.37	J	0.73	J	1.1	J	0.79	J	0.41	J
Chromium	3708	11.2		8.2		10.3		18.2		9.0	J	9.0		12.0	
Mercury	2.3	0.066		0.018	U	0.060		0.41		0.091		0.022	U	0.065	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-444-1824		OFF-SD-446-0006		OFF-SD-446-1824		OFF-SD-460-0006		OFF-SD-460-1824		OFF-SD-461-0006		OFF-SD-461-1824	
Sample Location		SD-444		SD-446		SD-446		SD-460		SD-460		SD-461		SD-461	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		77	J	300	U	53	J	65	U	62	U	67	U	55	U
Acenaphthylene		140	U	330		58	J	65	U	62	U	67	U	55	U
Benzo(a)anthracene	34270	960		2300		590		120		29	J	67	U	55	U
Benzo(a)pyrene	9360	860		2500		700	J	140		40	J	46	J	55	U
Benzo(b)fluoranthene	51269	950		3100		920	J	200		42	J	56	J	55	U
Dibenzo(a,h)anthracene	6742	140	U	270	J	150	UJ	65	U	62	U	67	U	55	U
Indeno(1,2,3-cd)pyrene	72519	290	J	1000	J	290	J	110		62	U	67	U	55	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	3.7	J	4.2	J	7.9	J	3.9	J	3.6	J	3.0	J	5.4	J
Cadmium	10	0.55	J	0.59	J	1.2	J	0.024	U	0.023	U	0.026	U	0.021	U
Chromium	3708	14.6		17.2		25.6		14.0		14.7		15.2		11.9	
Mercury	2.3	0.20		0.11		0.33		0.047	J	0.032	J	0.047	J	0.015	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-462-0006		OFF-SD-462-1824		OFF-SD-463-0006		OFF-SD-463-1824		OFF-SD-464-0006		OFF-SD-464-1824		OFF-SD-465-0006	
Sample Location		SD-462		SD-462		SD-463		SD-463		SD-464		SD-464		SD-465	
Date Sampled		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene		68	U	60	U	61	U	59	U	70	U	56	U	63	U
Acenaphthylene		68	U	60	U	61	U	59	U	70	U	56	U	63	U
Benzo(a)anthracene	34270	110		60	U	61	U	59	U	34	J	56	U	32	J
Benzo(a)pyrene	9360	130		60	U	61	U	59	U	70	U	56	U	63	UJ
Benzo(b)fluoranthene	51269	160		60	U	61	U	59	U	70	U	56	U	63	UJ
Dibenzo(a,h)anthracene	6742	68	U	60	U	61	U	59	U	70	U	56	U	63	UJ
Indeno(1,2,3-cd)pyrene	72519	98		60	U	61	U	59	U	70	U	56	U	63	UJ
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA	-	NA
TAL Metal Analysis (MG/KG)															
Arsenic	5.48	3.4	J	4.8	J		NA	2.3	J	3.8	J	4.6	J	2.2	J
Cadmium	10	0.026	U	0.023	U		NA	0.024	UJ	0.028	U	0.021	U	0.024	UJ
Chromium	3708	14.0		13.2			NA	10.6		14.5		14.5		9.9	
Mercury	2.3	0.028	J	0.019	U		NA	0.016	U	0.069		0.017	U	0.050	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-465-1824		OFF-SD-466-0006		OFF-SD-466-1824		OFF-SD-467-0006		OFF-SD-467-1824		OFF-SD-468-0006	
Sample Location		SD-465		SD-466		SD-466		SD-467		SD-467		SD-468	
Date Sampled		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/12/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5	
QC Identifier	Lobster Ingestion PRG	None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)													
2-Methylnaphthalene		58	U	62	U	63	U	69	U	61	U	1600	U
Acenaphthylene		58	U	74	J	63	U	69	U	61	U	1600	U
Benzo(a)anthracene	34270	26	J	420	J	280		63	J	61	U	660	J
Benzo(a)pyrene	9360	58	U	370		420		53	J	61	U	710	J
Benzo(b)fluoranthene	51269	24	J	450		450		74		61	U	1200	J
Dibenzo(a,h)anthracene	6742	58	U	62	U	62	J	69	U	61	U	1600	U
Indeno(1,2,3-cd)pyrene	72519	58	U	150	J	210		69	U	61	U	1600	U
Pesticide/PCB Analysis (UG/KG)													
Sum of PCB Congeners	175		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)													
Arsenic	5.48	4.4	J	2.2	J	3.0	J	2.2	J	6.3	J	9.9	J
Cadmium	10	0.021	UJ	0.025	UJ	0.025	UJ	0.024	UJ	0.022	UJ	0.058	U
Chromium	3708	9.7		7.0		12.8		11.2		13.1		46.9	
Mercury	2.3	0.020	U	0.023	J	0.093		0.032	J	0.043		0.50	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1B
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
LIFETIME RECREATIONAL INGESTION OF LOBSTER
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-468-1824		OFF-SD-469-0006		OFF-SD-469-1824	
Sample Location		SD-468		SD-469		SD-469	
Date Sampled		11/12/2001		11/12/2001		11/12/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Lobster Ingestion PRG	None		None		None	
Semivolatile Organic Analysis (UG/KG)							
2-Methylnaphthalene		100	U	150	U	100	UJ
Acenaphthylene		100	U	70	J	47	J
Benzo(a)anthracene	34270	180		460		160	J
Benzo(a)pyrene	9360	200		500		240	J
Benzo(b)fluoranthene	51269	280		690		350	J
Dibenzo(a,h)anthracene	6742	100	U	98	J	100	UJ
Indeno(1,2,3-cd)pyrene	72519	160		350		170	J
Pesticide/PCB Analysis (UG/KG)							
Sum of PCB Congeners	175		NA		NA		NA
TAL Metal Analysis (MG/KG)							
Arsenic	5.48	10.0	J	11.1	J	14.7	J
Cadmium	10	0.89		0.051	U	0.037	U
Chromium	3708	49.1		50.6		55.8	
Mercury	2.3	0.89		0.41		0.64	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-1-SD-0015		OFF-2-SD-0015		OFF-3-SD-0015		OFF-4-SD-0015		OFF-5-SD-0015		OFF-5-SD-2025		OFF-5-SD-5560		OFF-6-SD-0015	
Sample Location		OFF-1		OFF-2		OFF-3		OFF-4		OFF-5		OFF-5		OFF-5		OFF-6	
Date Sampled		3/27/1998		3/27/1998		3/27/1998		3/27/1998		3/27/1998		4/27/1998		4/27/1998		3/27/1998	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.7-0.8		1.8-2.0		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene	185	26	J	77.6	J	89.2	J	38.1	J	330	J	42.5		3.6	U	170	J
Acenaphthylene	697	93		488		350		424		509		144		4.6	U	195	
Benzo(a)anthracene		100		3600		5690		2280		9300		882		8	U	4250	
Benzo(a)pyrene		595		2410		3450	J	2090		4830		973		3	U	1990	
Benzo(b)fluoranthene			NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	2434	441	J	1290	J	2810	J	352	J	3410	J	345		2.8	U	1390	J
Indeno(1,2,3-cd)pyrene	5633	1010		3070		6560	J	1200		7390		524		1.2	J	3030	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners		18.9		22.9		29.8		36.1		51.6		37		3.0		38.2	
TAL Metal Analysis (MG/KG)																	
Arsenic		6.3	J	8.0	J	3.6	J	4.3	J	3.6	J	4.9	J	5.3	J	4.1	J
Cadmium		0.31		0.14		0.18		0.060		0.23		0.55		1.29		0.15	
Chromium		31.1		36.6		26.5		24.3		27.4		17.6		29.5		23.0	
Mercury		0.371		0.081		0.050	U	0.050	U	0.050	U	0.071		0.050	U	0.050	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-6-SD-2025		OFF-6-SD-3540		OFF-7-SD-0015		OFF-8-SD-0015		OFF-9-SD-0015		OFF-10-SD-0015		OFF-10-SD-1520		OFF-10-SD-2530	
Sample Location		OFF-6		OFF-6		OFF-7		OFF-8		OFF-9		OFF-10		OFF-10		OFF-10	
Date Sampled		4/27/1998		4/27/1998		3/27/1998		4/7/1998		4/7/1998		4/3/1998		4/7/1998		4/7/1998	
Interval		0.7-0.8		1.1-1.3		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.5-0.7		0.8-1.0	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene	185	280		9.6		54.9		14.4		3.1	J	3.1	J	3	J	2.6	J
Acenaphthylene	697	95.8		3.1	J	169		18.5		5.7		4.1	J	3	J	2.1	J
Benzo(a)anthracene		988		118		1160		214		57.3		35.2		23.4		15.5	
Benzo(a)pyrene		1750		116		1330		218		76.1		45.1		31.3		19.8	
Benzo(b)fluoranthene			NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	2434	357		22.3		293		41.5		13.6	U	8.6	J	6.6		4.8	
Indeno(1,2,3-cd)pyrene	5633	1140		72.2		968		136		48.1		35.3		26.9		14.8	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners		106.9		2.7		30.5		10.6		4.7		5.5		2.9		0.40	
TAL Metal Analysis (MG/KG)																	
Arsenic		7.5	J	3.7	J	6.8	J	4.3	J	4.3	J	3.4	J	2.9	J	3.3	J
Cadmium		0.68		0.14		0.29		0.19		0.11		0.15		0.18		0.070	
Chromium		35.3		29.7		43.1		42.3		38.6		32.1		30.1		39.2	
Mercury		0.176		0.050	U	0.119		0.148		0.050	U	0.070		0.070		0.073	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-11-SD-0015		OFF-11-SD-5055		OFF-11-SD-105110		OFF-12-SD-0015		OFF-13-SD-0015		OFF-14-SD-0015		OFF-15-SD-0015		OFF-16-SD-0015	
Sample Location		OFF-11		OFF-11		OFF-11		OFF-12		OFF-13		OFF-14		OFF-15		OFF-16	
Date Sampled		4/3/1998		4/7/1998		4/7/1998		4/3/1998		4/3/1998		4/7/1998		4/7/1998		4/3/1998	
Interval		0.0-0.5		1.6-1.8		3.4-3.6		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene	185	17.5	J	3.6	U	3.6	U	117	J	65.6	J	15.5		9.5		23.9	J
Acenaphthylene	697	9		1.1	J	4.6	U	58.3		156	J	25.2		11.9		35.8	J
Benzo(a)anthracene		168		44.7		8	U	1200		1160	J	216		106		195	J
Benzo(a)pyrene		148		37.5		3	U	1420		1150	J	255		103		220	J
Benzo(b)fluoranthene			NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	2434	23.9	J	4.8		0.8	J	280	J	213	J	52.2		44		49.6	J
Indeno(1,2,3-cd)pyrene	5633	86.3		23.1		1.5	J	777		646	J	172		116		156	J
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners		44.2		2.0		0.70		65.1		95.5		24.8		7.3		22.7	
TAL Metal Analysis (MG/KG)																	
Arsenic		2.7	J	5.0	J	4.7	J	5.2	J	6.0	J	8.5	J	3.7	J	5.0	J
Cadmium		0.22		0.27		0.20		0.53		0.80		0.12		0.18		0.36	
Chromium		30.2		32.1		231.7		58.6		73.7		44.9		41.0		48.0	
Mercury		0.125		0.050	U	0.051		0.376		1.355		0.196		0.10		0.208	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-17-SD-0015		OFF-18-SD-0015		OFF-18-SD-5055		OFF-18-SD-105110		OFF-19-SD-0015		OFF-20-SD-0015		OFF-21-SD-0015		OFF-22-SD-0015	
Sample Location		OFF-17		OFF-18		OFF-18		OFF-18		OFF-19		OFF-20		OFF-21		OFF-22	
Date Sampled		4/3/1998		4/3/1998		4/7/1998		4/7/1998		4/7/1998		4/3/1998		4/3/1998		3/27/1998	
Interval		0.0-0.5		0.0-0.5		1.6-1.8		3.4-3.6		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)																	
2-Methylnaphthalene	185	19.7	J	63.8	J	210		91.1		31.5		40.4	J	13.1	J	3.1	J
Acenaphthylene	697	41.1		141		210		80.2		40.6		14.8		18.3		4.4	J
Benzo(a)anthracene		251		730		787		1260		316		320		151		35.6	
Benzo(a)pyrene		333		964		931		1170		322		257		176		38.8	
Benzo(b)fluoranthene			NA		NA		NA		NA		NA		NA		NA		NA
Dibenzo(a,h)anthracene	2434	76.1	J	273	J	248		204		57.4		50.3	J	40.4	J	12.2	J
Indeno(1,2,3-cd)pyrene	5633	237		785		821		619		195		150		126		33.9	
Pesticide/PCB Analysis (UG/KG)																	
Sum of PCB Congeners		16.6		62.9		46.8		12		28.4		18.9		15.6		2.8	
TAL Metal Analysis (MG/KG)																	
Arsenic		4.7	J	6.3	J	5.6	J	6.4	J	5.8	J	4.2	J	4.9	J	3.8	J
Cadmium		0.38		0.69		1.12		0.50		0.21		0.25		0.39		0.19	
Chromium		44.1		73.6		79.7		76.4		55.6		52.5		52.9		47.8	
Mercury		0.225		0.562		0.97		1.901		0.299		0.171		0.112		0.111	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-23-SD-0015		OFF-SD-406-0006		OFF-SD-407-0006		OFF-SD-408-0006		OFF-SD-408-0006-D		OFF-SD-409-0006		OFF-SD-409-0006-D	
Sample Location		OFF-23		SD-406		SD-407		SD-408		SD-408		SD-409		SD-409	
Date Sampled		4/3/1998		11/12/2001		11/12/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		Field Dup. OFF-SD-408-0006		Field Dup. OFF-SD-408-0006		Field Dup. OFF-SD-409-0006		Field Dup. OFF-SD-409-0006	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	43.4		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Acenaphthylene	697	77.5		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Benzo(a)anthracene		616		64	U	66	U	85		110	J	58	J	110	J
Benzo(a)pyrene		758		64	U	66	U	90		130	J	69		120	J
Benzo(b)fluoranthene			NA	64	U	66	U	120		170	J	78		160	J
Dibenzo(a,h)anthracene	2434	179		64	U	66	U	60	U	64	UJ	61	U	77	UJ
Indeno(1,2,3-cd)pyrene	5633	511		64	U	66	U	74		100	J	61	U	77	UJ
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners		44.6			NA		NA		NA		NA	NA			NA
TAL Metal Analysis (MG/KG)															
Arsenic		4.8	J	2.4		2.1		3.1	J	3.0	J	6.4	J	4.9	J
Cadmium		0.43		0.025	U	0.022	U	0.021	U	0.025	U	0.022	U	0.031	U
Chromium		53.2		10.8		11.4		11.3		13.6		11.2		15.4	
Mercury		0.387		0.032	J	0.038	J	0.029	J	0.035	J	0.030	J	0.073	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-410-0006		OFF-SD-415-0006		OFF-SD-416-0006		OFF-SD-418-0006		OFF-SD-419-0006		OFF-SD-419-0006-D		OFF-SD-420-0006	
Sample Location		SD-410		SD-415		SD-416		SD-418		SD-419		SD-419		SD-420	
Date Sampled		11/14/2001		11/12/2001		11/14/2001		11/8/2001		11/8/2001		11/8/2001		11/8/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		Field Dup. OFF-SD-419-0006		Field Dup. OFF-SD-419-0006		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	470		62	U	61	U	120	U	130	U	140	U	280	U
Acenaphthylene	697	400		24	J	280		120	U	91	J	130	J	120	J
Benzo(a)anthracene		9200		120	J	1200		180		580		530		860	
Benzo(a)pyrene		9500		140	J	1400		160		470		540		850	
Benzo(b)fluoranthene		12000		160		1600		180		600		700		1000	
Dibenzo(a,h)anthracene	2434	1500		62	U	220		120	U	130	U	140	U	280	U
Indeno(1,2,3-cd)pyrene	5633	5200		91		860		80	J	200		200	J	310	J
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA	NA			NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		4.4	J	2.2		3.3	J	3.2	J	2.7	J	2.9	J	3.4	J
Cadmium		0.025	U	0.023	U	0.021	U	0.47	J	0.44	J	0.45	J	0.52	J
Chromium		17.5		10.6		10.8		11.3		11.8		12.4		14.6	
Mercury		0.060		0.049		0.037	J	0.053		0.057		0.061		0.085	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-421-0006		OFF-SD-422-0006		OFF-SD-423-0006		OFF-SD-426-0006		OFF-SD-427-1824		OFF-SD-427-1824-D		OFF-SD-427-0006	
Sample Location		SD-421		SD-422		SD-423		SD-426		SD-427		SD-427		SD-427	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/14/2001		11/12/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		0.0-0.5		0.0-0.5		0.0-0.5		1.5-2.0		1.5-2.0		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		Field Dup. OFF-SD-427-1824		Field Dup. OFF-SD-427-1824		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	260	U	290	U	380	U	63	U	60	U	58	U	82	U
Acenaphthylene	697	260	U	210	J	380	U	63	U	60	U	58	U	82	U
Benzo(a)anthracene		320		1300		1600		63	U	60	U	58	U	82	U
Benzo(a)pyrene		340		1000		1600		63	U	60	U	58	U	82	U
Benzo(b)fluoranthene		420		1200		2100		63	U	60	U	58	U	82	U
Dibenzo(a,h)anthracene	2434	260	U	290	U	380	U	63	U	60	U	58	U	82	U
Indeno(1,2,3-cd)pyrene	5633	150	J	500		560	J	63	U	60	U	58	U	82	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		2.6	J	3.5	J	6.9	J	2.8	J	2.4	J	2.0		2.6	
Cadmium		0.42	J	0.57	J	1.1	J	0.024	UJ	0.022	U	0.021	U	0.029	U
Chromium		12.7		15.9		27.5		10.2		13.5		13.7		14.0	
Mercury		0.078		0.096		0.23		0.025	J	0.026	J	0.027		0.041	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
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TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-428-0006		OFF-SD-428-1824		OFF-SD-429-0006		OFF-SD-430-0006		OFF-SD-430-1824		OFF-SD-431-0006		OFF-SD-431-1824	
Sample Location		SD-428		SD-428		SD-429		SD-430		SD-430		SD-431		SD-431	
Date Sampled		11/14/2001		11/14/2001		11/12/2001		11/12/2001		11/12/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	73	U	60	U	65	U	63	U	61	U	62	U	58	U
Acenaphthylene	697	64	J	47	J	65	U	63	U	61	U	62	U	58	U
Benzo(a)anthracene		580		370		65	U	63	U	61	U	62	U	58	U
Benzo(a)pyrene		530	J	320	J	65	U	63	U	61	U	62	U	58	U
Benzo(b)fluoranthene		740	J	420	J	65	U	63	U	61	U	62	U	58	U
Dibenzo(a,h)anthracene	2434	73	UJ	60	UJ	65	U	63	U	61	U	62	U	58	U
Indeno(1,2,3-cd)pyrene	5633	200	J	120	J	65	U	63	U	61	U	62	U	58	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		4.5	J	3.1	J	4.7	J	2.6	J	4.5	J	1.4	J	3.2	J
Cadmium		0.030	UJ	0.023	UJ	0.024	U	0.026	U	0.022	U	0.024	U	0.023	U
Chromium		15.6		11.8		17.6		11.6		14.8		12.3		14.8	
Mercury		0.059		0.096		0.070		0.061		0.032	J	0.040	J	0.033	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-433-0006		OFF-SD-433-1824		OFF-SD-434-0006		OFF-SD-434-0006-D		OFF-SD-434-1824		OFF-SD-435-0006		OFF-SD-435-1824	
Sample Location		SD-433		SD-433		SD-434		SD-434		SD-434		SD-435		SD-435	
Date Sampled		11/12/2001		11/12/2001		11/14/2001		11/14/2001		11/14/2001		11/12/2001		11/12/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	None		None		Field Dup. OFF-SD-434-0006		Field Dup. OFF-SD-434-0006		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	68	U	61	U	65	U	67	U	62	U	72	U	60	U
Acenaphthylene	697	68	U	61	U	93		51	J	94		72	U	60	U
Benzo(a)anthracene		68	U	61	U	400		330		540		72	U	60	U
Benzo(a)pyrene		68	U	61	U	340	J	280	J	460		32	J	60	U
Benzo(b)fluoranthene		37	J	61	U	440	J	360	J	570		48	J	60	U
Dibenzo(a,h)anthracene	2434	68	U	61	U	65	UJ	67	UJ	60	J	72	U	60	U
Indeno(1,2,3-cd)pyrene	5633	68	U	61	U	120	J	94	J	190		27	J	60	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		2.2	J	5.4	J	3.6	J	3.4	J	3.3	J	2.5	J	2.3	J
Cadmium		0.025	U	0.022	U	0.026	UJ	0.026	UJ	0.023	UJ	0.027	U	0.020	U
Chromium		11.9		12.2		11.8		12.1		11.1		14.1		11.1	
Mercury		0.053		0.019	U	0.030	J	0.036	J	0.033	J	0.050		0.018	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
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TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-436-0006		OFF-SD-436-0006-D		OFF-SD-436-1824		OFF-SD-437-0006		OFF-SD-437-1824		OFF-SD-438-0006		OFF-SD-438-1824	
Sample Location		SD-436		SD-436		SD-436		SD-437		SD-437		SD-438		SD-438	
Date Sampled		11/12/2001		11/12/2001		11/12/2001		11/8/2001		11/8/2001		11/8/2001		11/8/2001	
Interval		0.0-0.5		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	Field Dup. OFF-SD-436-0006		Field Dup. OFF-SD-436-0006		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	64	U	65	U	26	J	140	U	120	U	130	U	120	U
Acenaphthylene	697	210		210		280		140	U	120	U	150		120	U
Benzo(a)anthracene		980		1200		1200		140		120	U	770		120	U
Benzo(a)pyrene		850		1000		1100		130	J	120	U	740		120	U
Benzo(b)fluoranthene		1000		1300		1300		160		120	U	880		120	U
Dibenzo(a,h)anthracene	2434	140		170		160		140	U	120	U	130	U	120	U
Indeno(1,2,3-cd)pyrene	5633	540		610		680		62	J	120	U	280	J	120	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		6.0	J	3.9		5.5	J	3.4	J	2.3	J	4.1	J	1.9	J
Cadmium		0.022	U	0.025	U	0.024	U	0.40	J	0.34	J	0.43	J	0.27	J
Chromium		11.8		10.8		14.9		11.6		9.4		11.7		11.4	
Mercury		0.023	J	0.027		0.047		0.057		0.019	U	0.045		0.019	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
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TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-440-0006		OFF-SD-440-1824		OFF-SD-441-0006		OFF-SD-441-1824		OFF-SD-443-0006		OFF-SD-443-1824		OFF-SD-444-0006	
Sample Location		SD-440		SD-440		SD-441		SD-441		SD-443		SD-443		SD-444	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/8/2001		11/13/2001		11/13/2001		11/8/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	120	U	120	U	630	U	160	U	67	U	67	U	130	U
Acenaphthylene	697	140		120	U	630	U	160	U	110		67	U	100	J
Benzo(a)anthracene		580		120	U	600	J	180		670		58	J	530	
Benzo(a)pyrene		580		120	U	570	J	170		550		43	J	540	
Benzo(b)fluoranthene		660		120	U	670		180		690		53	J	680	
Dibenzo(a,h)anthracene	2434	120	U	120	U	630	U	160	U	67	U	67	U	130	U
Indeno(1,2,3-cd)pyrene	5633	270		120	U	310	J	85	J	180		67	U	220	J
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners		NA			NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		2.6	J	1.8	J	1.7	J	4.5	J	3.1	J	3.4	J	2.1	J
Cadmium		0.41	J	0.25	J	0.37	J	0.73	J	1.1	J	0.79	J	0.41	J
Chromium		11.2		8.2		10.3		18.2		9.0	J	9.0		12.0	
Mercury		0.066		0.018	U	0.060		0.41		0.091		0.022	U	0.065	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
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TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-444-1824		OFF-SD-446-0006		OFF-SD-446-1824		OFF-SD-460-0006		OFF-SD-460-1824		OFF-SD-461-0006		OFF-SD-461-1824	
Sample Location		SD-444		SD-446		SD-446		SD-460		SD-460		SD-461		SD-461	
Date Sampled		11/8/2001		11/8/2001		11/8/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	77	J	300	U	53	J	65	U	62	U	67	U	55	U
Acenaphthylene	697	140	U	330		58	J	65	U	62	U	67	U	55	U
Benzo(a)anthracene		960		2300		590		120		29	J	67	U	55	U
Benzo(a)pyrene		860		2500		700	J	140		40	J	46	J	55	U
Benzo(b)fluoranthene		950		3100		920	J	200		42	J	56	J	55	U
Dibenzo(a,h)anthracene	2434	140	U	270	J	150	UJ	65	U	62	U	67	U	55	U
Indeno(1,2,3-cd)pyrene	5633	290	J	1000	J	290	J	110		62	U	67	U	55	U
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		3.7	J	4.2	J	7.9	J	3.9	J	3.6	J	3.0	J	5.4	J
Cadmium		0.55	J	0.59	J	1.2	J	0.024	U	0.023	U	0.026	U	0.021	U
Chromium		14.6		17.2		25.6		14.0		14.7		15.2		11.9	
Mercury		0.20		0.11		0.33		0.047	J	0.032	J	0.047	J	0.015	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-462-0006		OFF-SD-462-1824		OFF-SD-463-0006		OFF-SD-463-1824		OFF-SD-464-0006		OFF-SD-464-1824		OFF-SD-465-0006	
Sample Location		SD-462		SD-462		SD-463		SD-463		SD-464		SD-464		SD-465	
Date Sampled		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001	
Interval		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	68	U	60	U	61	U	59	U	70	U	56	U	63	U
Acenaphthylene	697	68	U	60	U	61	U	59	U	70	U	56	U	63	U
Benzo(a)anthracene		110		60	U	61	U	59	U	34	J	56	U	32	J
Benzo(a)pyrene		130		60	U	61	U	59	U	70	U	56	U	63	UJ
Benzo(b)fluoranthene		160		60	U	61	U	59	U	70	U	56	U	63	UJ
Dibenzo(a,h)anthracene	2434	68	U	60	U	61	U	59	U	70	U	56	U	63	UJ
Indeno(1,2,3-cd)pyrene	5633	98		60	U	61	U	59	U	70	U	56	U	63	UJ
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		3.4	J	4.8	J		NA	2.3	J	3.8	J	4.6	J	2.2	J
Cadmium		0.026	U	0.023	U		NA	0.024	UJ	0.028	U	0.021	U	0.024	UJ
Chromium		14.0		13.2			NA	10.6		14.5		14.5		9.9	
Mercury		0.028	J	0.019	U		NA	0.016	U	0.069		0.017	U	0.050	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-465-1824		OFF-SD-466-0006		OFF-SD-466-1824		OFF-SD-467-0006		OFF-SD-467-1824		OFF-SD-468-0006		OFF-SD-468-1824	
Sample Location		SD-465		SD-466		SD-466		SD-467		SD-467		SD-468		SD-468	
Date Sampled		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/14/2001		11/12/2001		11/12/2001	
Interval		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	None		None		None		None		None		None		None	
Semivolatile Organic Analysis (UG/KG)															
2-Methylnaphthalene	185	58	U	62	U	63	U	69	U	61	U	1600	U	100	U
Acenaphthylene	697	58	U	74	J	63	U	69	U	61	U	1600	U	100	U
Benzo(a)anthracene		26	J	420	J	280		63	J	61	U	660	J	180	
Benzo(a)pyrene		58	U	370		420		53	J	61	U	710	J	200	
Benzo(b)fluoranthene		24	J	450		450		74		61	U	1200	J	280	
Dibenzo(a,h)anthracene	2434	58	U	62	U	62	J	69	U	61	U	1600	U	100	U
Indeno(1,2,3-cd)pyrene	5633	58	U	150	J	210		69	U	61	U	1600	U	160	
Pesticide/PCB Analysis (UG/KG)															
Sum of PCB Congeners			NA		NA		NA		NA		NA		NA		NA
TAL Metal Analysis (MG/KG)															
Arsenic		4.4	J	2.2	J	3.0	J	2.2	J	6.3	J	9.9	J	10.0	J
Cadmium		0.021	UJ	0.025	UJ	0.025	UJ	0.024	UJ	0.022	UJ	0.058	U	0.89	
Chromium		9.7		7.0		12.8		11.2		13.1		46.9		49.1	
Mercury		0.020	U	0.023	J	0.093		0.032	J	0.043		0.50		0.89	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.1C
CONTAMINANTS IN EXCEEDANCE OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
ECOLOGICAL EXPOSURES
OLD FIREFIGHTING TRAINING AREA
NAVAL STATION NEWPORT, NEWPORT, RHODE ISLAND

