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1994

EPA Superfund
Record of Decision:

NAVAL UNDERSEA WARFARE ENGINEERING STATION (4 WASTE AREAS)
EPA ID: WA1170023419
OU 02
KEYPORT, WA
09/01/1994

NORTHWEST AREA
COMPREHENSIVE
LONG-TERM
ENVIRONMENTAL
ACTION NAVY

FINAL
RECORD OF DECISION
for Operable Unit 2

Naval Undersea Warfare Center Division
Keyport, Washington
CTO-0010

September 1994

ENGINEERING FIELD ACTIVITY
NORTHWEST, NAVAL FACILITIES
ENGINEERING COMMAND
CONTRACT #N62474-89-D-9295

THE URS TEAM
URS Consultants
Science Applications
International Corp.
Shannon & Wilson, Inc.

FINAL

RECORD OF DECISION

FOR THE

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY
(CLEAN) NORTHWEST AREA

OPERABLE UNIT 2
AREAS 2, 3, 5, 8, and 9

NAVAL UNDERSEA WARFARE CENTER
DIVISION KEYPORT
CONTRACT TASK ORDER NO. 0010

PREPARED BY:

URS CONSULTANTS, INC.
SEATTLE, WASHINGTON

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PREPARED FOR:

ENGINEERING FIELD ACTIVITY, NORTHWEST
WESTERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND
SILVERDALE, WASHINGTON

SEPTEMBER 1994

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Naval Undersea Warfare Center (NUWC) Division
Operable Unit 2, Areas 2, 3, 5, 8, and 9
Keyport, Washington

STATEMENT OF BASIS AND PURPOSE

The NUWC Division, Keyport site consists of two operable units: Operable Unit 1 addresses Area 1, and operable Unit 2 addresses the remaining Areas. The site was split into two operable units because of public concerns about the Area 1 landfill. This was done to allow more time to consider alternatives for Area 1 while proceeding to a decision for the other Areas.

This decision document presents the selected remedial action for Operable Unit 2, chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and, to the extent practicable, the National Contingency Plan. This decision is based on the administrative record file for this site.

The lead agency for this decision is the United States Navy (Navy). The United States Environmental Protection Agency (EPA) approves of this decision and with the Washington State Department of Ecology (Ecology), has participated in scoping the site investigation and in evaluating alternatives for remedial action. The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDIES

This operable unit is the second of two that are planned for the site. The first operable unit will address contamination associated with the Area 1 landfill at the site. Remedial actions for the first operable unit have not yet been selected. The second operable unit addresses contamination associated with the remaining Areas of the site (Areas 2, 3, 5, 8 and 9). Major components of the selected remedies include:

- Area 2: Implementation of institutional controls and groundwater monitoring.

- Area 3: No action.

- Area 5: Limited groundwater sampling to confirm no action.

- Area 8: Excavation of vadose zone soil hot spots in two phases. The soil will be transported for off-site land disposal in accordance with Resource Conservation and Recovery Act requirements. Implementation of institutional controls and monitoring of groundwater, sediments, and shellfish.

- Area 9: Limited sediment sampling to confirm no action.

STATUTORY DETERMINATIONS

The selected remedies are protective of human health and the environment, comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. The remedies utilize permanent solutions and alternative treatment technologies to the maximum extent practicable for this site. However, because treatment of the principal risks of the site was not found to be practicable, these remedies do not satisfy the statutory preference for treatment as a principal element of the remedy. The low contaminant concentrations at Area 2 preclude a remedy in which the contamination could be treated in a cost-effective manner. The proximity to Liberty Bay, depth of contamination, and lack of space at Area 8 cause implementation constraints that preclude a remedy in which contaminants court be treated effectively onsite. Instead, contaminants in soil hot spots excavated from the vadose zone will be treated offsite as necessary to comply with the Resource Conservation and Recovery Act (RCRA) requirements for land disposal.

Because the remedies for Areas 2 and 8 will result in hazardous substances remaining onsite above concentrations allowing unlimited use and exposure, a review will be conducted within 5 years after commencement of remedial actions to ensure that the remedies continue to provide adequate protection of human health and the environment.

Signature sheet for the Naval Undersea Warfare Center Division, Keyport Operable Unit 2 Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

______________________________________ ______________________________

Dennis K. Gibbs, Captain, USN — Date
Commander, Naval Undersea Warfare Center Division, Keyport
United States Navy

Signature sheet for the Naval Undersea Warfare Center Division, Keyport Operable Unit 2 Record of Decision between the United States Navy and the United States Environmental Protection Agency, wish concurrence by the Washington State Department of Ecology.