Sample Number		OFF-SD-469-0006		OFF-SD-469-1824	
Sample Location		SD-469		SD-469	
Date Sampled		11/12/2001		11/12/2001	
Interval		0.0-0.5		1.5-2.0	
QC Identifier	Ecological PRG	None		None	
Semivolatile Organic Analysis (UG/KG)					
2-Methylnaphthalene	185	150	U	100	UJ
Acenaphthylene	697	70	J	47	J
Benzo(a)anthracene		460		160	J
Benzo(a)pyrene		500		240	J
Benzo(b)fluoranthene		690		350	J
Dibenzo(a,h)anthracene	2434	98	J	100	UJ
Indeno(1,2,3-cd)pyrene	5633	350		170	J
Pesticide/PCB Analysis (UG/KG)					
Sum of PCB Congeners			NA		NA
TAL Metal Analysis (MG/KG)					
Arsenic		11.1	J	14.7	J
Cadmium		0.051	U	0.037	U
Chromium		50.6		55.8	
Mercury		0.41		0.64	

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; NA - Not Analyzed

TABLE 4.2
SUMMARY OF PRELIMINARY REMEDIATION GOALS (PRGs) FOR MARINE SEDIMENT
OLD FIREFIGHTING TRAINING AREA, NSN NEWPORT, RHODE ISLAND

Contaminant	Ecological PRGs (2)	Human Health Lifetime Recreational Exposure PRGs	Lifetime Recreational Lobster Ingestion PRGs (1)
Polyaromatic Hydrocarbons (ug/kg)			
2-Methylnaphthalene	185		
Acenaphthylene	697		
Benz(a)anthracene		1338	34270
Benzo(a)pyrene		134	9360
Benzo(b)fluoranthene		1338	51296
Dibenz(a,h)anthracene	2434	134	6742
Indeno(1,2,3-cd)pyrene	5633		72519
PCB/Pesticides			
Total PCB Congeners			175
Metals (mg/kg)			
Arsenic**		6.2**	5.48
Cadmium			10
Chromium			3708
Mercury			2.3

Note: All Human health PRGs are based on an exposure specific risk of 1E-6.

Lifetime Recreational exposure to sediment compared to stations above low tide line
Lobster Ingestion PRGs only compared to stations at and below low tide line
Ecological PRGs only compared to stations at and below low tide line
** arsenic PRG for human health is based on HHRA and background assessment
(1) - Lifetime recreational ingestion of lobster scenario.
(2) - Ecological PRGs for metals are eliminated based on low AVS-SEM values indicating no toxicity from metals - see text

APPENDIX E

AREA AND VOLUME ESTIMATES

APPENDIX E
AREA AND VOLUME ESTIMATES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

This appendix provides the supporting documentation for the estimation of areas and volumes of soil and sediment to be addressed at the OFFTA site.

E.1 SOIL AND DEBRIS AREAS/VOLUMES

The estimation of volume for the soil alternatives was accomplished in two parts: the mounds at the site and the remaining soil below grade. To estimate the volume of the mounds, a contour map was used, and the area between each successive concentric contour line was measured. A base elevation for the surrounding terrain was chosen for each mound, and the volume within each contour was calculated based on its height above the base elevation. A spreadsheet showing the measurements and calculations is provided in Table E-1.

The second volume estimate was performed for the remaining soil below grade, assuming that the mounds were removed to the elevation of the surrounding terrain. The depths of contamination were estimated for different blocks of the site as shown on Figure 2-3. For example, the depth of contamination for a large portion of the western end of the site is estimated at 2 feet, indicated by blue on Figure 2-3. The assigned depth of each block was then multiplied by its area to estimate the volume of each block. The volumes of all blocks were then summed, as shown in Table E-2. The areas are presented on the color-coded map in Figure 2-3.

An estimate was made of the percentage of the volume that is debris. The estimate for the mound was 50% debris, and the estimate for the remaining volume was 20% debris. Estimated debris and soil volumes are provided in Table E-3. Resulting debris and soil volumes are as follows:

Media	Mounds (cy)	Soil (cy)	TOTAL (cy)
Debris	5,450	7,520	12,970
Soil	5,450	30,080	35,530
TOTAL	10,900	37,600	48,500

E.2 SEDIMENT ACTION AREAS/VOLUMES AND EELGRASS AREAS

The sediment where COCs exceed selected PRGs are considered actionable sediments. The actionable sediment area was estimated using Figure 2-4, which shows the action areas delineated. Areas (in square feet (sf)) associated with the beach (intertidal) area and nearshore (subtidal) areas at sampling stations SD-410, OFF-3, OFF-5, and OFF-6 are shown in the table below.

The depth of the actionable sediment at the beach (intertidal) area (shown in orange on Figure 2-4) is assumed to be 2 feet and is based on the maximum depth of observed contamination in the beach samples. The depth of the actionable sediment of the nearshore (subtidal) areas (shown in blue on Figure 2-4) is assumed to be 1 foot and was chosen based on the majority of samples collected in the nearshore. Table 2-16 lists all the PRG exceedances for both the beach and nearshore areas.

It should be noted that some beach sediments exceed the ecological PRGs and are a subset of those sediments that exceed the human health based PRGs, and as such, they are included in the beach sediment removal areas. These areas are shown on Figure 2-4 as blue-orange hatch.

The total volume of sediment is calculated by multiplying the estimated areas by the appropriate depth (2 feet for the beach, 1 foot for the nearshore).

A separate estimate was made for eelgrass bed areas. Figure 2-4 shows the area of the eelgrass beds that overlap with the area of contaminated sediment. The associated depth of contaminated sediment in the eelgrass beds is 1 foot, in keeping with the assumption made for the nearshore sediment.

In summary, the areas and volumes of the sediment and eelgrass are as follows. Supporting information is provided in Table E-4.

Medium	Area (sq ft)	Volume (cu yd)
Actionable Beach (Intertidal) Sediment (2 foot depth)	77,171	5,716
Actionable Nearshore (Subtidal) Sediment, Including Eelgrass Area* (1 foot depth)	7,842*	290*
Actionable Sediment Within Eelgrass Area* (1 foot depth)	2,039*	76*

* Area of actionable sediment within eelgrass beds is subject to change based on results of the Phase 2 predesign investigation

TABLE E-1
MOUND VOLUME ESTIMATES
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

	Contour Interval (ft)	Height above 11 ft	Map Area* (sq in)	Area (sf)	Volume (cf)	Volume (cy)
Central Mound	>30	19	0.33	528	10032	371.6
	29-30	18.5	0.35	560	10360	383.7
	28-29	17.5	0.36	576	10080	373.3
	27-28	16.5	0.37	592	9768	361.8
	26-27	15.5	0.45	720	11160	413.3
	25-26	14.5	0.49	784	11368	421.0
	24-25	13.5	0.58	928	12528	464.0
	23-24	12.5	0.59	944	11800	437.0
	22-23	11.5	0.67	1072	12328	456.6
	21-22	10.5	0.69	1104	11592	429.3
	20-21	9.5	0.72	1152	10944	405.3
	19-20	8.5	0.8	1280	10880	403.0
	18-19	7.5	0.88	1408	10560	391.1
	17-18	6.5	0.97	1552	10088	373.6
	16-17	5.5	1.04	1664	9152	339.0
	15-16	4.5	1.11	1776	7992	296.0
	14-15	3.5	1.27	2032	7112	263.4
	13-14	2.5	1.3	2080	5200	192.6
	12-13	1.5	1.48	2368	3552	131.6
						6907.3

	Contour Interval (ft)	Height above 8 ft	Map Area* (sq in)	Area (sf)	Volume (cf)	Volume (cy)
West Mound	>17	9	0.67	1072	9648	357.3
	16-17	8.5	0.95	1520	12920	478.5
	15-16	7.5	1.04	1664	12480	462.2
	14-15	6.5	1.21	1936	12584	466.1
	13-14	5.5	1.3	2080	11440	423.7
	12-13	4.5	1.54	2464	11088	410.7
	11-12	3.5	1.96	3136	10976	406.5
	10-11	2.5	1.69	2704	6760	250.4
	9-10	1.5	1.65	2640	3960	146.7
						3402.1

	Contour Interval (ft)	Height above 9 ft	Map Area* (sq in)	Area (sf)	Volume (cf)	Volume (cy)
Far West Mound	>13	4	0.81	1296	5184	192.0
	12-13	3.5	0.74	1184	4144	153.5
	11-12	2.5	0.95	1520	3800	140.7
	10-11	1.5	0.97	1552	2328	86.2
						572.4

GRAND TOTAL 10881.8 cy

* Plan scale: 1" = 40'

TABLE E-2
CONTAMINATED SOIL VOLUME ESTIMATE
EXCLUDING THE MOUNDS
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

Depth of Excav. (ft)	Area* (sq in)	Area (sf)	Volume (cf)	Volume (cy)
2	4.85	7760	15520	574.8
8	16.24	25984	207872	7699.0
4	35.91	57456	229824	8512.0
8	0.29	464	3712	137.5
8	14.75	23600	188800	6992.6
6	5.34	8544	51264	1898.7
9	3.58	5728	51552	1909.3
2	56.19	89904	179808	6659.6
10	4.47	7152	71520	2648.9
6	1.59	2544	15264	565.3
		229136		37597.6

* Areas in square inches were measured on map with a scale of 1"=40'

TABLE E-3
DEBRIS AND SOIL PERCENTAGE
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

MOUNDS

Total Volume	10,900	cubic yards

Classification	Percent by Vol.	Associated Volume
Debris	50%	5,450
Soil	50%	5,450
TOTALS	**100%**	**10,900**

REMAINING AREA EXCLUDING MOUNDS

Total Volume	37,600	cubic yards

Classification	Percent by Vol.	Associated Volume
Debris	20%	7,520
Soil	80%	30,080
TOTALS	**100%**	**37,600**

TABLE E-4
CONTAMINATED SEDIMENT VOLUME ESTIMATE
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

AREA AND VOLUME OF SEDIMENT:

Area or Sampling Station		Area (sf)	Depth (ft)	Volume (cf)	Volume (cy)
Intertidal	Beach	77,171	2	154,342	5,716
Subtidal	SD-410*	1,824	1	1,824	68
	OFF-3	480	1	480	18
	OFF-5	1,788	1	1,788	66
	OFF-6	1,711	1	1,711	63
	TOTALS	**82,974**	**--**	**160,145**	**5,931**

* includes only the area outside the eelgrass beds

AREA OF EELGRASS:

Sampling Station Area		Area (sf)	Depth (ft)	Associated Volume (cf)	Associated Volume (cy)
Subtidal	SD-410**	2,039	1	2,039	76
	TOTALS	**2,039**	**1**	**2,039**	**76**

** includes only the area inside the eelgrass beds
Area is subject to change based on Phase 2 PDI data.

APPENDIX F

COST ESTIMATES

Tetra Tech NUS			*Calculation Sheet*
Client: Navy CLEAN	File No.	**By:** RD, PJ	**Page** 1 of 1
Subject: Assumptions and Cost Basis, Soil Alternative 1, OFFTA FS		**Checked by:** JD	**Date:** July 10, 2002

Soil Alternative 1: No Action

CAPITAL COST ASSUMPTIONS: N/A

O&M COST ASSUMPTIONS: N/A

5-YEAR COST ASSUMPTIONS:

1. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

Soil Alternative 2: Removal, Treatment using LTTS and Soil Washing, and Backfill

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consisting of soil borings/cores to further delineate the site and to delineate lateral extent of contaminants exceeding the PRGs. Assume 20 soil borings at an average 15-foot depth with associate analytical costs for PAHs, and metals.

   - Mobilization/demobilization @ $13,500
   - Sample collection @ $600 each or $12,000
   - Analytical @ $350/sample for 25 samples including QA/QC samples or $8750
   - Data validation $3,200
   - Reporting @ $3,500
   - Oversight and management @ $4,500

   LTTS and Soil Wash Pilot test – No charge, included in subcontract proposal effort.

   Total costs approx. = $45,450.

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. Metal debris and concrete debris will be removed from the site and the shoreline before excavating.

4. Soil and debris will be piled up separately. Any visual contamination on the debris will be washed of before sending to storage pile. Wash water will be collected in 55-gallon drums and disposed of accordingly.

5. Excavation, Backfill, and Disposal Work

   - Approximately 48,500 cy (In place volume) will be excavated as shown in the areal contamination map. Depth of excavation will be up to the water table or bottom of contaminated depth interval, whichever reached first

   - It is assumed that staging areas are available at no cost in the vicinity of OFFTA.

   - Excavated soil and debris will be staged separately. Debris will be sent to RCRA Landfill (D) for proper disposal. Because of uncertainty of extent of subsurface contamination, and most of the treated soil will be used as backfill, it is conservatively assumed that all excavated soil will be processed through the treatment train. Site will be backfilled with treated soil supplemented by new fill material.

   - Treatment train consists of LTTS and soil washing operations. It is assumed that soil marked for treatment will be free of large debris and aggregates. Excavated volumes (not including bulking factor) are assumed to be as shown in Table 1. Attachment 1 presents the amount of soil assumed to be excavated, reused, and disposed assuming 20% bulking factor. Total debris for Landfill (RCRA-D) disposal assuming 20% bulking factor is estimated as 15,560 cy. The remaining 42,640 cy (which includes 20% bulking factor) will be treated and used as backfill.

- To ensure that there is enough space for the staging of the excavated soil, it is assumed that the excavation and treatment will be done in 2 phases.. The first phase will consists of excavation and treatment on the east of OFFTA site and the second phase will consist of excavation and treatment on the west of OFFTA site.

- Preparation, maintenance, and removal of the staging area was estimated at a lump sum of $11,000, which includes 2 laborers and a backhoe for 10 days and misc. materials.

- A rip-rap revetment system will be installed along the shoreline to control wave erosion. It is assumed that engineered erosion control and wave break structure will be placed along the 1,360-foot length of the action area using land-based equipment.

- The costs for disposal are as per recent project (Melville Landfill). TSDF disposal (to Model City, NY) is $120 per ton and RCRA-D disposal for debris is $70 per ton and soil that can be used as cover is $25/ton (Fall River Landfill). Imported fill is $7 per ton.

- Soil wash liquid disposal: POTW disposal is $1.54 /1000 gal (E-2000-33-19-7102). Transport for 5,000-gal tank for 20 miles - $1.65 /mile (E-2000-33-19-0207)

Table 1

Mounds

Total Volume	10,900	cy

Classification	Percent by Vol.	Associated Volume
Debris	50%	5,450
Soil	50%	5,450
Totals	100%	10,900

Remaining Area Excluding Mounds

Total Volume	37,600	cy

Classification	Percent by Vol.	Associated Volume
Debris	20%	7,520
Soil	80%	30,080
Totals	100%	37,600

Note: The volumes do not include bulking factor.

O&M COST ASSUMPTIONS:

1. Post-Remediation sampling will be conducted as a part of groundwater alternatives.

5-YEAR COST ASSUMPTIONS:

5-year review at 200 LOE @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Only one review to occur in year 5.

COST SENSITIVITY:

Cost sensitivity for this alternative was evaluated using the volume of soils to be excavated, treated, and returned to the excavation. Associated costs with labor, equipment rental, and duration on site were adjusted accordingly. Remaining costs associated with mobilization, demobilization, set up of work areas, new storm drains, shoreline protection and predesign costs were presumed to be fixed. Most of these fixed costs are associated with mobilization and setup of the treatment system at the site. Cost analysis for changes based on soil volumes with an increase up to 30% and decrease of to 30% were calculated and are presented below.

Change in Soil Volume	Total Capital Costs	Change in Costs
30% increase	$17,765,000	25% increase
25% increase	$17,166,000	21% increase
20% increase	$16,568,000	17% increase
15% increase	$15,969,000	13% increase
10% increase	$15,371,000	8% increase
5% increase	$14,772,000	4% increase
Cost as estimated	**$14,174,000**	
5% decrease	$13,575,000	4% decrease
10% decrease	$12,977,000	8% decrease
15% decrease	$12,378,000	13% decrease
20% decrease	$11,780,000	17% decrease
25% decrease	$11,182,000	21% decrease
30% decrease	$10,583,000	25% decrease

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 2 - REMOVAL, TREATMENT WITH LTTS AND SOIL WASHING AND BACKFILL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
1- PRE-DESIGN INVESTIGATION													
1.1 Soil borings and analyses	1	ls	$45,450.00	$0.00	$0.00	$0.00	$45,450	$0	$0	$0	$45,450	See Assumptions	Historical data
2 - MOBILIZATION/DEMOBILIZATION													
2.1 Mobilize/demobilize equipment	1	ls				$7,500.00	$0	$0	$0	$7,500	$7,500		Historical data
2.2 Office trailer	6	mo				$181.00	$0	$0	$0	$1,086	$1,086	32 x 8	M98-015-904-0300
2.3 Sanitary facilities	6	mo				$120.00	$0	$0	$0	$720	$720		M98-016-420-6410
2.4 Truck scale	6	mo				$2,862.00	$0	$0	$0	$17,172	$17,172		E98-3304-0462
2.5 Site survey/construction layout	5.5	acres		$45.00	$445.00		$0	$248	$2,448	$0	$2,695		M98-013-306-0320
2.6 Electric/phone hookups	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	Utilities nearby	Historical data
2.7 Project closeout report	1	ls			$10,000.00		$0	$0	$10,000	$0	$10,000		Historical data
3 - SITE PREPARATION													
3.1 Clear and grub site - minimal	5.5	acres			$980.00	$2,700.00	$0	$0	$5,390	$14,850	$20,240		M98-021-104-0160
3.2 Install/remove silt fence	3000	lf		$0.45	$0.42		$0	$1,350	$1,260	$0	$2,610	perimeter of exav areas 1 and 2	M98-022-704-1000 - labor twice
3.3 Construct diversion dikes/channels	2000	lf					$0	$0	$0	$0	$0		M98-022-702-0010
3.4 Construct temporary sediment basin/vegetate/backfill	800	cy			$4.85	$5.60	$0	$0	$3,880	$4,480	$8,360		T. Riley
3.5 Truck decon. pad													
a) Concrete pad - 8"	40	cy		$70.00	$125.00	$5.00	$0	$2,800	$5,000	$200	$8,000		Historical data
b) Gravel base - 6"	30	cy		$7.50	$3.33	$8.00	$0	$225	$100	$240	$565		Historical data
c) Curb	120	lf		$3.07	$1.99	$0.05	$0	$368	$239	$6	$613		Historical data
d) Collection sump	1	ls		$1,450.00	$500.00	$220.00	$0	$1,450	$500	$220	$2,170		Historical data
e) Splash guard	780	sf		$1.25	$1.00		$0	$975	$780	$0	$1,755		Historical data
3.6 Construction entrance	1	ls		$620.00	$86.00	$50.00	$0	$620	$86	$50	$756		NovaChemical
3.7 Construct soil staging area	1	ls		$11,000			$0	$11,000	$0	$0	$11,000	30 mil poly sheeting, straw bales	M98-022-706-0100
3.8 Maintain soil staging area	1	ls		$5,500.00	$0.00	$0.00	$0	$5,500	$0	$0	$5,500	50% of const cost - includes 6 mil poly to cover piles daily	Historical data
3.9 Remove decontamination pad	1	ls			$250.00	$500.00	$0	$0	$250	$500	$750		Historical data
3.10 Decontamination pad, silt fence disposal	150	ton	$10.00				$1,500	$0	$0	$0	$1,500	C&D Debris	Historical data
3.1 Personnell and equipment decon. facilities and services													
a) Personnel decon. Trailer	6	mo	$1,500.00	$0.00	$200.00	$0.00	$9,000	$0	$1,200	$0	$10,200		Vendor catalog
b) PPE rolloff cont.	6	mo	$500.00	$0.00	$0.00	$0.00	$3,000	$0	$0	$0	$3,000		Historical data
4 - SITE MANAGEMENT STAFFING													
4.1 Site manager	480	hr	$0.00	$0.00	$36.00	$0.00	$0	$0	$17,280	$0	$17,280		Historical data
4.2 Site engineer	960	hr	$0.00	$0.00	$32.00	$0.00	$0	$0	$30,720	$0	$30,720		Historical data
4.3 Site supervisor/foreman	960	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$28,800	$0	$28,800		Historical data
4.4 Site safety officer	960	hr	$0.00	$0.00	$25.00	$0.00	$0	$0	$24,000	$0	$24,000		Historical data
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT													
5.1 Project manager	96	hr	$0.00	$0.00	$45.00	$0.00	$0	$0	$4,320	$0	$4,320		Historical data
5.2 Project administrator	180	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$5,400	$0	$5,400		Historical data
5.3 Health and safety director	60	hr	$0.00	$0.00	$35.00	$0.00	$0	$0	$2,100	$0	$2,100		Historical data
5.4 Procurement/subcontracting	240	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$7,200	$0	$7,200		Historical data
5.5 Clerical support	240	hr	$0.00	$0.00	$12.50	$0.00	$0	$0	$3,000	$0	$3,000		Historical data

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 2 - REMOVAL, TREATMENT WITH LTTS AND SOIL WASHING AND BACKFILL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
6 - EXCAVATION													
6.1 Excavate/load material (Includes 20 % bulking factor)	58200	cy			$0.48	$1.16	$0	$0	$28,144	$67,767	$95,911	Level C PPE	M98-022-238-1300
6.2 Segregate material with FID	80	day			$100.00	$100.00	$0	$0	$8,000	$8,000	$16,000	Laborer and Equipment	Historical data
6.3 Haul material to for stockpiling	58200	cy			$0.37	$2.15	$0	$0	$21,534	$125,130	$146,664		M98-022-266-2040
6.4 Dump/stockpile material	58200	cy			$0.44	$1.04	$0	$0	$25,317	$60,383	$85,700		M98-022-266-1600
6.5 Stockpiled material sampling/analysis - 1/150 cy	388	ea	$85.00		$100.00		$32,980	$0	$38,800	$0	$71,780	TPH, Paint Filter Test	BOA; E98-3302-1750
6.6 Stockpiled material sampling/analysis - 1/500 cy	116	ea	$1,050.00		$200.00		$122,220	$0	$23,280	$0	$145,500	TCLP, VOC, SVOC, Pb, pH, reactivity, ignitability	BOA
6.7 Excavation confirmatory sampling/analysis	380	ea	$60.00		$100.00		$22,800	$0	$38,000	$0	$60,800	TPH	BOA
6.8 Excavation confirmatory sampling/analysis	95	ea	$500.00		$100.00		$47,500	$0	$9,500	$0	$57,000	TCLP, SVOCs, Metals	BOA
6.9 Trench Box	6	mo				$1,500.00	$0	$0	$0	$9,000	$9,000	6' x 20'	M98-016-420-7040
6.1 Replace storm drains	550	LF		$10.60	$4.47	$0.88	$0	$5,830	$2,459	$484	$8,773	18 ID RCP Drain	M98-027-150-2230
7 - DEWATER EXCAVATIONS													
7.1 4-inch trash pump	6	mo			$840.00	$840.00	$0	$0	$5,040	$5,040	$10,080		M98-016-420-5600
7.2 20,000 gallon temporary storage tank	6	mo				$1,219.00	$0	$0	$0	$7,314	$7,314		E98-1904-0406
7.3 Pump out tanks with 5,000 gallon tanker truck	6	mo			$1,500.00	$3,000.00	$0	$0	$9,000	$18,000	$27,000		M98-016-420-7625
7.4 Transportation - 5,000 -gal tanker for 10 miles	80	tanks	$16.50				$1,320	$0	$0	$0	$1,320	10 miles for 5000 gal tank - $1.65/mile- one tank/day	E-2000-33-19-0207
7.5 Disposal of excavation water	400	kgal	$1.54				$616	$0	$0	$0	$616	$1.54/kgal	E-2000-33197102
8 - TREATMENT OF CONTAMINATED MATERIAL													
8.1 LTTS equipment mobilization	1	ls	$512,500				$512,500	$0	$0	$0	$512,500	For unit to treat 50,000 tons	E-2000-33140224
8.2 LTTS treatment	63960	ton	$30.75				$1,966,770	$0	$0	$0	$1,966,770		E-2000-33140233
8.3 Carbon unit for offgas	1	ls	$8,429.00				$8,429	$0	$0	$0	$8,429	dual bed	E-2000-33131921
8.4 Soil washing unit	6	mo	$127,305				$763,830	$0	$0	$0	$763,830	100 ton/hr unit	E-2000-33130924
8.5 Operating labor	1200	hr	$664.77				$797,724	$0	$0	$0	$797,724	4-months, 20 day/mo, 10hr/day and 50% more for re-pass.	E-2000-33130929
8.6 Materials	120	day	$904.10				$108,492	$0	$0	$0	$108,492	Acid at 10 units of 750 lbs/day and 50% more for re-pass	E-2000-33330110
8.7 T&D nonhazardous material-debris (RCRA Landfill-D)	23340	ton	$70.00				$1,633,800	$0	$0	$0	$1,633,800	Fall River Landfill	Vendor Quote
8.8 Pump out tanks with 6,000 gallon tanker truck (washwater)	6	mo			$1,500.00	$3,000.00	$0	$0	$9,000	$18,000	$27,000	4-months, 20 day/mo, 10hr/day	E-2000-33130929
8.9 Disposal of washwater	1080	kgal	$1.54				$1,663	$0	$0	$0	$1,663	$1.54/kgal	E-2000-33197102
8.10 Transportation - 5,000 -gal tanker for 10 miles	216	loads	$16.50				$3,564	$0	$0	$0	$3,564	10 miles for 5000 gal tank - $1.65/mile	E-2000-33-19-0207
8.11 Treated soil confirmatory sampling/analysis (1/150 yds)	388	ea	$60.00		$100.00		$23,280	$0	$38,800	$0	$62,080	TPH	BOA
8.12 Treated soil confirmatory sampling/analysis (1/150 yds)	388	ea	$500.00		$100.00		$194,000	$0	$38,800	$0	$232,800	TCLP, SVOCs, Metals	BOA
8.13 Air Pollution Permit	180	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$5,400	$0	$5,400	Historical data	Historical data
8.14 Reactivation of spent carbon	4000	lb	$2.05				$8,200	$0	$0	$0	$8,200	Reactivation of 2000 lb carbon	Historical data
9 - RESTORATION													
9.1 Import clean fill	2480	cy		$10.50			$0	$26,040	$0	$0	$26,040	Regualr fill	Foster Wheeler
9.2 Place/grade fill	45120	cy			$0.30	$0.83	$0	$0	$13,536	$37,450	$50,986	no compaction	Historical data

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 2 - REMOVAL, TREATMENT WITH LTTS AND SOIL WASHING AND BACKFILL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
9.3 Import/place/grade topsoil	3900	cy		$14.00	$0.23	$0.69	$0	$54,600	$897	$2,691	$58,188	6 inches	M98-022-216-7020
9.4 Revegetation	230	msf		$28.00	$7.00	$7.35	$0	$6,440	$1,610	$1,691	$9,741	utility mix, 7#/msf, hydroseed w/ mulch	M98-029-308-5400
9.5 Shoreline riprap placement	1512	SY	$65.00	$0.00	$0.00	$0.00	$98,280	$0	$0	$0	$98,280		Historical data
10 - NEW MONITORING WELLS (4)													
10.1 Hollow-stem auger	100	ft			$24.87		$0	$0	$2,487	$0	$2,487	Four wells each at 25' depth	Echos2000-33 23 1101
10.2 2-inch PVC well casing	100	ft		$10.08			$0	$1,008	$0	$0	$1,008		NPTC Master Agreement, Cherry Point
10.3 Construction (2-man crew)	1	day	$456.80				$457	$0	$0	$0	$457		ECHOS2000-hlabk-1 OPERATOR, 1 SEMISKILLED LABOR
10.4 2-inch PVC well Screen	60	ft		$14.02			$0	$841	$0	$0	$841		ECHOS 2000-33 23 0201
Subtotal							$6,409,375	$119,295	$473,556	$407,972	$7,410,198		
Overhead on Labor Cost @ 30%									$142,067		$142,067		
G & A on Labor Cost @ 10%									$47,356		$47,356		
G & A on Material Cost @ 10%								$11,930			$11,930		
G & A on Subcontract Cost @ 10%							$640,938				$640,938		
Total Direct Cost							$7,050,313	$131,225	$662,978	$407,972	$8,252,487		
Indirects on Total Direct Labor Cost @ 75%									$497,234		$497,234		
Profit on Total Direct Cost @ 10%											$825,249		
Subtotal											$9,574,970		
Health & Safety Monitoring @ 6%											$574,498		
Cost adjustment for location @ 7%											$670,248		
Total Field Cost											$10,819,716		
Contingency on Total Field Cost @ 25%											$2,704,929		
Engineering on Total Field Cost @ 6%											$649,183		
TOTAL COST											$14,173,828		
											$14,174,000		

Notes
G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:

1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.

Present Worth Analysis
Soil Alternative 2 - Removal, Treatment with LTTS and Soil Washing, and Backfill
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/10/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$14,174,000			$14,174,000
1	0.962		$0		$0
2	0.926		$0		$0
3	0.892		$0		$0
4	0.858		$0		$0
5	0.826		$0	$21,500	$17,757
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$0	$0	$0
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$0	$0	$0
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$0	$0	$0
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$0	$0	$0
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$0	$0	$0
		TOTAL PRESENT WORTH =			$14,191,757
					$14,192,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Soil Alternative 3: Removal and Disposal at TSDF

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consisting of soil borings/cores advanced to further delineate the site and to delineate lateral extent of contaminants exceeding the PRGs. Assume 20 soil borings at an average 15-foot depth with associate analytical costs for PAHs, and metals.

   - Mobilization/demobilization @ $13,500
   - Sample collection @ $600 each or $12,000
   - Analytical @ $350/sample for 25 samples including QA/QC samples or $8750
   - Data validation $3,200
   - Reporting @ $3,500
   - Oversight and management @ $4,500

   Total costs approx. = $45,450

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. Metal debris and concrete debris will be removed from the site and the shoreline before excavating.

4. Soil and debris will be piled up separately. Any visual contamination on the debris will be washed of before sending to storage pile. Wash water will be collected in 55-gallon drums and disposed of accordingly.

5. Excavation, Backfill and Disposal Work

   - Approximately 48,500 cy (In place volume) will be excavated as shown in the areal contamination map. Depth of excavation will be up to the water table or bottom of contaminated depth interval, whichever reached first.

   - It is assumed that staging areas are available at no cost in the vicinity of OFFTA.

   - Excavated soil and debris will be staged separately. It is assumed that 90% of the excavated soil can be disposed of at solid waste landfill (RCRA – D) and can be used as landfill cover material. Soil requiring treatment (10%) at TSDF will be staged separately. Debris will also be disposed of at solid waste landfill (RCRA – D). Because of uncertainty of the extent of subsurface contamination, and to eliminate any potential contamination, excavated areas will be backfilled with new fill material. Material for landfill disposal will be as follows: Soil for landfill cover-48,000 tons, Soil for TSDF – 5,300 tons, Debris for RCRA-D landfill – 19,450 tons.

   - Excavated volumes (not including bulking factor) are assumed to be as shown in Table 1. Attachment 1 presents the amount of soil assumed to be excavated and disposed assuming 20% bulking factor. Total debris for Landfill (RCRA-D) disposal assuming 20% bulking factor is estimated as 15,560 cy. Out of 42,640 cy of soil (which includes 20% bulking factor), 38,400 cy will be disposed at solid waste landfill (RCRA –D) and the remaining (4,240 cy) will be sent to TSDF for treatment and disposal.

- A rip-rap revetment system will be installed along the shoreline to control wave erosion. It is assumed that 10-foot wide layer of rip-rap will be placed along the 1,360-foot length of the action area using land-based equipment.

- Preparation, maintenance, and removal of the staging area was estimated at a lump sum of $11,000, which includes 2 laborers and a backhoe for 10 days and misc. materials.

- The costs for disposal are as per recent project (Melville Landfill). TSDF disposal (to Model City, NY) is $120 per ton and RCRA-D disposal is $70 per ton for debris and $25 per ton for soil that can be used as cover (Fall River Landfill). Imported fill is $7 per ton.

Table 1

Mounds

Total Volume	10,900	cy

Classification	Percent by Vol.	Associated Volume
Debris	50%	5,450
Soil	50%	5,450
Totals	100%	10,900

Remaining Area Excluding Mounds

Total Volume	37,600	cy

Classification	Percent by Vol.	Associated Volume
Debris	20%	7,520
Soil	80%	30,080
Totals	100%	37,600

Note: The volumes do not include bulking factor.

O&M COST ASSUMPTIONS:

1. Post-Remediation Groundwater Sampling will not be conducted as part of this alternative. O&M costs for groundwater are described in the groundwater alternatives and cost estimates.

5-YEAR COST ASSUMPTIONS:

1. 5-year review in year 5 at 200 LOE @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Review to occur in year 5.

COST SENSITIVITY:

Cost sensitivity for this alternative was evaluated using the volume of soils to be excavated, stockpiled, transported off site, disposed of, and replaced with clean fill. Associated costs for labor, equipment rental, and duration on site were adjusted accordingly. Remaining costs associated with mobilization, demobilization, set up of work areas, site restoration, new storm drains, shoreline protection and predesign were presumed to be fixed. Cost analysis for changes based on soil volumes with an increase up to 30% and decrease of to 30% were calculated and are presented below.

Change in Soil Volume	Total Capital Costs	Change in Costs
30% increase	$12,389,000	27% increase
25% increase	$11,946,000	23% increase
20% increase	$11,503,000	18% increase
15 % increase	$11,061,000	14% increase
10 % increase	$10,618,000	9% increase
5 % increase	$10,175,000	5% increase
Cost as estimated	**$9,733,000**	
5% decrease	$9,290,000	5% decrease
10% decrease	$8,847,000	9% decrease
15% decrease	$8,405,000	14% decrease
20% decrease	$7,962,000	18% decrease
25% decrease	$7,519,000	23% decrease
30% decrease	$7,077,000	27% decrease

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 3 - REMOVAL AND TSDF DISPOSAL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
1- PRE-DESIGN INVESTIGATION													
1.1 Soil borings and analyses	1	ls	$45,450.00	$0.00	$0.00	$0.00	$45,450	$0	$0	$0	$45,450	See Assumptions	Historical data
2 - MOBILIZATION/DEMOBILIZATION													
2.1 Mobilize/demobilize equipment	1	ls				$7,500.00	$0	$0	$0	$7,500	$7,500		Historical data
2.2 Office trailer	4	mo				$181.00	$0	$0	$0	$724	$724	32 x 8	M98-015-904-0300
2.3 Sanitary facilities	4	mo				$120.00	$0	$0	$0	$480	$480		M98-016-420-6410
2.4 Truck scale	4	mo				$2,862.00	$0	$0	$0	$11,448	$11,448		E98-3304-0462
2.5 Site survey/construction layout	5.5	acres		$45.00	$445.00		$0	$248	$2,448	$0	$2,695		M98-013-306-0320
2.6 Electric/phone hookups	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	Utilities nearby	Historical data
2.7 Project closeout report	1	ls			$10,000.00		$0	$0	$10,000	$0	$10,000		Historical data
3 - SITE PREPARATION													
3.1 Clear and grub site - minimal	5.5	acres			$980.00	$2,700.00	$0	$0	$5,390	$14,850	$20,240		M98-021-104-0160
3.2 Install/remove silt fence	3000	lf		$0.45	$0.42		$0	$1,350	$1,260	$0	$2,610	perimeter of exav areas 1 and 2	M98-022-704-1000 - labor twice
3.3 Construct diversion dikes/channels	2000	lf					$0	$0	$0	$0	$0		M98-022-702-0010
3.4 Construct temporary sediment basin/vegetate/backfill	800	cy			$4.85	$5.60	$0	$0	$3,880	$4,480	$8,360		T. Riley
3.5 Truck decon. pad													
a) Concrete pad - 8"	40	cy		$70.00	$125.00	$5.00	$0	$2,800	$5,000	$200	$8,000		Historical data
b) Gravel base - 6"	30	cy		$7.50	$3.33	$8.00	$0	$225	$100	$240	$565		Historical data
c) Curb	120	lf		$3.07	$1.99	$0.05	$0	$368	$239	$6	$613		Historical data
d) Collection sump	1	ls		$1,450.00	$500.00	$220.00	$0	$1,450	$500	$220	$2,170		Historical data
e) Splash guard	780	sf		$1.25	$1.00		$0	$975	$780	$0	$1,755		Historical data
3.6 Construction entrance	1	ls		$620.00	$86.00	$50.00	$0	$620	$86	$50	$756		NovaChemical
3.7 Construct soil staging area	1	ls		$11,000.00			$0	$11,000	$0	$0	$11,000	30 mil poly sheeting, straw bales	M98-022-706-0100
3.8 Maintain soil staging area	1	ls		$5,500.00	$0.00	$0.00	$0	$5,500	$0	$0	$5,500	50% of const cost - includes 6 mil poly to cover piles daily	Historical data
3.9 Remove decontamination pad	1	ls			$250.00	$500.00	$0	$0	$250	$500	$750		Historical data
3.10 Decontamination pad, silt fence disposal	150	ton	$10.00				$1,500	$0	$0	$0	$1,500	C&D Debris	Historical data
3.11 Personnell and equipment decon. facilities and services													
a) Personnel decon. Trailer	4	mo	$1,500.00	$0.00	$200.00	$0.00	$6,000	$0	$800	$0	$6,800		Vendor catalog
b) PPE rolloff cont.	4	mo	$500.00	$0.00	$0.00	$0.00	$2,000	$0	$0	$0	$2,000		Historical data
4 - SITE MANAGEMENT STAFFING													
4.1 Site manager	320	hr	$0.00	$0.00	$36.00	$0.00	$0	$0	$11,520	$0	$11,520		Historical data
4.2 Site engineer	640	hr	$0.00	$0.00	$32.00	$0.00	$0	$0	$20,480	$0	$20,480		Historical data
4.3 Site supervisor/foreman	640	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$19,200	$0	$19,200		Historical data
4.4 Site safety officer	640	hr	$0.00	$0.00	$25.00	$0.00	$0	$0	$16,000	$0	$16,000		Historical data
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT													
5.1 Project manager	64	hr	$0.00	$0.00	$45.00	$0.00	$0	$0	$2,880	$0	$2,880		Historical data
5.2 Project administrator	120	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$3,600	$0	$3,600		Historical data
5.3 Health and safety director	40	hr	$0.00	$0.00	$35.00	$0.00	$0	$0	$1,400	$0	$1,400		Historical data
5.4 Procurement/subcontracting	160	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$4,800	$0	$4,800		Historical data
5.5 Clerical support	160	hr	$0.00	$0.00	$12.50	$0.00	$0	$0	$2,000	$0	$2,000		Historical data
6 - EXCAVATION													
6.1 Excavate/load material (Includes 20 % bulking factor)	58200	cy			$0.48	$1.16	$0	$0	$28,144	$67,767	$95,911	Level C PPE	M98-022-238-1300
6.2 Segregate material with FID	80	day			$100.00	$100.00	$0	$0	$8,000	$8,000	$16,000	Laborer and Equipment	Historical data
6.3 Haul material to for stockpiling	58200	cy			$0.37	$2.15	$0	$0	$21,534	$125,130	$146,664		M98-022-266-2040
6.4 Dump/stockpile material	58200	cy			$0.44	$1.04	$0	$0	$25,317	$60,383	$85,700		M98-022-266-1600
6.5 Stockpiled material sampling/analysis - 1/150 cy	388	ea	$85.00		$100.00		$32,980	$0	$38,800	$0	$71,780	TPH, Paint Filter Test	BOA; E98-3302-1750
6.6 Stockpiled material sampling/analysis - 1/500 cy	116	ea	$1,050.00		$200.00		$122,220	$0	$23,280	$0	$145,500	TCLP, VOC, SVOC, Pb, pH, reactivity, ignitability	BOA
6.7 Excavation confirmatory sampling/analysis	380	ea	$60.00		$100.00		$22,800	$0	$38,000	$0	$60,800	TPH	BOA
6.8 Excavation confirmatory sampling/analysis	95	ea	$500.00		$100.00		$47,500	$0	$9,500	$0	$57,000	TCLP, SVOCs, Metals	BOA
6.9 Trench Box	4	mo				$1,500.00	$0	$0	$0	$6,000	$6,000	6' x 20'	M98-016-420-7040
6.1 Replace storm drains	550	LF		$10.60	$4.47	$0.88	$0	$5,830	$2,459	$484	$8,773	18 iD RCP Drain	M98-027-150-2230

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 3 - REMOVAL AND TSDF DISPOSAL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
7 - DEWATER EXCAVATIONS													
7.1 4-inch trash pump	4	mo			$840.00	$840.00	$0	$0	$3,360	$3,360	$6,720		M98-016-420-5600
7.2 20,000 gallon temporary storage tank	4	mo				$1,219.00	$0	$0	$0	$4,876	$4,876		E98-1904-0406
7.3 Pump out tanks with 5,000 gallon tanker truck	4	mo			$1,500.00	$3,000.00	$0	$0	$6,000	$12,000	$18,000		M98-016-420-7625
7.4 Transportation - 5,000 -gal tanker for 10 miles	80	tanks	$16.50				$1,320	$0	$0	$0	$1,320	10 miles for 5000 gal tank - $1.65/mile- one tank/day	E-2000-33-19-0207
7.5 Disposal of excavation water	400	kgal	$1.54				$616	$0	$0	$0	$616	$1.54/kgal	E-2000-33197102
8 - TRANSPORTATION AND DISPOSAL OF CONTAMINATED MATERIAL													
8.1 Load nonhazardous material into trucks	53960	cy			$0.19	$0.28	$0	$0	$10,252	$15,109	$25,361		M98-022-216-4070
8.2 Load hazardous material into trucks	4240	cy			$0.28	$0.35	$0	$0	$1,168	$1,484	$2,652	Level C PPE	M98-022-216-4070 + PPE m/u
8.3 Level C PPE (4-man field crew)	32	mday		$34.54			$0	$1,105	$0	$0	$1,105	8 days to load matl; 500 cy per day	E98-3302-0406/0402/0423/0425/0429/0449
8.4 T&D nonhazardous material - debries (RCRA Landfill-D)	23340	ton	$70.00				$1,633,800	$0	$0	$0	$1,633,800	FallRiver Landfill	Vendor Quote
8.5 T&D hazardous material (RCRA Landfill-C)	6360	ton	$120.00				$763,200	$0	$0	$0	$763,200	Model City, NY - 1.5 tons/cubic yard	Foster Wheeler
8.6 T&D nonhazardous soil cover (RCRA Landfill-D)	57600	ton	$25.00				$1,440,000	$0	$0	$0	$1,440,000	FallRiver Landfill	Vendor Quote
9 - RESTORATION													
9.1 Import clean fill	45120	cy		$10.50			$0	$473,760	$0	$0	$473,760	Regular fill	Foster Wheeler
9.2 Place/grade fill	45120	cy			$0.30	$0.83	$0	$0	$13,536	$37,450	$50,986	no compaction	Historical data
9.3 Import/place/grade topsoil	3900	cy		$14.00	$0.23	$0.69	$0	$54,600	$897	$2,691	$58,188	6 inches	M98-022-216-7020
9.4 Revegetation	230	msf		$28.00	$7.00	$7.35	$0	$6,440	$1,610	$1,691	$9,741	utility mix, 7#/msf, hydroseed w/ mulch	M98-029-308-5400
9.5 Shorline riprap placement	1512	SY	$65.00	$0.00	$0.00	$0.00	$98,280	$0	$0	$0	$98,280		Historical data
10 - NEW MONITORING WELLS (4)													
10.1 Hollow-stem auger	100	ft			$24.87		$0	$0	$2,487	$0	$2,487	Four wells each at 25' depth	Echos2000-33 23 1101
10.2 2-inch PVC well casing	100	ft		$10.08			$0	$1,008	$0	$0	$1,008		NPTC Master Agreement, Cherry Point
10.3 Construction (2-man crew)	1	day	$456.80				$457	$0	$0	$0	$457		ECHOS2000-hlabk-1 OPERATOR, 1 SEMISKILLED LABOR
10.4 2-inch PVC well Screen	60	ft		$14.02			$0	$841	$0	$0	$841		ECHOS 2000-33 23 0201
Subtotal							$4,220,123	$568,120	$346,956	$387,121	$5,522,320		
Overhead on Labor Cost @ 30%									$104,087		$104,087		
G & A on Labor Cost @ 10%									$34,696		$34,696		
G & A on Material Cost @ 10%								$56,812			$56,812		
G & A on Subcontract Cost @ 10%							$422,012				$422,012		
Total Direct Cost							$4,642,135	$624,932	$485,739	$387,121	$6,139,927		
Indirects on Total Direct Labor Cost @ 75%									$364,304		$364,304		
Profit on Total Direct Cost @ 10%											$613,993		
Subtotal											$7,118,224		
Health & Safety Monitoring @ 6%											$427,093		
Cost adjustment for location @ 7%											$498,276		
Total Field Cost											$8,043,593		
Contingency on Total Field Cost @ 15%											$1,206,539		
Engineering on Total Field Cost @ 6%											$482,616		
TOTAL COST											$9,732,748		
											$9,733,000		

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE 3 - REMOVAL AND TSDF DISPOSAL
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost				Extended Cost				Subtotal	Comments	Source
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Direct Cost		

Notes
G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:

1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.

Present Worth Analysis
Soil Alternative 3 - Removal and Disposal at TSDF
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/10/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$9,733,000			$9,733,000
1	0.962		$0		$0
2	0.926		$0		$0
3	0.892		$0		$0
4	0.858		$0		$0
5	0.826		$0	$21,500	$17,757
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$0	$0	$0
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$0	$0	$0
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$0	$0	$0
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$0	$0	$0
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$0	$0	$0
		TOTAL PRESENT WORTH =			$9,750,757
					$9,751,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Tetra Tech NUS			*Calculation Sheet*
Client: Navy CLEAN	File No.	**By:** RD, PJ	**Page** 1 of 1
Subject: Assumptions and Cost Basis, Groundwater Alternative 1, OFFTA FS		**Checked by:** JD	**Date:** July 17, 2002

Groundwater Alternative 1: No Action

CAPITAL COST ASSUMPTIONS: N/A

O&M COST ASSUMPTIONS: N/A

5-YEAR COST ASSUMPTIONS:

1. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

Present Worth Analysis
Groundwater Alternative 1 - No Action
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/17/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$0			$0
1	0.962		$0		$0
2	0.926		$0		$0
3	0.892		$0		$0
4	0.858		$0		$0
5	0.826		$0	$21,500	$17,757
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$0	$21,500	$14,665
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$0	$21,500	$12,112
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$0	$21,500	$10,003
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$0	$21,500	$8,261
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$0	$21,500	$6,823
		TOTAL PRESENT WORTH =			$69,621
					$70,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Groundwater Alternative 2: Limited Action

CAPITAL COST ASSUMPTIONS:

1. Groundwater Use Restrictions

   Assume 500 hours Level of Effort (LOE) @ $100/hr to implement. Approx. $2500 ODCs. Total = $52,500.

O&M COST ASSUMPTIONS:

1. Sampling for long-term monitoring will be conducted at 13 wells annually for years 1-5 and every five years thereafter. A total of 16 samples will be collected at each event and will be analyzed for DRO, GRO, SVOCs, and metals. Analysis costs will be $822.42 for each sample ($86.25+97.75+348.75+289.67 = $822.42. Source: Recent analysis cost, E-2000-33021619, 33021621). Sampling effort will be at 200 Level of Effort (LOE) @$100/hr. Total cost for event: $33,159.

2. Annual report to RIDEM for use restriction monitoring will be 100 Level of Effort (LOE) @ $100/hr to implement. Approx. $1000 ODCs. Total = $11,000.

5-YEAR COST ASSUMPTIONS:

1. 5-year review at 200 LOE @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

Present Worth Analysis
Groundwater Alternative 2 - Limited Action
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/17/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$52,500			$52,500
1	0.962		$44,159		$42,501
2	0.926		$44,159		$40,906
3	0.892		$44,159		$39,371
4	0.858		$44,159		$37,893
5	0.826		$44,159	$21,500	$54,227
6	0.795		$11,000		$8,744
7	0.765		$11,000		$8,416
8	0.736		$11,000		$8,100
9	0.709		$11,000		$7,796
10	0.682		$44,159	$21,500	$44,786
11	0.656		$11,000		$7,221
12	0.632		$11,000		$6,950
13	0.608		$11,000		$6,689
14	0.585		$11,000		$6,438
15	0.563		$44,159	$21,500	$36,988
16	0.542		$11,000		$5,964
17	0.522		$11,000		$5,740
18	0.502		$11,000		$5,525
19	0.483		$11,000		$5,317
20	0.465		$44,159	$21,500	$30,548
21	0.448		$11,000		$4,926
22	0.431		$11,000		$4,741
23	0.415		$11,000		$4,563
24	0.399		$11,000		$4,392
25	0.384		$44,159	$21,500	$25,229
26	0.370		$11,000		$4,068
27	0.356		$11,000		$3,915
28	0.343		$11,000		$3,768
29	0.330		$11,000		$3,627
30	0.317		$44,159	$21,500	$20,837
		TOTAL PRESENT WORTH =			$542,686
					$543,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Tetra Tech NUS			Calculation Sheet
Client: Navy CLEAN	File No.	**By:** RD, PJ	**Page** 1 of 1
Subject: Assumptions and Cost Basis, Groundwater Alternative 3, OFFTA FS		**Checked by:** JD, SSP	**Date:** July 17, 2002

Groundwater Alternative 3: Extraction and Treatment

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consists of one round of sampling 13 wells. A total of 16 samples will be collected at each event and will be analyzed for DRO, GRO, SVOCs, and metals. Analysis costs will be $822.42 for each sample ($86.25+97.75+348.75+289.67 = $822.42. Source: Recent analysis cost, E-2000-33021619, 33021621). Sampling effort will be at 200 Level of Effort (LOE) @$100/hr. Total cost for event: $33,159.

   PDI will also include slug tests for hydraulic conductivity and analyses for TOC and grain size. Total cost $5,000.

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. Eight extraction wells will be installed. Wells will be 6" casings in a 10" borehole installed by a hollow-stem auger.

4. Discharge will be into a nearby sanitary sewer line for transmittal to POTW.

O&M COST ASSUMPTIONS:

1. Electric usage will be 40,000 kWH/year at $0.10/kWH. Total = $4,000.

2. Ion exchange sludge/spent resin handling will be $1,500/yr.

3. Carbon usage will be 1,000 lb/year at $1.25/lb. Price includes changeout and regeneration/disposal Total = $1,250.

4. Maintenance will be required 8 hrs/month @$100/hr. Maintenance parts will be $1,000/yr. Yearly total = $10,600.

5. Discharge of treated water to POTW will be 5,500,000 gallons/year at $1.50/1000gal. Total = $8,250.

6. Sampling for long-term monitoring will be conducted at 13 wells quarterly for years 1-5 and annually for years 6-30. A total of 16 samples will be collected at each event and will be analyzed for DRO, GRO, SVOCs, and metals. Analysis costs will be $822.42 for each sample ($86.25+97.75+348.75+289.67 = $822.42. Source: Recent analysis cost, E-2000-33021619, 33021621). Sampling effort will be at 200 Level of Effort (LOE) @$100/hr. Total cost for event: $33,159.

5-YEAR COST ASSUMPTIONS:

1. 5-year review in year 5 at 200 LOE @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Review to occur in year 5.

CAPITAL COST ESTIMATE
GROUNDWATER ALTERNATIVE 3 - EXTRACTION AND TREATMENT
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
1- PRE-DESIGN INVESTIGATION													
1.1 Groundwater analyses	1	ls	$33,159.00	$0.00	$0.00	$0.00	$33,159	$0	$0	$0	$33,159	See Assumptions	Historical data
1.2 Hydrogeologic analyses	1	ls	$5,000.00	$0.00	$0.00	$0.00	$5,000	$0	$0	$0	$5,000	See Assumptions	Historical data
2 - MOBILIZATION/DEMOBILIZATION													
2.1 Mobilize/demobilize equipment	1	ls				$7,500.00	$0	$0	$0	$7,500	$7,500		Historical data
2.2 Office trailer	2	mo				$181.00	$0	$0	$0	$362	$362	32 x 8	M98-015-904-0300
2.3 Sanitary facilities	2	mo				$120.00	$0	$0	$0	$240	$240		M98-016-420-6410
2.4 Electric/phone hookups	1	ls	$2,000.00				$2,000	$0	$0	$0	$2,000	Utilities nearby	Historical data
2.5 Project closeout report	1	ls			$10,000.00		$0	$0	$10,000	$0	$10,000		Historical data
3 - SITE PREPARATION													
3.1 Construction entrance	1	ls		$620.00	$86.00	$50.00	$0	$620	$86	$50	$756		Historical data
3.2 Personnel and equipment decon. facilities and services													
a) Personnel decon. Trailer	2	mo	$1,500.00	$0.00	$200.00	$0.00	$3,000	$0	$400	$0	$3,400		Vendor catalog
b) PPE rolloff cont.	2	mo	$500.00	$0.00	$0.00	$0.00	$1,000	$0	$0	$0	$1,000		Historical data
4 - SITE MANAGEMENT STAFFING													
4.1 Site manager	160	hr	$0.00	$0.00	$36.00	$0.00	$0	$0	$5,760	$0	$5,760		Historical data
4.2 Site engineer	320	hr	$0.00	$0.00	$32.00	$0.00	$0	$0	$10,240	$0	$10,240		Historical data
4.3 Site supervisor/foreman	80	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$2,400	$0	$2,400		Historical data
4.4 Site safety officer	80	hr	$0.00	$0.00	$25.00	$0.00	$0	$0	$2,000	$0	$2,000		Historical data
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT													
5.1 Project manager	32	hr	$0.00	$0.00	$45.00	$0.00	$0	$0	$1,440	$0	$1,440		Historical data
5.2 Project administrator	60	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$1,800	$0	$1,800		Historical data
5.3 Health and safety director	20	hr	$0.00	$0.00	$35.00	$0.00	$0	$0	$700	$0	$700		Historical data
5.4 Procurement/subcontracting	80	hr	$0.00	$0.00	$30.00	$0.00	$0	$0	$2,400	$0	$2,400		Historical data
5.5 Clerical support	80	hr	$0.00	$0.00	$12.50	$0.00	$0	$0	$1,000	$0	$1,000		Historical data
6 - EXTRACTION WELLS													
6.1 Hollow-stem auger 10-inch dia	160	ft	$24.87				$3,979	$0	$0	$0	$3,979		
6.2 6-inch PVC well casing	40	ft	$15.97				$639	$0	$0	$0	$639		
6.3 6-inch well screen	120	ft	$23.53				$2,824	$0	$0	$0	$2,824		
6.4 6-inch well bentonite seal	8	ea	$95.96				$768	$0	$0	$0	$768		
6.5 2-inch PVC piping	1000	ft	$6.50				$6,500	$0	$0	$0	$6,500		
6.6 1000-gal double walled steel tank	1	ea	$2,078.00				$2,078	$0	$0	$0	$2,078		
6.7 2-inch PVC tees	20	ea	$1.69				$34	$0	$0	$0	$34		
6.8 Submersible pumps, 1/3hp w/controls	8	ea	$1,457.00				$11,656	$0	$0	$0	$11,656		
7 - ION EXCHANGE UNIT													
7.1 Ion exchange pilot study	1	ea	$50,000.00				$50,000	$0	$0	$0	$50,000		Estimate
7.2 Ion exchange unit w/standby w/valves and controls	1	unit	$65,000.00				$65,000	$0	$0	$0	$65,000		Vendor information
7.3 0.5 hp transfer pump with motor, valves, piping (one stan	2	ea				$1,400.00	$0	$0	$0	$2,800	$2,800		Vendor information
7.4 Prefabricated building on slab	1	ea				$60,000.00	$0	$0	$0	$60,000	$60,000		Vendor information
7.6 Installation cost	120	hr			$30.00		$0	$0	$3,600	$0	$3,600		Vendor information
8 - CARBON ADSORPTION UNIT													
8.1 330 lb Permanent GAC unit	3	unit	$2,700.00				$8,100	$0	$0	$0	$8,100		Vendor information
8.2 0.5 hp transfer pump with motor, valves, piping (one stan	2	ea				$1,400.00	$0	$0	$0	$2,800	$2,800		Vendor information
9 - RESTORATION													
9.1 Site cleanup	1	ls	$1,000.00				$1,000	$0	$0	$0	$1,000		Estimate
Subtotal							$196,736	$620	$41,826	$73,752	$312,934		
Overhead on Labor Cost @ 30%									$12,548		$12,548		
G & A on Labor Cost @ 10%									$4,183		$4,183		
G & A on Material Cost @ 10%								$62			$62		
G & A on Subcontract Cost @ 10%							$19,674				$19,674		
Total Direct Cost							$216,410	$682	$58,556	$73,752	$349,400		
Indirects on Total Direct Labor Cost @ 75%									$43,917		$43,917		
Profit on Total Direct Cost @ 10%											$34,940		

CAPITAL COST ESTIMATE
GROUNDWATER ALTERNATIVE 3 - EXTRACTION AND TREATMENT
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments	Source
Subtotal											$428,257		
Health & Safety Monitoring @ 6%											$25,695		
Cost adjustment for location @ 7%											$29,978		
Total Field Cost											$483,931		
Contingency on Total Field Cost @ 15%											$72,590		
Engineering on Total Field Cost @ 6%											$29,036		
TOTAL COST											$585,556		
											$586,000		

Notes
G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:

1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.

Present Worth Analysis
Groundwater Alternative 3 - Extraction and Treatment
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/17/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$586,000			$586,000
1	0.962		$158,236		$152,296
2	0.926		$158,236		$146,580
3	0.892		$158,236		$141,078
4	0.858		$158,236		$135,782
5	0.826		$158,236	$21,500	$148,442
6	0.795		$58,759		$46,707
7	0.765		$58,759		$44,954
8	0.736		$58,759		$43,266
9	0.709		$58,759		$41,642
10	0.682		$58,759	$21,500	$54,744
11	0.656		$58,759		$38,575
12	0.632		$58,759		$37,127
13	0.608		$58,759		$35,733
14	0.585		$58,759		$34,392
15	0.563		$58,759	$21,500	$45,213
16	0.542		$58,759		$31,859
17	0.522		$58,759		$30,663
18	0.502		$58,759		$29,512
19	0.483		$58,759		$28,404
20	0.465		$58,759	$21,500	$37,341
21	0.448		$58,759		$26,312
22	0.431		$58,759		$25,324
23	0.415		$58,759		$24,373
24	0.399		$58,759		$23,459
25	0.384		$58,759	$21,500	$30,839
26	0.370		$58,759		$21,731
27	0.356		$58,759		$20,915
28	0.343		$58,759		$20,130
29	0.330		$58,759		$19,374
30	0.317		$58,759	$21,500	$25,470
		TOTAL PRESENT WORTH =			$2,128,235
					$2,128,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Tetra Tech NUS			*Calculation Sheet*
Client: Navy CLEAN	File No.	**By:** RD	**Page** 1 of 1
Subject: Assumptions and Cost Basis, Sediment Alternative 1, OFFTA FS		**Checked by:** JD, PJ	**Date:** March 11, 2002

Sediment Alternative 1: No Action

CAPITAL COST ASSUMPTIONS: N/A

O&M COST ASSUMPTIONS: N/A

5-YEAR COST ASSUMPTIONS:

1. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

Present Worth Analysis
Sediment Alternative 1 - No Action
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/09/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$0			$0
1	0.962		$0		$0
2	0.926		$0		$0
3	0.892		$0		$0
4	0.858		$0		$0
5	0.826		$0	$21,500	$17,757
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$0	$21,500	$14,665
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$0	$21,500	$12,112
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$0	$21,500	$10,003
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$0	$21,500	$8,261
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$0	$21,500	$6,823
		TOTAL PRESENT WORTH =			$69,621
					$70,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Sediment Alternative 2: Limited Action

CAPITAL COST ASSUMPTIONS:

1. Access Restrictions:

A row of fencing will be installed at each end of OFFTA, connected to the existing fence corners, and extend to the mean low water line. Buoys will be installed at 100-foot increments along the shoreline, ten feet offshore of the mean-low tide line. Warning signs will be posted on the fence and buoys and at strategic locations on shore to warn people of the hazards associated with the use of the area.

- 150 lf fence @ $19.09 = $2,865
- 15 line posts @ $60.00 = $900
- 6 end posts @ $81.50 = $489
- 10 buoys and anchors @ $400 ea. = $4,000
- 2 days of boat rental = $1,000
- 15 - 12"X18" warning signs @ $42.44ea. = $636

Total Fence, Sign, and Buoy Cost = $9,890.

O&M COST ASSUMPTIONS:

1. Long-term Monitoring:

Intertidal and subtidal sediment will be monitored on an annual basis for the first five years, then every five years for a period of 30 years. The six stations exceeding ecological PRGs will be monitored, and six stations will be selected to represent the intertidal area where human trespasser expsore is anticipated to occur. Samples will be analyzed for PAHs, Metals and toxicity as necessary.

Analyses:
- Sediment chemistry (PAHs, arsenic); 12 samples plus 2 QC samples
- Biota chemistry 6 samples (PAHs, arsenic);
- Toxicity Amphipod; 6 samples
- Toxicity Arabacia; 6 samples

Labor Costs: (1 event/year)
- Sediment sampling: Sample collection with equipment and crew = approximately $485/sample. Collection of 12 samples = $5,820 (QC samples collected at no additional cost)
- Biota sampling: Sample collection with equipment and crew = approximately $1043/sample. Collection of 6 samples = $6,258
- Project mgmt/coord. ≈ 30 hours/year @ $80/hr (w/O&P) = $2,400
- Annual: add $300 M&IE; ODCs & supplies @ $200; & shipping @ $200.
- Data Validation $13,939.
- Report prep. $12,460.

Total Labor ≅ $41,377 annually for years 1-5 and at 5 -year review cycles

Estimated analytical costs:

- Sediment chemistry (PAHs, arsenic) $283/sample @ 14 samples/yr = $3,962
- Biota chemistry (PAHs, arsenic) @ $1100/sample @ 6 samples/yr = $6,600
- Toxicity Amphipod @ $863/ sample @ 6 samples/yr = $5,178
- Toxicity Arabacia @ $662/ sample @ 6 samples/yr = $3,972

Total Analytical ≅ $19,712 annually for years 1-5 and at 5 -year review cycles

2. Inspection and Maintenance:

   Quarterly inspections (fence, buoys and biota) including fieldwork and reporting, Engineer @ 16 Level of Effort (LOE) @ 80/hr = $1280/quarter; approximately $300/quarter ODCs = $1,580/quarter or $6,320/year; assume 10% of total replacement cost per year for fence/sign/buoy maintenance $2,466. Total = $8,786 annually

5-YEAR COST ASSUMPTIONS:

1. Each reviews at 200 LOE @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

Present Worth Analysis
Sediment Alternative 2 - Limited Action
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/09/02

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$9,890			$9,890
1	0.962		$69,875		$67,252
2	0.926		$69,875		$64,728
3	0.892		$69,875		$62,298
4	0.858		$69,875		$59,960
5	0.826		$69,875	$21,500	$75,466
6	0.795		$8,786		$6,984
7	0.765		$8,786		$6,722
8	0.736		$8,786		$6,469
9	0.709		$8,786		$6,227
10	0.682		$69,875	$21,500	$62,326
11	0.656		$8,786		$5,768
12	0.632		$8,786		$5,551
13	0.608		$8,786		$5,343
14	0.585		$8,786		$5,142
15	0.563		$69,875	$21,500	$51,475
16	0.542		$8,786		$4,764
17	0.522		$8,786		$4,585
18	0.502		$8,786		$4,413
19	0.483		$8,786		$4,247
20	0.465		$69,875	$21,500	$42,512
21	0.448		$8,786		$3,934
22	0.431		$8,786		$3,787
23	0.415		$8,786		$3,644
24	0.399		$8,786		$3,508
25	0.384		$69,875	$21,500	$35,111
26	0.370		$8,786		$3,249
27	0.356		$8,786		$3,127
28	0.343		$8,786		$3,010
29	0.330		$8,786		$2,897
30	0.317		$69,875	$21,500	$28,998
		TOTAL PRESENT WORTH =			$653,387
					$653,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94

Sediment Alternative 3: Limited Removal and Disposal (Beach Area)

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consisting of soil borings/cores advanced to further determine the grain size and nature of the sediments and to delineate lateral extent of contaminants exceeding the PRGs. Assume 25 soil borings at an average 5-foot depth with associate analytical costs for PAHs, arsenic, and geotechnical testing.

   - Mobilization/demobilization @ $33,750
   - Sample collection @ $600 each or $15,000
   - Analytical @ $283/sample for 55 samples including QA/QC samples or $15,565
   - Data validation $6,600
   - Reporting @ $5,000
   - Oversight and management @ $5,500

   Total costs approx. = $81,415.

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. It is assumed that no subgrade preparation will be required prior to dredging/excavating the contaminated sediments. Large debris and boulders will be removed from the sediments after they have been dredged, but prior to dewatering.

4. Erosion controls will be provided to reduce migration of sediments during the dredging operations by means of a silt boom. The silt boom will be anchored outside the perimeter of the dredge area as needed to control dewatering discharge and disturbance during excavation of the intertidal area.

5. A portable cofferdam system (Portadam) will be erected around the low tide line as shown in Figure 2-4 (orange area). The area will be dewatered as needed with pumps so that the excavation of the sediments can occur in dry conditions. An estimated 5,716 cy will be excavated in this manner. It is assumed that the portadam will be installed in two phases. According to the vendor estimates, it should take 8 days to install phase 1 (eastern half), 8-10 days to remove phase I and install phase II (western half), and 5-7 days to remove the structures.

6. Excavation, Backfilling and Disposal Work

   - Approximately 1.77 acres of area will be dredged to a depth of 2 feet (approximately 5,716 cu yd) to remove contaminated sediment.

   - It is assumed that OFFTA area will be used as a materials staging, dewatering, and project office area at no cost. Dewatered dredge spoils will be staged at this area pending transport to the TSDF/off-site landfill.

   - It is assumed that over-the-road transport of waste will be done with out need for any improvements to the bridge near the site.

- Water quality testing will be performed daily during dredging removal activities. It is assumed that three samples will be collected daily from outside of the silt curtain work area. Samples will be analyzed for PAHs, arsenic, and total suspended solids (TSS).

- Dry excavated sediments will be screened and hauled directly to the landfill from the excavation site. Backfill materials will be placed immediately following removal of the contaminated sediments.

- Access to the work area will be from along the western side of OFFTA. Excavation, handling, and placement of materials will be accomplished using tracked excavators, a wheeled front-end loader, screener, and off-road dump trucks at a rate of 600 cy/day. Costs include a survey crew to verify grades during placement.

- The backfill materials consisting of sand/gravel/stone will be placed over an area approximately 1.77 acres. Assuming a bulking factor of 20%, approximately 6,859 cy of backfill will be placed. Also, since 20% of the dredged material (1,372cy) will be screened and re-used, only 5,487 cy of material will be required from off-site sources.

- Because of low contamination levels it is assumed that most of the sediment can be disposed of at RCRA-D landfill. For the estimation purposes, 90% of the sediment (after backfill) is assumed to be disposed of at RCRA-D landfill, 9% of sediment will need stabilization after which it would be disposed of at RCRA-D landfill, and 1% of sediment would be disposed of at TSDF (RCRA-C).

- The costs for disposal are as per recent project (Melville Landfill). TSDF disposal (to Model City, NY) is $120 per ton (as per Carl Tippman of Foster Wheeler from McAllister project) and RCRA-D disposal is $70 per ton (disposal cost from Fall River Landfill) including transportation.

O&M COST ASSUMPTIONS:

1. Long-term Monitoring:

Long term monitoring will be conducted for two purposes. First, the subtidal areas where sediments will still contain COCs above PRG concentrations will be monitored for ecological risk parameters to determine if the removal of the source areas and the intertidal sediments have a positive effect on these sediments over the long term, and to evaluate the effectiveness of the remedy every five years. Secondly, the monitoring effort will evaluate the remediated area to assure these sediments are not becoming recontaminated from other sources. The sediment program outlined below will accommodate both objectives, and will be conducted at the same intervals.

a. Analyses:
- Sediment chemistry (PAHs, arsenic); 12 samples plus 2 QC samples
- Biota chemistry 4 samples (PAHs, arsenic);
- Toxicity Amphipod; 4 samples
- Toxicity Arabacia; 4 samples

b. Labor Costs: (1 event/year)
- Sediment sampling: Sample collection with equipment and crew = approximately $485/sample. Collection of 12 samples = $5,820 (QC samples collected at no additional cost)
- Biota sampling: Sample collection with equipment and crew = approximately $1043/sample. Collection of 4 samples = $4,172

- Project mgmt/coord. ≈ 30 hours/year @ $80/hr (w/O&P) = $2,400
- Annual: add $300 M&!E; ODCs & supplies @ $200; & shipping @ $200.
- Data Validation $13,939.
- Report prep. $12,460.

Total Labor ≅ $39,291annually for years 1-5 and at 5 -year review cycles

c. Estimated analytical costs:

- Sediment chemistry (PAHs, arsenic) $283/sample @ 14 samples/yr = $3,962
- Biota chemistry (PAHs, arsenic) @ $1100/sample @ 4 samples/yr = $4,400
- Toxicity Amphipod @ $863/ sample @ 4 samples/yr = $3,452
- Toxicity Arabacia @ $662/ sample @ 4 samples/yr = $2,648

Total Analytical ≅ $14,462 annually for years 1-5 and at 5 -year review cycles

2. Inspection for Habitat Recovery:

   Qualitative inspections to be performed by an Marine Biologist: Assume 2 days (8 hr/day) for inspection and travel and 2 days (16 hr) to prepare an inspection report. 32 hours total @ $80/hr = $2,560 plus $300 ODCs & travel costs, and $2,000 equipment costs (boat and underwater video). Total quarterly Inspection costs are $4,860. Total annual costs are $19,440 for years 1-5 and at 5-year review cycles.

3. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event. Reviews to occur in years 5, 10, 15, 20, 25, and 30.

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 3 - LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
1- PRE-DESIGN INVESTIGATION												
1.1 Sediment/soil borings and analyses	1	ls	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	See Assumptions
2 - MOBILIZATION/DEMOBILIZATION												
2.1 Office trailer (1 each)	3	mo	$400.00	$0.00	$0.00	$0.00	$1,200.00	$0.00	$0.00	$0.00	$1,200.00	Historical data -300 CY/d
2.2 Portable communication equipment sets	4	ea	$400.00	$0.00	$0.00	$0.00	$1,600.00	$0.00	$0.00	$0.00	$1,600.00	Historical data-McAllister
2.3 Equipment mob./demob. (support equip)	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	Historical data-McAllister
2.4 Site utility hook-ups (electric, phone, etc.)	1	ls	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	Historical data-McAllister
2.5 Site utilities	3	mo	$4,000.00	$0.00	$0.00	$0.00	$12,000.00	$0.00	$0.00	$0.00	$12,000.00	Historical data-McAllister
2.6 Pick-up truck (rental, 3 each)	3	mo	$2,850.00	$450.00	$0.00	$0.00	$8,550.00	$1,350.00	$0.00	$0.00	$9,900.00	Historical data-McAllister
2.7 Certification/close-out reports	1	ea	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$27,000.00	Historical data-McAllister
3 - PERSONNEL AND EQUIP. DECON. FACILITIES AND SERVICES												
3.1 1) Personnel decon. trailer	3	mo	$1,500.00	$0.00	$200.00	$0.00	$4,500.00	$0.00	$600.00	$0.00	$5,100.00	Vendor catalog
3.2 2) PPE rolloff cont.	3	mo	$500.00	$0.00	$0.00	$0.00	$1,500.00	$0.00	$0.00	$0.00	$1,500.00	Historical data-McAllister
4 - SITE MANAGEMENT STAFFING												
4.1 Site manager	240	hr	$0.00	$0.00	$36.00	$0.00	$0.00	$0.00	$8,640.00	$0.00	$8,640.00	Historical data-McAllister
4.2 Site engineer	480	hr	$0.00	$0.00	$32.00	$0.00	$0.00	$0.00	$15,360.00	$0.00	$15,360.00	Historical data-McAllister
4.3 Site supervisor/foreman	480	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$14,400.00	$0.00	$14,400.00	Historical data-McAllister
4.4 Site safety officer	480	hr	$0.00	$0.00	$25.00	$0.00	$0.00	$0.00	$12,000.00	$0.00	$12,000.00	Historical data-McAllister
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT												
5.1 Project manager	48	hr	$0.00	$0.00	$45.00	$0.00	$0.00	$0.00	$2,160.00	$0.00	$2,160.00	Historical data-McAllister
5.2 Project administrator	90	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$2,700.00	$0.00	$2,700.00	Historical data-McAllister
5.3 Health and safety director	30	hr	$0.00	$0.00	$35.00	$0.00	$0.00	$0.00	$1,050.00	$0.00	$1,050.00	Historical data-McAllister
5.4 Procurement/subcontracting	120	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$3,600.00	$0.00	$3,600.00	Historical data-McAllister
5.5 Clerical support	120	hr	$0.00	$0.00	$12.50	$0.00	$0.00	$0.00	$1,500.00	$0.00	$1,500.00	Historical data-McAllister
6 - REMOVAL/WATER TREATMENT												
6.1 Beach Area Debris Removal/disposal at RCRA D Landfill	500	ton	$75.00	$0.00	$0.00	$0.00	$37,500.00	$0.00	$0.00	$0.00	$37,500.00	Fall River Landfill - $5 for removal and
6.2 Erosion control, silt boom	3,000	lf	$0.00	$10.00	$4.00	$4.00	$0.00	$30,000.00	$12,000.00	$12,000.00	$54,000.00	Historical data-McAllister
6.3 Mobilization/demobilization (shore based equip.)	1	ls	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	Vendor Info.
6.4 Staging area preparation, maintenance, and removal	1	ls	$0.00	$1,000.00	$7,000.00	$3,000.00	$0.00	$1,000.00	$7,000.00	$3,000.00	$11,000.00	Vendor Info.
6.5 Mobilization/demobilization (Off-shore based equip.)	1	ls	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	Historical data-McAllister
6.6 Temporary Portadam	1	ls	$130,368.50	$0.00	$0.00	$0.00	$130,368.50	$0.00	$0.00	$0.00	$130,368.50	Vendor Info.
6.7 Excavate/Dredge, haul beach sediments (Incuudes 20 % bulking	6,859	cy	$7.00	$0.00	$0.00	$0.00	$48,014.40	$0.00	$0.00	$0.00	$48,014.40	E-1703-0217/023200020
6.8 Dredge water treatment	23	day	$4,500.00	$0.00	$0.00	$0.00	$102,888.00	$0.00	$0.00	$0.00	$102,888.00	Vendor Info.
6.9 Sediment confirmation testing	25	ea	$883.00	$0.00	$0.00	$0.00	$22,075.00	$0.00	$0.00	$0.00	$22,075.00	Historical data-McAllister
6.10 Water quality testing	23	day	$3,600.00	$50.00	$200.00	$150.00	$82,310.40	$1,143.20	$4,572.80	$3,429.60	$91,456.00	Historical data-McAllister
6.11 Disposal/transport to RCRA D Landfill	6,173	ton	$70.00	$0.00	$0.00	$0.00	$432,129.60	$0.00	$0.00	$0.00	$432,129.60	Fall River Landfill
6.12 Disposal/transport to RCRA D Landfill w/ stabilization	617	ton	$90.00	$0.00	$0.00	$0.00	$55,559.52	$0.00	$0.00	$0.00	$55,559.52	Estimate
6.13 Disposal/transport to RCRA C Landfill	69	ton	$120.00	$0.00	$0.00	$0.00	$8,231.04	$0.00	$0.00	$0.00	$8,231.04	Modelcity,NY

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 3 - LIMITED REMOVAL AND DISPOSAL (BEACH AREA)
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
7 - BACKFILL PLACEMENT												
7.1 Beach imported sand/gravel backfill (2 ft)	5,487	cy	$25.17	$15.00	$1.66	$0.00	$138,116.85	$82,310.40	$9,109.02	$0.00	$229,536.27	Vendor Info.
7.2 Beach screened sand/gravel backfill (2 ft)	1,372	cy	$25.17	$0.00	$1.66	$0.00	$34,529.21	$0.00	$2,277.25	$0.00	$36,806.47	Vendor Info.
7.3 Water quality monitoring (3 samples/day)	11	day	$3,600.00	$50.00	$200.00	$150.00	$41,155.20	$571.60	$2,286.40	$1,714.80	$45,728.00	Historical/Vendor
Subtotal							$1,308,643	$118,375	$114,255	$23,144	$1,564,418	
Overhead on Labor Cost @ 30%									$34,277		$34,277	
G & A on Labor Cost @ 10%									$11,426		$11,426	
G & A on Material Cost @ 10%								$11,838			$11,838	
G & A on Subcontract Cost @ 10%							$130,864				$130,864	
Total Direct Cost							$1,439,507	$130,213	$159,958	$23,144	$1,752,822	
Indirects on Total Direct Labor Cost @ 75%									$119,968		$119,968	
Profit on Total Direct Cost @ 10%											$175,282	
Subtotal											$2,048,072	
Health & Safety Monitoring @ 6%											$122,884	
Cost adjustment for location @ 7%											$143,365	
Total Field Cost											$2,314,322	
Contingency on Total Field Cost @ 25%											$578,580	
Engineering on Total Field Cost @ 6%											$138,859	
TOTAL COST											$3,031,761	
											$3,032,000	

Notes
G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:
1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.
5) Excavation cost is based on hourly rate of $130.61 for 2CY track loader (E2000-17030217); With 300 CY/ 8hr, rate is approxi. $ 3.48/CY
6) Costs for Hauling to staging area are based on $3.49/CY (02320-0200). Cost for excavation and hauling is approx. $7/CY

Present Worth Analysis
Sediment Alternative 3 - Limited Removal and Disposal (Beach Area)
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/09/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (I = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$3,032,000			$3,032,000
1	0.962		$73,223		$70,474
2	0.926		$73,223		$67,829
3	0.892		$73,223		$65,283
4	0.858		$73,223		$62,833
5	0.826		$73,223	$21,500	$78,231
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$73,223	$21,500	$64,610
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$73,223	$21,500	$53,361
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$73,223	$21,500	$44,070
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$73,223	$21,500	$36,397
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$73,223	$21,500	$30,060
		TOTAL PRESENT WORTH =			$3,605,148
					$3,605,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Sediment Alternative 4: Removal and Disposal Option A

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consisting of soil borings/cores advanced to further determine the grain size and nature of the sediments and to delineate lateral extent of contaminants exceeding the PRGs. Assume 25 soil borings at an average 5-foot depth with associate analytical costs for PAHs, arsenic, and geotechnical testing.

   - Mobilization/demobilization @ $33,750
   - Sample collection @ $600 each or $15,000
   - Analytical @ $283/sample for 55 samples including QA/QC samples or $15,565
   - Data validation $6,600
   - Reporting @ $5,000
   - Oversight and management @ $5,500

   Total costs approx. = $81,415.

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. It is assumed that no subgrade preparation will be required prior to dredging/excavating the contaminated sediments. Large debris and boulders will be removed from the sediments after they have been dredged, but prior to dewatering.

4. Erosion controls will be provided to reduce migration of sediments during the dredging operations by means of a silt boom. The silt boom will be anchored in the subtidal area around the perimeter of the dredge area.

5. Temporary excavator causeway will be constructed at the SD-410 Location to excavate near shore contaminated sediments. The causeway will be built at a height of 12' (approximately 2' above the water level) and will be of graded crushed gravel base. The road will be of 20' wide at the top and 42' at the base with 1:1 slope. A total of approximately 215 cy of crushed stone (RIDOT R-3) will be required. At a cost of $21.56 per cy of installed stone (ECHOS 026112205), cost is estimated at $4,650. Excavation will be carried out using trackhoe with extended reach arm. Wider slopes and additional material that may be required to shore the causeway would fall within the 25% contingency.

6. A portable cofferdam system (Portadam) will be erected around the excavation area as shown in Figure 2-4 (orange and blue areas, with the exception of the area near SD-410). The area will be dewatered as needed with pumps so that the excavation of the sediments can occur in dry conditions. An estimated 5,930 cy will be excavated in this manner. It is assumed that the portadam will be installed in two phases. According to the vendor estimates, it should take 8 days to install phase 1 (eastern half), 8-10 days to remove phase I and install phase II (western half), and 5-7 days to remove the structures.

7. Excavation, Backfilling, and Disposal work

   - Approximately 1.77 acres of area will be dredged to a depth of 2 feet (Beach area) and 0.20 acres of area will be dredged to a depth of one feet (Near shore area but not including eel grass area) to remove contaminated sediment. The volume of contaminated sediments to

be removed from the beach area and the near shore area is approximately 5,716 and 214 cy, respectively.

- It is assumed that OFFTA area will be used as a materials staging, dewatering, and project office area at no cost. Dewatered dredge spoils will be staged at this area pending transport to the TSDF/off-site landfill.

- It is assumed that over-the-road transport of waste will be done with out need for any improvements to the bridge near the site.

- Water quality testing will be performed daily during dredging removal activities. It assumed that three samples would be collected daily from outside of the silt curtain work area. Samples will be analyzed for PAHs, arsenic, and total suspended solids (TSS).

- Dry excavated sediments will be screened and hauled directly to the landfill from the excavation site. Backfill materials will be placed immediately following removal of the contaminated sediments.

- Access to the work area will be from along the western side of OFFTA Excavation, handling, and placement of materials will be accomplished using tracked excavators, a wheeled front-end loader, screener, and off-road dump trucks at a rate of 600 cy/day. Costs include a survey crew to verify grades during placement.

- The backfill materials consisting of sand/gravel/stone will be placed over an area approximately 82,974 SF. Assuming a bulking factor of 20%, approximately 7,234 cy of backfill will be placed. Also, since 20% of the dredged material (1,447 cy) will be screened and re-used, only 5,787 cy of material will be required from off-site sources.

- Because of low contamination levels, it is assumed that most of the sediment can be disposed of at RCRA-D landfill. For the estimation purposes, 90% of the sediment (after backfill) is assumed to be disposed of at RCRA-D landfill, 9% of sediment will need stabilization after which it would be disposed of at RCRA-D landfill, and 1% of sediment would be disposed of at TSDF (RCRA-C).

- The costs for disposal are as per recent project (Melville Landfill). TSDF disposal (to Model City, NY) is $120 per ton (as per Carl Tippman of Foster Wheeler) and RCRA-D disposal is $70 per ton (disposal cost from Fall River Landfill) including transportation.

O&M COST ASSUMPTIONS:

1. Long-term Monitoring:

Long term monitoring will be conducted for two purposes. First, the subtidal area (station SD-410) where sediments will still contain COCs above PRG concentrations will be monitored for ecological risk parameters to determine if the removal of the source areas and the intertidal sediments have a positive effect on these sediments over the long term, and to evaluate the effectiveness of the remedy every five years. Secondly, the monitoring effort will evaluate the remediated area to assure these sediments are not becoming recontaminated from other sources. The sediment program outlined below will accommodate both objectives, and will be conducted at the same intervals.

a. Analyses:
- Sediment chemistry (PAHs, arsenic); 12 samples plus 2 QC samples
- Biota chemistry 2 samples (PAHs, arsenic);
- Toxicity Amphipod; 2 samples
- Toxicity Arabacia; 2 samples

b. Labor Costs: (1 event/year)
- Sediment sampling: Sample collection with equipment and crew = approximately $485/sample. Collection of 12 samples = $5,820 (QC samples collected at no additional cost)
- Biota sampling: Sample collection with equipment and crew = approximately $1043/sample. Collection of 2 samples = $2,086
- Project mgmt/coord. ≈ 20 hours/year @ $80/hr (w/O&P) = $1,600
- Annual: add $300 M&IE; ODCs & supplies @ $200; & shipping @ $200.
- Data Validation $6,969.
- Report prep. $6,230.

Total Labor ≅ $23,205 annually for years 1-5 and at 5 -year review cycles

c. Estimated analytical costs:
- Sediment chemistry (PAHs, arsenic) $283/sample @ 14 samples/yr = $3,962
- Biota chemistry (PAHs, arsenic) @ $1100/sample @ 2 samples/yr = $2,200
- Toxicity Amphipod @ $863/ sample @ 2 samples/yr = $1,726
- Toxicity Arabacia @ $662/ sample @ 2 samples/yr = $1,324

Total Analytical ≅ $9,212 annually for years 1-5 and at 5 -year review cycles

2. Inspection for Habitat Recovery:

Qualitative inspections to be performed by an Marine Biologist: Assume 2 days (8 hr/day) for inspection and travel and 2 days (16 hr) to prepare an inspection report. 32 hours total @ $80/hr = $2,560 plus $300 ODCs & travel costs, and $2,000 equipment costs (boat and underwater video). Total quarterly Inspection costs are $4,860. Total annual costs are $19,440 1-5 years and every 5 years for 5-30 years.

3. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event Assumed only one review to occur in year 5 because virtually all sediment > PRGs will be removed.

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 4 - REMOVAL AND DISPOSAL OPTION A
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
1- PRE-DESIGN INVESTIGATION												
1.1 Sediment/soil borings and analyses	1	ls	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	See Assumptions
2 - MOBILIZATION/DEMOBILIZATION												
2.1 Office trailer (1 each)	6	mo	$400.00	$0.00	$0.00	$0.00	$2,400.00	$0.00	$0.00	$0.00	$2,400.00	Historical data -300 CY/d
2.2 Portable communication equipment sets	4	ea	$400.00	$0.00	$0.00	$0.00	$1,600.00	$0.00	$0.00	$0.00	$1,600.00	Historical data-McAllister
2.3 Equipment mob./demob. (support equip)	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	Historical data-McAllister
2.4 Site utility hook-ups (electric, phone, etc.)	1	ls	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	Historical data-McAllister
2.5 Site utilities	6	mo	$4,000.00	$0.00	$0.00	$0.00	$24,000.00	$0.00	$0.00	$0.00	$24,000.00	Historical data-McAllister
2.6 Pick-up truck (rental, 3 each)	6	mo	$2,850.00	$450.00	$0.00	$0.00	$17,100.00	$2,700.00	$0.00	$0.00	$19,800.00	Historical data-McAllister
2.7 Certification/close-out reports	1	ea	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$27,000.00	Historical data-McAllister
3 - PERSONNEL AND EQUIPMENT DECON. FACILITIES AND SERVICES												
3.1 Personnel decon. trailer	6	mo	$1,500.00	$0.00	$200.00	$0.00	$9,000.00	$0.00	$1,200.00	$0.00	$10,200.00	Vendor catalog
3.2 PPE rolloff cont.	6	mo	$500.00	$0.00	$0.00	$0.00	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	Historical data-McAllister
4 - SITE MANAGEMENT STAFFING												
4.1 Site manager	480	hr	$0.00	$0.00	$36.00	$0.00	$0.00	$0.00	$17,280.00	$0.00	$17,280.00	Historical data-McAllister
4.2 Site engineer	960	hr	$0.00	$0.00	$32.00	$0.00	$0.00	$0.00	$30,720.00	$0.00	$30,720.00	Historical data-McAllister
4.3 Site supervisor/foreman	960	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$28,800.00	$0.00	$28,800.00	Historical data-McAllister
4.4 Site safety officer	960	hr	$0.00	$0.00	$25.00	$0.00	$0.00	$0.00	$24,000.00	$0.00	$24,000.00	Historical data-McAllister
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT												
5.1 Project manager	96	hr	$0.00	$0.00	$45.00	$0.00	$0.00	$0.00	$4,320.00	$0.00	$4,320.00	Historical data-McAllister
5.2 Project administrator	180	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$5,400.00	$0.00	$5,400.00	Historical data-McAllister
5.3 Health and safety director	60	hr	$0.00	$0.00	$35.00	$0.00	$0.00	$0.00	$2,100.00	$0.00	$2,100.00	Historical data-McAllister
5.4 Procurement/subcontracting	240	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$7,200.00	$0.00	$7,200.00	Historical data-McAllister
5.5 Clerical support	240	hr	$0.00	$0.00	$12.50	$0.00	$0.00	$0.00	$3,000.00	$0.00	$3,000.00	Historical data-McAllister
6 - REMOVAL/WATER TREATMENT												
6.1 Beach Debris Removal/disposal at RCRA D Landfill	500	ton	$75.00	$0.00	$0.00	$0.00	$37,500.00	$0.00	$0.00	$0.00	$37,500.00	Fall River Landfill - $5 for removal and transport, & $70 for disposal
6.2 Nearshore Debris Removal/Disposal at RCRA D Landfill	50	ton	$75.00	$0.00	$0.00	$0.00	$3,750.00	$0.00	$0.00	$0.00	$3,750.00	Fall River Landfill - $5 for removal and transport, & $70 for disposal
6.3 Erosion control, silt boom	3,000	lf	$0.00	$10.00	$4.00	$4.00	$0.00	$30,000.00	$12,000.00	$12,000.00	$54,000.00	Historical data-McAllister
6.4 Mob/Demob (shore based equip.)	1	ls	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	Vendor Info.
6.5 Staging area preparation, maintenance, and removal	1	ls	$0.00	$1,000.00	$7,000.00	$3,000.00	$0.00	$1,000.00	$7,000.00	$3,000.00	$11,000.00	Vendor Info.
6.6 Temperory excavator causeway construction	1	ls	$4,650.00	$0.00	$0.00	$0.00	$4,650.00	$0.00	$0.00	$0.00	$4,650.00	Historical data-McAllister
6.7 Temperory Portadam	1	ls	$130,368.50	$0.00	$0.00	$0.00	$130,368.50	$0.00	$0.00	$0.00	$130,368.50	Vendor Quote
6.8 Excavation equipment mob./demob.	1	ls	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	Historical data-McAllister
6.9 Excavate/haul beach sediments (Includes 20 % bulking factor)	6,859	cy	$7.00	$0.00	$0.00	$0.00	$48,014.40	$0.00	$0.00	$0.00	$48,014.40	E-1703-0217/023200020
6.10 Excavate and haul nearshore sediments (Includes 20 % bulking factor)	256	cy	$7.00	$0.00	$0.00	$0.00	$1,792.00	$0.00	$0.00	$0.00	$1,792.00	E-1703-0217/023200020
6.11 Dredge water treatment	36	day	$4,500.00	$0.00	$0.00	$0.00	$160,092.00	$0.00	$0.00	$0.00	$160,092.00	Vendor Info.
6.12 Sediment confirmation testing	25	ea	$883.00	$0.00	$0.00	$0.00	$22,075.00	$0.00	$0.00	$0.00	$22,075.00	Historical data-McAllister
6.13 Water quality testing	36	day	$3,600.00	$50.00	$200.00	$150.00	$128,073.60	$1,778.80	$7,115.20	$5,336.40	$142,304.00	Historical data-McAllister
6.14 Disposal/trans. - RCRA D Landfill	6,404	ton	$70.00	$0.00	$0.00	$0.00	$448,257.60	$0.00	$0.00	$0.00	$448,257.60	Vendor Info.
6.15 Disposal/trans. - RCRA D Landfill w/stabilization	640	ton	$90.00	$0.00	$0.00	$0.00	$57,633.12	$0.00	$0.00	$0.00	$57,633.12	Vendor Info.
6.16 Disposal/trans.- RCRA C Landfill	71	ton	$120.00	$0.00	$0.00	$0.00	$8,538.24	$0.00	$0.00	$0.00	$8,538.24	Vendor Info.(Modelcity,NY)

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 4 - REMOVAL AND DISPOSAL OPTION A
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
7 - BACKFILL PLACEMENT												
7.1 Beach imported sand/gravel backfill (2 ft)	5,487	cy	$0.00	$15.00	$4.93	$11.23	$0.00	$82,310.40	$27,052.68	$61,623.05	$170,986.14	Vendor Info.
7.2 Beach screened sand/gravel backfill (2 ft)	1,372	cy	$0.00	$0.00	$4.93	$11.23	$0.00	$0.00	$6,763.17	$15,405.76	$22,168.93	Vendor Info.
7.3 Nearshore imported sand/gravel backfill (1 ft)	205	cy	$25.17	$15.00	$1.66	$0.00	$5,154.82	$3,072.00	$339.97	$0.00	$8,566.78	Vendor Info.
7.4 Nearshore screened sand/gravel backfill (1 ft)	51	vy	$25.17	$0.00	$1.66	$0.00	$1,288.70	$0.00	$84.99	$0.00	$1,373.70	Vendor Info.
7.5 Water quality monitoring (3 samples/day)	12	day	$3,600.00	$50.00	$200.00	$150.00	$42,691.20	$592.93	$2,371.73	$1,778.80	$47,434.67	Historical/Vendor
Subtotal							$1,303,394	$123,454	$201,748	$102,144	$1,730,740	
Overhead on Labor Cost @ 30%									$60,524		$60,524	
G & A on Labor Cost @ 10%									$20,175		$20,175	
G & A on Material Cost @ 10%								$12,345			$12,345	
G & A on Subcontract Cost @ 10%							$130,339				$130,339	
Total Direct Cost							$1,433,734	$135,800	$282,447	$102,144	$1,954,124	
Indirects on Total Direct Labor Cost @ 75%									$211,835		$211,835	
Profit on Total Direct Cost @ 10%											$195,412	
Subtotal											$2,361,372	
Health & Safety Monitoring @ 6%											$141,682	
Cost adjustment for location @ 7%											$165,296	
Total Field Cost											$2,668,350	
Contingency on Total Field Cost @ 25%											$667,087	
Engineering on Total Field Cost @ 6%											$160,101	
TOTAL COST											$3,495,538	
											$3,496,000	

Notes
G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:

1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.
5) Excavation cost is based on hourly rate of $130.61 for 2CY track loader (E2000-17030217); With 300 CY/ 8hr, rate is approxi. $ 3.48/CY
6) Costs for Hauling to staging area are based on $3.49/CY (02320-0200). Cost for excavation and hauling is approx. $7/CY

Present Worth Analysis
Sediment Alternative 4 - Removal and Disposal Option A
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/09/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$3,496,000			$3,496,000
1	0.962		$51,857		$49,910
2	0.926		$51,857		$48,037
3	0.892		$51,857		$46,234
4	0.858		$51,857		$44,498
5	0.826		$51,857	$21,500	$60,585
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$51,857	$21,500	$50,036
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$51,857	$21,500	$41,325
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$51,857	$21,500	$34,130
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$51,857	$21,500	$28,187
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$51,857	$21,500	$23,280
		TOTAL PRESENT WORTH =			$3,922,222
					$3,922,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

Sediment Alternative 5: Removal and Disposal Option B

CAPITAL COST ASSUMPTIONS:

1. Pre-Design Investigation (PDI)

   PDI consisting of soil borings/cores advanced to further determine the grain size and nature of the sediments and to delineate lateral extent of contaminants exceeding the PRGs. Assume 25 soil borings at an average 5-foot depth with associate analytical costs for PAHs, arsenic, and geotechnical testing.

   - Mobilization/demobilization @ $33,750
   - Sample collection @ $600 each or $15,000
   - Analytical @ $283/sample for 55 samples including QA/QC samples or $15,565
   - Data validation $6,600
   - Reporting @ $5,000
   - Oversight and management @ $5,500

   Total costs approx. = $81,415.

2. Mobilization/Demobilization includes providing office trailers, temporary utilities and sanitary facilities, delivery and removal of major construction equipment, and providing all other facilities and materials needed by the management staff.

3. It is assumed that no subgrade preparation will be required prior to dredging/excavating the contaminated sediments. Large debris and boulders will be removed from the sediments after they have been dredged, but prior to dewatering.

4. Erosion controls will be provided to reduce migration of sediments during the dredging operations by means of a silt boom. The silt boom will be anchored in the subtidal area around the perimeter of the dredge area.

5. Temporary excavator causeway will be constructed at the SD-410 Location to excavate near shore contaminated sediments. The causeway will be built at a height of 12' (approximately 2' above the water level) and will be of graded crushed gravel base. The road will be of 20' wide at the top and 42' at the base with 1:1 slope. A total of approximately 215 cy of crushed stone (RIDOT R-3) will be required. At a cost of $21.56 per cy of installed stone (ECHOS 026112205), cost is estimated at $4,650. Excavation will be carried out using trackhoe with extended reach arm. Wider slopes and additional material that may be required to shore the causeway would fall within the 25% contingency.

6. A portable cofferdam system (Portadam) will be erected around sampling points OFF-3, OFF-5, and OFF-6 as shown in Figure 2-4 (three rightmost blue areas). The area will be continuously dewatered with pumps so that the excavation of the sediments can occur in dry conditions. An estimated 312.5 cy will be excavated in this manner. It is assumed that the portadam will be installed in two phases. According to the vendor estimates, it should take 5 days to install phase 1 (OFF-5 , 255 ft), 7-8 days to remove phase I and install phase II (OFF-3 (105 ft) and OFF-6 (150 ft)), and 3-4 days to remove the structures.

7. Excavation, Backfilling, and Disposal work

   - Approximately 1.77 acres of area will be dredged to a depth of 2 feet (Beach area) and 0.24 acres of area will be dredged to a depth of one feet (Near shore area including eel grass

area) to remove contaminated sediment. The volume of contaminated sediments to be removed from the beach area and the near shore area is approximately 5,716 and 290 cy, respectively.

- It is assumed that OFFTA area will be used as a materials staging, dewatering, and project office area at no cost. Dewatered dredge spoils will be staged at this area pending transport to the TSDF/off-site landfill.

- It is assumed that over-the-road transport of waste will be done with out any improvements to the bridge near the site.

- Water quality testing will be performed daily during dredging removal activities. It assumed that three samples would be collected daily from outside of the silt curtain work area. Samples will be analyzed for PAHs, arsenic, and total suspended solids (TSS).

- Dry excavated sediments will be screened and hauled directly to the landfill from the excavation site. Backfill materials will be placed immediately following removal of the contaminated sediments.

- Access to the work area will be from along the western side of OFFTA Excavation, handling, and placement of materials will be accomplished using tracked excavators, a wheeled front-end loader, screener, and off-road dump trucks at a rate of 600 cy/day. Costs include a survey crew to verify grades during placement.

- The backfill materials consisting of sand/gravel/stone will be placed over an area approximately 85,013 SF. Assuming a bulking factor of 20%, approximately 7,234 cy of backfill will be placed. Also, since 20% of the dredged material (1,447 cy) will be screened and re-used, only 5,787 cy of material will be required from off-site sources.

- Because of low contamination levels, it is assumed that most of the sediment can be disposed of at RCRA-D landfill. For the estimation purposes, 90% of the sediment (after backfill) is assumed to be disposed of at RCRA-D landfill, 9% of sediment will need stabilization after which it would be disposed of at RCRA-D landfill, and 1% of sediment would be disposed of at TSDF (RCRA-C).

- The costs for disposal are as per recent project (Melville Landfill). TSDF disposal (to Model City, NY) is $120 per ton (as per Carl Tippman of Foster Wheeler) and RCRA-D disposal is $70 per ton (disposal cost from Fall River Landfill) including transportation.

O&M COST ASSUMPTIONS:

1. Long-term Monitoring:

Long term monitoring will be conducted to assure that remediated areas are not being recontaminated by other sources and by sediment movement. The long term monitoring program will provide data to support the five year review reports. Long term monitoring will be conducted annually for the first five years, then every five years thereafter.

Analyses:
- Sediment chemistry (PAHs, arsenic); 12 samples plus 2 QC samples

Labor: (1 event/year)

- Sediment sampling: Sample collection with equipment and crew = approximately $485/sample. Collection of 12 samples = $5,820 (QC samples collected at no additional cost).
- Project mgmt/coord. ≈ 20 hours/year @ $80/hr (w/O&P) = $1,600
- Annual: add $300 M&IE; ODCs & supplies @ $200; & shipping @ $200.
- Data Validation $6,969.
- Report prep. $6,230.

Total Labor ≅ $21,119 Per event.

Estimated analytical costs:

- Sediment chemistry (PAHs, arsenic) $283/sample @ 12 samples/yr = $3,396

Total Analytical ≅ $3,396 per event.

2. Inspection for Habitat Recovery - annually for the first five years, then every five years thereafter:

   Qualitative inspections to be performed by an Marine Biologist: Assume 2 days (8 hr/day) for inspection and travel and 2 days (16 hr) to prepare an inspection report. 32 hours total @ $80/hr = $2,560 plus $300 ODCs & travel costs, and $2,000 equipment costs (boat and underwater video). Total quarterly Inspection costs are $4,860. Total annual costs are $19,440 each event.

3. 5-year reviews at 200 Level of Effort (LOE) @ $100/hr. Approx. $1500 ODCs. Total = $ 21,500 per event Assumed only one review to occur in year 5 because virtually all sediment > PRGs will be removed.

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 5 - REMOVAL AND DISPOSAL OPTION B
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
1- PRE-DESIGN INVESTIGATION												
1.1 Sediment/soil borings and analyses	1	ls	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	$0.00	$0.00	$0.00	$81,415.00	See Assumptions
2 - MOBILIZATION/DEMOBILIZATION												
2.1 Office trailer (1 each)	6	mo	$400.00	$0.00	$0.00	$0.00	$2,400.00	$0.00	$0.00	$0.00	$2,400.00	Historical data -300 CY/d
2.2 Portable communication equipment sets	4	ea	$400.00	$0.00	$0.00	$0.00	$1,600.00	$0.00	$0.00	$0.00	$1,600.00	Historical data-McAllister
2.3 Equipment mob./demob. (support equip)	1	ls	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	$0.00	$0.00	$0.00	$40,000.00	Historical data-McAllister
2.4 Site utility hook-ups (electric, phone, etc.)	1	ls	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	Historical data-McAllister
2.5 Site utilities	6	mo	$4,000.00	$0.00	$0.00	$0.00	$24,000.00	$0.00	$0.00	$0.00	$24,000.00	Historical data-McAllister
2.6 Pick-up truck (rental, 3 each)	6	mo	$2,850.00	$450.00	$0.00	$0.00	$17,100.00	$2,700.00	$0.00	$0.00	$19,800.00	Historical data-McAllister
2.7 Certification/close-out reports	1	ea	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$7,000.00	$2,000.00	$15,000.00	$3,000.00	$27,000.00	Historical data-McAllister
3 - PERSONNEL AND EQUIPMENT DECON. FACILITIES AND SERVICES												
3.1 Personnel decon. trailer	6	mo	$1,500.00	$0.00	$200.00	$0.00	$9,000.00	$0.00	$1,200.00	$0.00	$10,200.00	Vendor catalog
3.2 PPE roll off cont.	6	mo	$500.00	$0.00	$0.00	$0.00	$3,000.00	$0.00	$0.00	$0.00	$3,000.00	Historical data-McAllister
4 - SITE MANAGEMENT STAFFING												
4.1 Site manager	480	hr	$0.00	$0.00	$36.00	$0.00	$0.00	$0.00	$17,280.00	$0.00	$17,280.00	Historical data-McAllister
4.2 Site engineer	960	hr	$0.00	$0.00	$32.00	$0.00	$0.00	$0.00	$30,720.00	$0.00	$30,720.00	Historical data-McAllister
4.3 Site supervisor/foreman	960	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$28,800.00	$0.00	$28,800.00	Historical data-McAllister
4.4 Site safety officer	960	hr	$0.00	$0.00	$25.00	$0.00	$0.00	$0.00	$24,000.00	$0.00	$24,000.00	Historical data-McAllister
5 - HOME OFFICE PROJECT MANAGEMENT AND SUPPORT												
5.1 Project manager	96	hr	$0.00	$0.00	$45.00	$0.00	$0.00	$0.00	$4,320.00	$0.00	$4,320.00	Historical data-McAllister
5.2 Project administrator	180	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$5,400.00	$0.00	$5,400.00	Historical data-McAllister
5.3 Health and safety director	60	hr	$0.00	$0.00	$35.00	$0.00	$0.00	$0.00	$2,100.00	$0.00	$2,100.00	Historical data-McAllister
5.4 Procurement/subcontracting	240	hr	$0.00	$0.00	$30.00	$0.00	$0.00	$0.00	$7,200.00	$0.00	$7,200.00	Historical data-McAllister
5.5 Clerical support	240	hr	$0.00	$0.00	$12.50	$0.00	$0.00	$0.00	$3,000.00	$0.00	$3,000.00	Historical data-McAllister
6 - REMOVAL/WATER TREATMENT												
6.1 Beach Debris Removal/disposal at RCRA D Landfill	500	ton	$75.00	$0.00	$0.00	$0.00	$37,500.00	$0.00	$0.00	$0.00	$37,500.00	Fall River Landfill - $5 for removal and transport, & $70 for disposal
6.2 Nearshore Debris Removal/Disposal at RCRA D Landfill	50	ton	$75.00	$0.00	$0.00	$0.00	$3,750.00	$0.00	$0.00	$0.00	$3,750.00	Fall River Landfill - $5 for removal and transport, & $70 for disposal
6.3 Erosion control, silt boom	3,000	lf	$0.00	$10.00	$4.00	$4.00	$0.00	$30,000.00	$12,000.00	$12,000.00	$54,000.00	Historical data-McAllister
6.4 Mob/Demob (shore based equip.)	1	ls	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	$0.00	$0.00	$0.00	$5,000.00	Vendor Info.
6.5 Staging area preparation, maintenance, and removal	1	ls	$0.00	$1,000.00	$7,000.00	$3,000.00	$0.00	$1,000.00	$7,000.00	$3,000.00	$11,000.00	Vendor Info.
6.6 Temperory excavator causeway construction	1	ls	$4,650.00	$0.00	$0.00	$0.00	$4,650.00	$0.00	$0.00	$0.00	$4,650.00	Historical data-McAllister
6.7 Temperory Portadam	2	ls	$130,368.50	$0.00	$0.00	$0.00	$260,737.00	$0.00	$0.00	$0.00	$260,737.00	Vendor Quote
6.8 Excavation equipment mob./demob.	1	ls	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	$0.00	$0.00	$0.00	$10,000.00	Historical data-McAllister
6.9 Excavate/haul beach sediments (Includes 20% bulking factor)	6,859	cy	$7.00	$0.00	$0.00	$0.00	$48,014.40	$0.00	$0.00	$0.00	$48,014.40	E-1703-0217/023200020
6.1 Excavate and haul nearshore sediments (includes 20% bulking factor)	348.0	cy	$7.00	$0.00	$0.00	$0.00	$2,436.00	$0.00	$0.00	$0.00	$2,436.00	E-1703-0217/023200020
6.11 Dredge water treatment	36	day	$4,500.00	$0.00	$0.00	$0.00	$162,162.00	$0.00	$0.00	$0.00	$162,162.00	Vendor Info.
6.12 Sediment confirmation testing	25	ea	$883.00	$0.00	$0.00	$0.00	$22,075.00	$0.00	$0.00	$0.00	$22,075.00	Historical data-McAllister
6.13 Water quality testing	36	day	$3,600.00	$50.00	$200.00	$150.00	$129,729.60	$1,801.80	$7,207.20	$5,405.40	$144,144.00	Historical data-McAllister
6.14 Disposal/trans. - RCRA D Landfill	6,486	ton	$70.00	$0.00	$0.00	$0.00	$454,053.60	$0.00	$0.00	$0.00	$454,053.60	Vendor Info.
6.15 Disposal/trans. - RCRA D Landfill w/stabilization	649	ton	$90.00	$0.00	$0.00	$0.00	$58,378.32	$0.00	$0.00	$0.00	$58,378.32	Vendor Info.
6.16 Disposal/trans.- RCRA C Landfill	72	ton	$120.00	$0.00	$0.00	$0.00	$8,648.64	$0.00	$0.00	$0.00	$8,648.64	Vendor Info (Modelcity,NY)

CAPITAL COST ESTIMATE
SEDIMENT ALTERNATIVE 5 - REMOVAL AND DISPOSAL OPTION B
OFFTA FEASIBILITY STUDY
NAVSTA NEWPORT
NEWPORT, RHODE ISLAND

FINAL

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal Direct Cost	Comments/Source
7 - BACKFILL PLACEMENT												
7.1 Beach imported sand/gravel backfill (2 ft)	5,487	cy	$0.00	$15.00	$4.93	$11.23	$0.00	$82,310.40	$27,052.68	$61,623.05	$170,986.14	Vendor Info.
7.2 Beach screened sand/gravel backfill (2 ft)	1,372	cy	$0.00	$0.00	$4.93	$11.23	$0.00	$0.00	$6,763.17	$15,405.76	$22,168.93	Vendor Info.
7.3 Nearshore imported sand/gravel backfill (1 ft)	278.4	cy	$25.17	$15.00	$1.66	$0.00	$7,007.33	$4,176.00	$462.14	$0.00	$11,645.47	Vendor Info.
7.4 Nearshore screened sand/gravel backfill (1 ft)	69.6	cy	$25.17	$0.00	$1.66	$0.00	$1,751.83	$0.00	$115.54	$0.00	$1,867.37	Vendor Info.
7.6 Eelgrass beds restoration	2,039	sf	$5.00	$0.00	$0.00	$0.00	$10,195.00	$0.00	$0.00	$0.00	$10,195.00	Assumption
7.5 Water quality monitoring (3 samples/day)	12	day	$3,600.00	$50.00	$200.00	$150.00	$43,243.20	$600.60	$2,402.40	$1,801.80	$48,048.00	Historical/Vendor
Subtotal							$1,457,847	$124,589	$202,023	$102,236	$1,886,695	
Overhead on Labor Cost @ 30%									$60,607		$60,607	
G & A on Labor Cost @ 10%									$20,202		$20,202	
G & A on Material Cost @ 10%								$12,459			$12,459	
G & A on Subcontract Cost @ 10%							$145,785				$145,785	
Total Direct Cost							$1,603,632	$137,048	$282,832	$102,236	$2,125,748	
Indirects on Total Direct Labor Cost @ 75%									$212,124		$212,124	
Profit on Total Direct Cost @ 10%											$212,575	
Subtotal											$2,550,447	
Health & Safety Monitoring @ 6%											$153,027	
Cost adjustment for location @ 7%											$178,531	
Total Field Cost											$2,882,005	
Contingency on Total Field Cost @ 25%											$720,501	
Engineering on Total Field Cost @ 6%											$172,920	
TOTAL COST											$3,775,426	
Notes											**$3,775,000**	

G & A - General and Administrative
ODC - Other Direct Costs

References used for cost estimates:

1) Means Heavy Construction Cost Data, 2000, R.S. Means Co., Inc., Kingston, MA
2) Echos Environmental Remediation Unit Cost ,2000, 6th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
3) Echos Environmental Remediation Assemblies Cost , 1998, 4th Annual Edition, Delta Technologies Group, Inc., Englewood, CO
4) Historical data based on competitive bids submitted by subcontractors or actual costs at this or other sites.
5) Excavation cost is based on hourly rate of $130.61 for 2CY track loader (E2000-17030217); With 300 CY/ 8hr. rate is approxi. $ 3.48/CY
6) Costs for Hauling to staging area are based on $3.49/CY (02320-0200). Cost for excavation and hauling is approx. $7/CY

Present Worth Analysis
Sediment Alternative 5 - Removal and Disposal Option B
OFFTA Feasibility Study
NAVSTA Newport
Newport, Rhode Island
07/09/02

PRESENT WORTH ANALYSIS

YEAR	PRESENT WORTH FACTOR (i = 3.9%)	CAPITAL COSTS	O & M COSTS	5-YEAR COSTS	PRESENT WORTH
0	1.000	$3,775,000			$3,775,000
1	0.962		$43,955		$42,305
2	0.926		$43,955		$40,717
3	0.892		$43,955		$39,189
4	0.858		$43,955		$37,718
5	0.826		$43,955	$21,500	$54,059
6	0.795		$0		$0
7	0.765		$0		$0
8	0.736		$0		$0
9	0.709		$0		$0
10	0.682		$43,955	$0	$29,981
11	0.656		$0		$0
12	0.632		$0		$0
13	0.608		$0		$0
14	0.585		$0		$0
15	0.563		$43,955	$0	$24,761
16	0.542		$0		$0
17	0.522		$0		$0
18	0.502		$0		$0
19	0.483		$0		$0
20	0.465		$43,955	$0	$20,450
21	0.448		$0		$0
22	0.431		$0		$0
23	0.415		$0		$0
24	0.399		$0		$0
25	0.384		$43,955	$0	$16,890
26	0.370		$0		$0
27	0.356		$0		$0
28	0.343		$0		$0
29	0.330		$0		$0
30	0.317		$43,955	$0	$13,949
		TOTAL PRESENT WORTH =			$4,095,019
					$4,095,000

Discount rate of 3.9% as per Office of Management and Budget, Circular No. A-94,

APPENDIX G

GROUNDWATER MODEL FOR CONTAMINANT REMOVAL BY FLUSHING

Groundwater Model for Contaminant Removal by Flushing

The Feasibility Study Report presents alternatives for the removal of contaminated soils from the OFFTA site. Once the source material is removed, infiltrating recharge water and upgradient groundwater will flush out the residual contamination in the aquifer beneath the site. A continuous flushing model (Brusseau, 1996) was developed to estimate the time required for the natural system to flush out contaminants of concern after the source material has been removed. The continuous flushing model is an analytical solution to the governing equation for a mixed reactor system with linear reversible sorption. It was used to estimate the time required for groundwater concentrations of benzene, 2-methylnaphthalene, naphthalene, arsenic, lead, and manganese to reach cleanup levels everywhere within the fenced boundaries of the OFFTA site. (Even though arsenic was not selected as a contaminant of concern, it was included in the model because of its contribution to the site risk and its proposed MCL of 10 ug/L.)

The continuous flushing model assumes:

- the aquifer is homogenous and isotropic,
- groundwater flow is one-dimensional and steady state,
- sorption is linear, reversible, and rapid,
- the aquifer behaves as a mixed flow reactor, and
- the source material is contained within the fenced portion of the OFFTA site.

Definitions of input parameters and rationales used to select parameter values are outlined in Tables 1 and 2. The model output is presented in the last column of Table 3. According to the continuous flushing model, the estimated cleanup times for benzene, 2-methylnaphthalene, naphthalene, arsenic, lead, and manganese are 2 years, 19 years, 16 years, 70 years, 182 years, and 676 years, respectively. The model predicts that it takes only 315 days (0.86 years) to flush one pore volume of water through the OFFTA groundwater system. The contaminants are not completely removed from the system after 315 days, because they are present both in the groundwater and on the aquifer surfaces. Moreover, the cleanup times are not the same for all contaminants, because the contaminants differ in their propensity to sorb to the aquifer surfaces. The affinity of a contaminant for mineral surfaces and grain coatings is reflected in the value of the distribution coefficient (K_d). Contaminants with large K_ds tend to partition to the aquifer solids and are flushed out of the system relatively slowly. Contaminants with small K_ds tend to partition to the groundwater and are flushed out of the system relatively rapidly. The affinity of a contaminant for mineral surfaces and grain coatings is governed by many factors including: the chemical character of the solute, the composition of the aquifer's solid surfaces, and the groundwater chemistry.

Nonionic organic contaminants such as benzene and naphthalene tend to prefer organic surfaces to mineral surfaces or water. Their K_ds are based on the solubility of the compound and the quantity of organic carbon coating the aquifer surfaces (f_{oc}). Benzene is flushed out of the OFFTA groundwater system more rapidly than naphthalene because it is more soluble in water.

The mobility of arsenic and lead in groundwater is primarily a function of the types of complexes formed in solution, the affinities of the contaminants for the aquifer solids, and the solubilities of minerals containing the contaminants. The mobility of lead is limited in most natural waters because: 1) several insoluble lead minerals can control its solubility over a broad range of pH and solution compositions, and 2) lead has a strong affinity for clay, organic matter, and oxide surfaces. Lead mobility decreases as pH increases, because lead is a cation and the net charge on organic matter, oxide, and pH-dependent clay surfaces becomes more negative as

pH increases. Groundwater beneath the OFFTA site has a near neutral pH, so lead tends to partition to the solid phase and is flushed out of the system very slowly.

The partitioning behavior of arsenic is more complex. Arsenic can occur in a variety of valence states. Under oxidizing to mildly reducing conditions in the pH range of 4 to 9, the dominant species is As(V). The mobility of As(V) in groundwater is controlled by adsorption onto oxide particles and grain coatings. If the adsorption capacity of these surfaces is not surpassed, As(V) movement will be strongly retarded by its high affinity for these surfaces. Since As(V) occurs in groundwater as an anion, its affinity for oxide surfaces increases as the pH of the system decreases.

Under more reducing conditions As(III) is the dominant species. As(III) sorbs less strongly to oxide surfaces than does As(V), so it is more mobile. If the redox potential is low enough, metal oxides may no longer be stable and As(III) mobility may be even greater. However, if hydrogen sulfide is present in a strong reducing environment, dissolved arsenic concentrations will be limited by the precipitation of arsenic sulfides.

Groundwater pH and dissolved oxygen concentrations were monitored during low flow sampling in 1997. In nearly all of the sampled monitoring wells, solution pH ranged from 6.5 to 7.5, and dissolved oxygen readings were less than 1.0 mg/L. These measurements indicate the groundwater generally has a near neutral pH and a fairly low redox potential. It is not clear whether the redox potential is low enough to reduce arsenic to the +3 state, but even if arsenic is in the +5 state it will be relatively mobile because it sorbs less strongly to oxides in nonacidic environments. Spitz and Moreno (1996) list three distribution coefficients for arsenic in noncalcareous sandy and loamy soils: 0.005 ft^3/kg, > 1.38 ft^3/kg, and > 2.76 ft^3/kg. Arsenic at the OFFTA site was modeled with a K_d value of 0.276 ft^3/kg to reflect its relative mobility in groundwater with a near neutral pH and a fairly low redox potential.

The estimated cleanup times listed in Table 3 are based on average values for several hydrogeologic parameters. Actual cleanup times will vary across the site due to variations in travel distances, hydraulic gradients, and soil properties. Residual contamination near the interior of the site will tend to take longer to flush through the system than contamination near the shoreline. Contaminants traveling along flow paths with relatively low hydraulic gradients will tend to be flushed out of the system more slowly than those traveling along paths with steeper gradients. Contaminants should flush more quickly through the coarse sands and gravels at the site, because these soils usually have high hydraulic conductivities and low organic carbon and oxide grain coating contents. By contrast, contaminants should be flushed out of the till and silt units more slowly, because they tend to have relatively low hydraulic conductivities and high organic carbon and oxide grain coating contents. [The flushing model assumes all soils are fine to medium sands with silt and gravel, since this is the dominant soil type at the OFFTA site (TtNUS, 2001).]

The flushing model results are very sensitive to changes in the hydraulic conductivity, hydraulic gradient, and distribution coefficient. Order of magnitude changes in any one of these three input parameters, produces order of magnitude changes in predicted cleanup times. Fortunately, the hydraulic conductivity and hydraulic gradient values used in the model are fairly well constrained, because they are based on site-specific measurements. On the other hand, there are no site-specific data to constrain the distribution coefficients used to represent the sorptive behavior of the contaminants. It is uncertain how well the literature values used in the model represent the actual f_{oc} and K_d values for the OFFTA soils and contaminants. If site

specific f_{oc} and K_d data were collected and incorporated into the model, it would reduce the uncertainties associated with the model results and improve estimates of cleanup times.

Summary

A continuous flushing model was developed for the OFFTA site in order to estimate the time required for the natural system to flush residual contamination out of the aquifer after the overlying contaminated soils have been removed. According to the model, the estimated cleanup times for benzene, 2-methylnaphthalene, naphthalene, arsenic, lead, and manganese are 2 years, 19 years, 16 years, 70 years, 182 years, and 676 years, respectively. The long cleanup times for arsenic, lead, and manganese are due to their propensity to partition to the aquifer soils and resist flushing. Although pumping and treating the contaminated groundwater would accelerate flushing, sorption/desorption processes would limit improvements in cleanup times.

Table 1

Model Parameter	Dimensions	Definition
K_{oc}	$[L^3/M]$	organic carbon partition coefficient
f_{oc}	[ ]	fraction of organic carbon
K_d	$[L^3/M]$	distribution coefficient
B_d	$[M/L^3]$	soil bulk density
n	[ ]	soil porosity
R	[ ]	retardation factor
C_t	$[M/L^3]$	cleanup target concentration
C_o	$[M/L^3]$	initial concentration
A_p	$[L^2]$	area of contaminated groundwater in plan view
b	[L]	aquifer thickness
V_o	$[L^3]$	volume of contaminated groundwater (i.e. pore volume)
P	[L]	perimeter of downgradient edge of plume
A_d	$[L^2]$	discharge area
I	[ ]	horizontal hydraulic gradient
K	[L/T]	hydraulic conductivity
Q	$[L^3/T]$	discharge
T_t	[ ]	number of pore volumes required to reach cleanup target $= R[-\ln(C_t/C_o)]$
t_r	[T]	hydraulic residence time
t_t	[T]	time required to reach cleanup target $= t_r * T_t$ $= (V_o/Q)T_t$

Table 2

Model Parameter	Justification for Model Value(s)
K_{oc}	The organic carbon partition coefficients for benzene and naphthalene were obtained from laboratory measurements (Karickhoff et al., 1979; Rogers et al., 1980; Chiou et al., 1983).
f_{oc}	The fraction of soil organic carbon was estimated from published measures of f_{oc} for similar soils (USEPA, 1998).
K_d	Distribution coefficients for benzene and naphthalene were calculated from their K_{oc} and f_{oc} values. Distribution coefficients for arsenic and lead were derived from published adsorption data (Davis et al., 1993; Spitz and Moreno, 1996).
B_d	Soil bulk density was estimated from published measures of B_d for similar soils (USEPA, 1998).
n	Soil porosity was estimated from published measures of n for similar soils (USEPA, 1998).
C_t	Cleanup target concentrations were U.S. EPA MCLs for arsenic and benzene, the U.S. EPA action level for lead, and the RIDEM GA groundwater objective for naphthalene.
C_o	Initial contaminant concentrations were based on 1997 unfiltered, low flow groundwater sampling results. The model used the maximum detected concentration for arsenic, benzene, and naphthalene, because only 2 of the 15 groundwater samples contained detectable concentrations of these contaminants. The model used the mean detectable concentration for lead, since lead was detected in 10 of the 15 samples.
A_p	The model assumes the area of contaminated aquifer in plan view is the area inside the fenced portion of the OFFTA site.
b	The model assumes the overbuden aquifer is 15 feet thick. The sensitivity analysis demonstrates the cleanup time is not affected by the value selected for aquifer thickness.
P	The discharge perimeter is the length of the shoreline within the fenced portion of the OFFTA site.
I	The mean horizontal hydraulic gradient was computed from values presented in the OFFTA RI report (TtNUS, 2001). The mean horizontal hydraulic gradient used in the model was the average of the high tide and low tide gradients for January 1994 and July 1994.
K	The overburden hydraulic conductivity was taken from the OFFTA RI report (TtNUS, 2001).

Table 3

	Koc (ft^3/kg)	foc ()	Bd (kg/ft^3)	n ()	Ct (ug/L)	Co (ug/L)	Ap (ft^2)	b (ft)	Vo (ft^3)	K (ft/d)	I ()	P (ft)	Ad (ft^2)	Q (ft^3/d)	Kd (ft^3/kg)	R ()	Tt ()	tt = (Vo/Q)*Tt (years)
Arsenic	---	---	45.3	0.25	10	49.8	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.276	51	82	**70**
Lead	---	---	45.3	0.25	15	29	2.0E+05	15	735000	15	0.01	1040	15600	2340	1.766	321	212	**182**
Manganese	---	---	45.3	0.25	291	3367	2.0E+05	15	735000	15	0.01	1040	15600	2340	1.766	321	786	**676**
2-Methylnapthalene	300.61	0.001	45.3	0.25	128	190	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.301	55	22	**19**
Naphthalene	45.49	0.001	45.3	0.25	20	150	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.045	9	19	**16**
Benzene	2.23	0.001	45.3	0.25	5	33	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.002	1	3	**2**

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Model for contaminant removal by flushing

OBJECTIVE: Determine the number of pore volumes and the time required for contaminant to reach the cleanup target.

ASSUMPTIONS:
Aquifer is homogenious and isotropic.
Groundwater flow is steady state.
Sorption is linear, reversible, and rapid.
Aquifer is a perfectly mixed flow reactor (i.e. incoming clean water mixes completely within the aquifer in a time interval that is small relative to the hydraulic residence time).

DEFINITIONS:

Koc = organic carbon partition coefficient [L^3/M]
foc = fraction organic carbon [dimensionless]
Kd = distribution coefficient [L^3/M]
Bd = soil bulk density [M/L^3]
n = porosity [dimensionless]
R = retardation factor [dimensionless]
Ct = Cleanup target [M/L^3]
Co = initial concentration [M/L^3]
Ap = area of contaminated groundwater in plan view [L^2]
b = aquifer thickness [L]
Vo = volume of contaminated groundwater associated with aquifer (pore volume) [L^3]
P = perimeter of downgradient edge of plume [L]
Ad = discharge area [L^2]
I = hydraulic gradient in horizontal direction perpendicular to equipotentials [dimensionless]
K = hydraulic conductivity [L/T]
Q = discharge [L^3/T]

$Tt = R[-\ln(Ct/Co)]$ — Tt = Number of pore volumes required to reach cleanup target [dimensionless]
tr = hydraulic residence time [T]

$tt = tr*Tt = (Vo/Q)Tt$ — tt = time required to reach cleanup target [T]

	Koc (ft^3/kg)	foc ()	Bd (kg/ft^3)	n ()	Ct (ug/L)	Co (ug/L)	Ap (ft^2)	b (ft)	Vo (ft^3)	K (ft/d)	I ()	P (ft)	Ad (ft^2)	Q (ft^3/d)	Kd (ft^3/kg)	R ()	Tt ()	tt = (Vo/Q)*Tt (years)
Arsenic	---	---	45.3	0.25	10	49.8	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.276	51	82	**70**
Lead	---	---	45.3	0.25	15	29	2.0E+05	15	735000	15	0.01	1040	15600	2340	1.766	321	212	**182**
Manganese	---	---	45.3	0.25	291	3367	2.0E+05	15	735000	15	0.01	1040	15600	2340	1.766	321	786	**676**
2-Methylnapthalene	300.61	0.001	45.3	0.25	128	190	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.301	55	22	**19**
Naphthalene	45.49	0.001	45.3	0.25	20	150	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.045	9	19	**16**
Benzene	2.23	0.001	45.3	0.25	5	33	2.0E+05	15	735000	15	0.01	1040	15600	2340	0.002	1	3	**2**

REFERENCES:
Brusseau, M.L.. 1996. Evaluation of Simple Methods for Estimating Contaminant Removal by Flushing. *Ground Water*, 34(1) p. 19-22.

SOLUTION FOR MAXIMUM DRAWDOWN (S max.) IN A FULLY PENETRATING PUMPING WELL AT MAXIMUM DISCHARGE (from M.J. Gefell, et al, GROUNDWATER, MAY-JUNE, 1994)

S max. = $\{-b+/-[b^2-4ac]^{0.5}\}/2a$

a = [1/ln(R/r)]

b = -2{r+[H/ln(R/r)]}

c = 2rH

where

S max. = maximum water-table drawdown, ft
R = estimated radius of influence, ft
r = well effective radius, or radius of borehole w/ filter pack, ft
H = aquifer saturated thickness, ft
K = horizontal hydraulic conductivity, ft/day

Newport OFFTA	
r =	0.42
H =	15
K =	15
R =	201
a =	0.162
b =	-5.702
c =	12.6
S max. =	2.37

(KOZENY, 1953) SOLUTION FOR MAXIMUM GRAVITY DRAINAGE INTO A FULLY PENETRATING PUMPING WELL AT MAXIMUM DRAWDOWN (from M.J. Gefell, et al, GROUNDWATER, MAY-JUNE, 1994)

Q max. = AKi = 2(3.14)rhK

Q max. = maximum pumping rate at total drawdown in well, gpm
A = surface area of seepage face into well, ft^2
K =aquifer hydraulic conductivity, ft/day
i = 1, unit hydraulic gradient with steady state gravity drainage
r = well effective radius, or radius of borehole w/ filter pack, ft
h = saturated thickness at well, or height of seepage face into well, ft
h = H - S max., ft **(see calculation above for S max.)**

Newport OFFTA		
K =	15	
r =	0.42	
for h,	h, feet	Q, gpm
Q =	12.63	2.60

GROUNDWATER FLOW MODEL INPUTS
Newport OFFTA - Eight Recovery Wells Scenario

Model Used: EPA WHPA - MWCAP (EPA , Office of Groundwater, Version 2.0, March 1991).

```
UNITS USED FOR SIMULATION =   1
   0 = METERS AND DAYS
   1 = FEET AND DAYS

COORDINATE LIMITS OF STUDY AREA
     XMIN =    -750.00
     XMAX =     750.00
     YMIN =    -500.00
     YMAX =     250.00

MAXIMUM STEP LENGTH =      10.00

NUMBER OF WELLS =     8

                              WELL NUMBER    1

                          X COORDINATE =     -393.7
                          Y COORDINATE =      210.0
                       WELL DISCHARGE =      250.0
                       TRANSMISSIVITY =      225.0
                   HYDRAULIC GRADIENT =   0.010000
                ANGLE OF AMBIENT FLOW =      90.00
                     AQUIFER POROSITY =       0.25
                    AQUIFER THICKNESS =      15.00
                        BOUNDARY TYPE = STREAM BOUNDARY
        DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
          SELECTED CAPTURE ZONE OPTION = HYBRID
                    TRAVEL TIME VALUE =     730.00
                 NUMBER OF PATHLINES =          8

                              WELL NUMBER    2

                          X COORDINATE =     -281.2
                          Y COORDINATE =      210.0
                       WELL DISCHARGE =      250.0
                       TRANSMISSIVITY =      225.0
                   HYDRAULIC GRADIENT =   0.010000
                ANGLE OF AMBIENT FLOW =      90.00
                     AQUIFER POROSITY =       0.25
                    AQUIFER THICKNESS =      15.00
                        BOUNDARY TYPE = STREAM BOUNDARY
        DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
          SELECTED CAPTURE ZONE OPTION = HYBRID
                    TRAVEL TIME VALUE =     730.00
                 NUMBER OF PATHLINES =          8

                              WELL NUMBER    3

                          X COORDINATE =     -168.7
```

```
                    Y COORDINATE =      210.0
                  WELL DISCHARGE =      250.0
                  TRANSMISSIVITY =      225.0
             HYDRAULIC GRADIENT =   0.010000
          ANGLE OF AMBIENT FLOW =      90.00
               AQUIFER POROSITY =       0.25
              AQUIFER THICKNESS =      15.00
                  BOUNDARY TYPE = STREAM BOUNDARY
DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
   SELECTED CAPTURE ZONE OPTION = HYBRID
             TRAVEL TIME VALUE =     730.00
           NUMBER OF PATHLINES =          8

                    WELL NUMBER    4

                    X COORDINATE =      -56.2
                    Y COORDINATE =      210.0
                  WELL DISCHARGE =      250.0
                  TRANSMISSIVITY =      225.0
             HYDRAULIC GRADIENT =   0.010000
          ANGLE OF AMBIENT FLOW =      90.00
               AQUIFER POROSITY =       0.25
              AQUIFER THICKNESS =      15.00
                  BOUNDARY TYPE = STREAM BOUNDARY
DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
   SELECTED CAPTURE ZONE OPTION = HYBRID
             TRAVEL TIME VALUE =     730.00
           NUMBER OF PATHLINES =          8

                    WELL NUMBER    5

                    X COORDINATE =       56.2
                    Y COORDINATE =      210.0
                  WELL DISCHARGE =      250.0
                  TRANSMISSIVITY =      225.0
             HYDRAULIC GRADIENT =   0.010000
          ANGLE OF AMBIENT FLOW =      90.00
               AQUIFER POROSITY =       0.25
              AQUIFER THICKNESS =      15.00
                  BOUNDARY TYPE = STREAM BOUNDARY
DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
   SELECTED CAPTURE ZONE OPTION = HYBRID
             TRAVEL TIME VALUE =     730.00
           NUMBER OF PATHLINES =          8

                    WELL NUMBER    6

                    X COORDINATE =      168.7
                    Y COORDINATE =      210.0
                  WELL DISCHARGE =      250.0
                  TRANSMISSIVITY =      225.0
             HYDRAULIC GRADIENT =   0.010000
          ANGLE OF AMBIENT FLOW =      90.00
               AQUIFER POROSITY =       0.25
```

```
                    AQUIFER THICKNESS =      15.00
                        BOUNDARY TYPE = STREAM BOUNDARY
       DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
         SELECTED CAPTURE ZONE OPTION = HYBRID
                    TRAVEL TIME VALUE =     730.00
                 NUMBER OF PATHLINES =          8

                          WELL NUMBER    7

                       X COORDINATE =      281.2
                       Y COORDINATE =      210.0
                     WELL DISCHARGE =      250.0
                     TRANSMISSIVITY =      225.0
                 HYDRAULIC GRADIENT =   0.010000
              ANGLE OF AMBIENT FLOW =      90.00
                   AQUIFER POROSITY =       0.25
                    AQUIFER THICKNESS =      15.00
                        BOUNDARY TYPE = STREAM BOUNDARY
       DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
         SELECTED CAPTURE ZONE OPTION = HYBRID
                    TRAVEL TIME VALUE =     730.00
                 NUMBER OF PATHLINES =          8

                          WELL NUMBER    8

                       X COORDINATE =      393.7
                       Y COORDINATE =      210.0
                     WELL DISCHARGE =      250.0
                     TRANSMISSIVITY =      225.0
                 HYDRAULIC GRADIENT =   0.010000
              ANGLE OF AMBIENT FLOW =      90.00
                   AQUIFER POROSITY =       0.25
                    AQUIFER THICKNESS =      15.00
                        BOUNDARY TYPE = STREAM BOUNDARY
       DISTANCE FROM WELL TO BOUNDARY =      40.00
ORIENTATION OF LOCAL COORDINATE SYSTEM =     270.00
         SELECTED CAPTURE ZONE OPTION = HYBRID
                    TRAVEL TIME VALUE =     730.00
                 NUMBER OF PATHLINES =          8
```

CLIENT: NAVSTA Newport		JOB NUMBER: CTO 833	
SUBJECT: Design Extraction Well System for Groundwater Plume Capture, OFFTA Site			
BASED ON: RI data, EPA WHPA Model		DRAWING NO.:	
BY: J. Davis	CHECKED BY:	APPROVED BY:	DATE: July 2002

PPROBLEM:

Design a system of groundwater extraction wells with a capture zone sufficient to mitigate the groundwater plume area at the OFFTA site. Based on the monitoring wells that exceed the PRGs for groundwater, almost the entire OFFTA site is underlain by impacted groundwater. Therefore it is necessary for the capture zone to encompass most of the site.

DATA:

Data presented in the RI Report were used to select aquifer parameters required to model the effects of groundwater extraction wells on the surficial aquifer. The model inputs are listed on the "Groundwater Flow Model Inputs" sheet following this calculation sheet. Prior to modeling, the "maximum gravity drainage for a fully penetrating well" in the surficial aquifer was estimated to limit the proposed pumping rate to be modeled (see following sheet). This calculation indicated that the upper limit of pumping would be about 2.6 gpm per well (for noninterfering wells). However, anecdotal evidence from experience at the site suggests that a pumping rate of 2.6 gpm per well would be difficult to sustain. Half of that amount, 1.3 gpm, was therefore used to estimate the capture zone. In addition to the pumping rate, the "radius of influence" (required for estimating the maximum gravity drainage) for pumping conducted in the surficial aquifer was estimated using an analytical solution (see following sheet).

MODEL:

The Multiple Well Capture Zone Module (MWCAP) computational code provided in the US EPA WHAP, "A Modular Semi-Analytical Model for the Delineation of Wellhead Protection Areas", Office of Ground Water, March 1991, was used to simulate the capture zone for groundwater extraction wells proposed in Groundwater Alternative 3. The MWCAP code delineates steady-state, time-related or hybrid capture zones for pumping wells in homogeneous aquifer with steady and uniform ambient ground-water flow. The code can simulate the effects of a nearby body of water (e.g., Narragansett Bay) where groundwater is discharging. However, the effects of well interference in multi-well systems are ignored and each well is assumed to operate independently of each other. The two major assumptions for the MWCAP code are 1) flow in the aquifer is at steady state, and 2) flow in the aquifer is horizontal. For the problem at OFFTA, both of these assumptions are reasonable. And, if the well spacing avoids aggressive overlapping of each well's capture zone, then little error should be introduced by the model's assumption of independent extraction wells.

RESULTS:

Professional judgement, trial and error, and the model simulations were used to determine the final scenario of eight extraction wells at OFFTA. The goal was to balance the number of wells with the pumping rate required to capture the plume.

Several combinations of pumping rate and number of extraction wells were simulated. The MWCAP model was run for two years to estimate the capture zone over time. The model simulation is shown on the following figure. As shown on the figure, an extraction rate of 1.3 gpm at each of eight extraction wells is sufficient to capture the groundwater flowing beneath OFFTA (i.e., as indicated by overlapping capture zones). Significant interference by induced flow from the Narragansett Bay is not indicated by the model simulation.

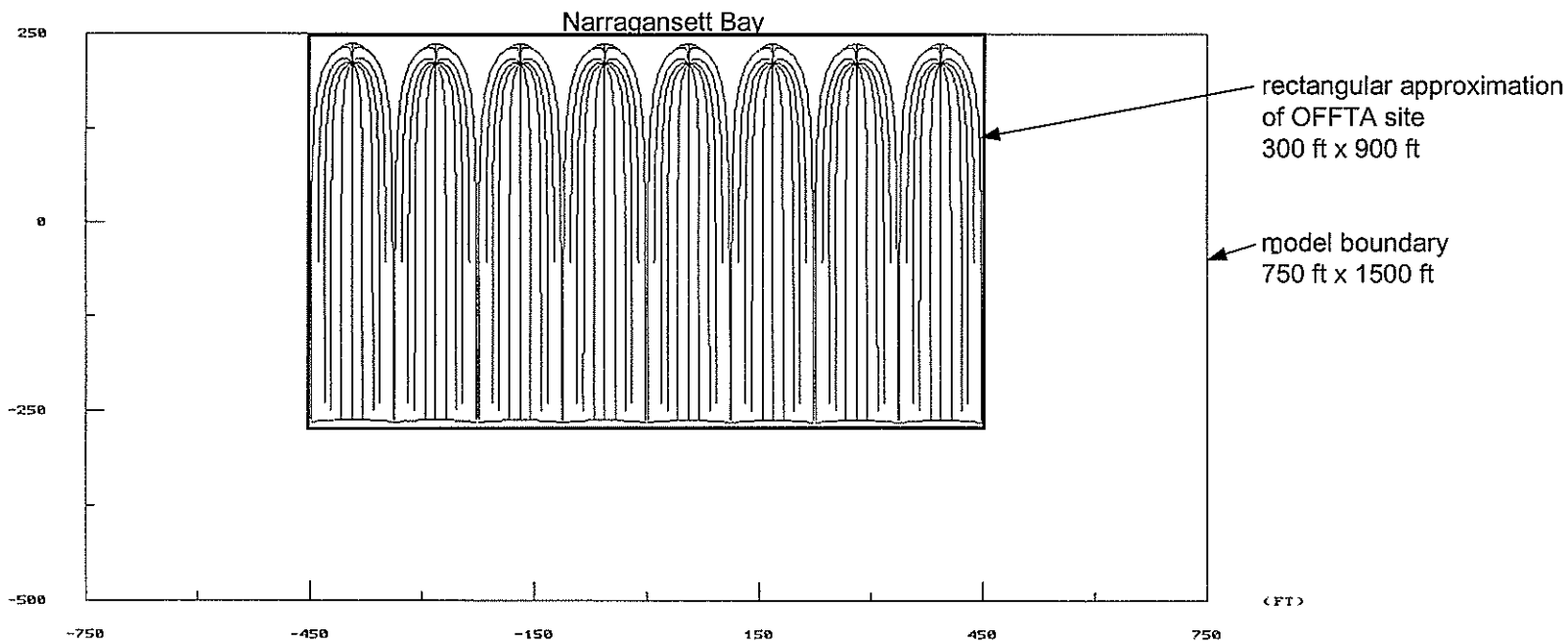
CONCLUSIONS:

A pumping rate of 1.3 gpm for each of eight recovery wells located across the northern perimeter of OFFTA should be sufficient to capture a potential groundwater plume that underlies all of the site. The capture zones of each well will begin to overlap at steady state, assuming no significant recharge, and well interference may increase the capture zone. In addition, no affects from Narragansett Bay are anticipated.

The simulated capture zone indicates that all of the water (i.e., one pore volume) beneath the contaminated area of OFFTA can be extracted within approximately 2 years of pumping. A pilot pump test should be performed at OFFTA to validate the aquifer parameters used in the modeling and to support the final extraction well design.

FIGURE F-1
RECOVERY WELL CAPTURE ZONE
FEASIBILITY STUDY
OLD FIRE FIGHTING TRAINING AREA
NAVSTA NEWPORT, NEWPORT, RHODE ISLAND

- 8 recovery wells pumping at 1.3 gpm each
- steady-state capture zone at 2 years shown



Tetra Tech, Inc. **CALCULATION WORKSHEET** PAGE 1 OF 1

CLIENT NAVSTA Newport	JOB NUMBER CTO 833
SUBJECT Estimate Radius of Influence for Recovery Wells at OFFTA	
BASED ON	DRAWING NUMBER

BY	CHECKED BY	APPROVED BY	DATE
J. Davis			July 2002

Problem: Estimate Radius of Influence, R_o, for a well pumping from the surficial aquifer

Equation: Equation to estimate the order of magnitude of R_o (Powers, 1981)

$$R_o = r_w + \sqrt{\frac{Tt}{C_s}}$$

where r_w = well radius, ft
T = aquifer transmissivity
$= Kb$
K = hydraulic conductivity
b = saturated thickness
t = time of pumping, days
C_s = aquifer specific yield

Data: K = 15 ft/day, taken from OFFTA RI (TtNUS, 2001)
b = 15 ft
C_s = 0.167, which is 1/3 of total pore volume (assuming $n = 0.25$)
r_w = 0.42 ft, assuming 6 inch well in 10 inch borehole with filter pack
t = assume recovery well reaches steady state in 30 days

Calculation:

$$R_o = 0.42\text{ft} + \sqrt{\frac{(15\text{ ft/d})(15\text{ ft})(30\text{ d})}{0.167}}$$

$$R_o = \underline{\underline{201\text{ ft}}}$$

Reference: Powers, J.P., 1981. Construction Dewatering, John Wiley & Sons.