Chuck Clark — Date
Regional Administrator, Region 10
United States Environmental Protection Agency

Signature sheet for the Naval Undersea Warfare Center Division, Keyport Operable Unit 2 Record of Decision between the United States Navy and the United States Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Carol Kraege — Date
Acting Program Director
Toxics Cleanup Program
Washington State Department of Ecology

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TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

ARAR - applicable or relevant and appropriate requirement
bgs - below ground surface
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R. - Code of Federal Regulations
COPC - chemical of potential concern
DNAPL - dense non-aqueous phase liquid
Ecology - Washington State Department of Ecology
EPA - U.S. Environmental Protection Agency
FFA - Federal Facilities Agreement
FS - Feasibility Study
HI - hazard index
HPLC - high pressure liquid chromatograph
HQ - hazard quotient
LD-50 - lethal dose for 50 percent of the exposed population
LOEL- lowest-observed-effects level
MCL - maximum contaminant level
MSL- mean sea level
MTCA - Model Toxics Control Act
NACIP - Navy Assessment and Control of Installation Pollutants
NOEL - no-observed-effects level
NPL - National Priorities List
NUWC - Naval Undersea Warfare Center
O&M - operation and maintenance
OU - Operable Unit
PAH - polynuclear aromatic hydrocarbon
PGDN - propylene glycol dinitrate
PSAPCA - Puget Sound Air Pollution Control Agency
PUD - public utility district
RAO - remedial action objective
RCRA - Resource Conservation and Recovery Act
RfD - reference dose
RI - Remedial Investigation
RME - reasonable maximum exposure
ROD - Record of Decision
SARA - Superfund Amendments and Reauthorization Act
SQS - Sediment quality standard
SVOC - semivolatile organic compound
TCLP - toxicity characteristic leaching procedure
TRV - toxicological reference value
UCL - upper confidence limit
U.S.C. - United States Code
VOC - volatile organic compound
WAC - Washington Administrative Code

DECISION SUMMARY

1.0 INTRODUCTION

The following Sections comprise the Decision Summary of the Record of Decision (ROD). Sections 2.0 through 6.0 describe the site, present the site history and enforcement activities, summarize the highlights of community participation, and describe the scope and role of the response actions and the remedial investigation (RI) and feasibility study (FS) methods for Operable Unit 2 (OU 2) of the Naval Undersea Warfare Center (NUWC) Division, Keyport site as a whole. Sections 7.0 through 13.0 present the remaining components of the Decision Summary for each of the five sub-sites within OU 2 individually.

2.0 SITE NAME, LOCATION AND DESCRIPTION

NUWC Division, Keyport occupies 340 acres (including tidelands) adjacent to the town of Keyport in Kitsap County, Washington, on a small peninsula in the central portion of Puget Sound (Figure 2-1). The peninsula is bordered by Liberty Bay on the east and north and by Port Orchard inlet on the southeast (Figure 2-2). Communities in the vicinity of NUWC Division, Keyport include Keyport, Poulsbo, Brownsville, Silverdale, Lemolo, and the Port Madison Indian Reservation. Except for the town of Keyport, most of the land use close to NUWC Division, Keyport is low-density residential.

The NUWC Division, Keyport National Priorities List (NPL) site is shown in Figure 2-2. The site was split into the following areas of concern:

- Area 1 - Keyport Landfill
- Area 2 - Van Meter Road Spill/Drum Storage Area
- Area 3 - Otto Fuel Leak Area
- Area 5 - Sludge Disposal Area
- Area 8 - Plating Shop Waste/Oil Spill Area
- Area 9 - Liberty Bay

OU 2 consists of Areas 2, 3, 5, 8, and 9. A description and history are given for each of these Areas in Section 3.0.

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2.1 GEOLOGY AND GROUNDWATER RESOURCES

During the Quatenary Period (last 2 million years), the Puget lowland was repeatedly covered by continental ice sheets which advanced from the north and often extended beyond Olympia, Washington. Characteristic sedimentary deposits were formed during the advance and retreat of these glaciers, as well as during interglacial periods. These glacial and nonglacial deposits are over 1,000 feet thick and overlie much older bedrock. Most water wells in the central and northern part of Kitsap County are completed in these Quaternary deposits, typically in glacial sands and gravels, which lie above bedrock.

In Kitsap County over a dozen major regional geologic units have been identified above bedrock. These units include generally coarse-grained glacial deposits and generally fine-grained nonglacial deposits. These fine-grained nonglacial deposits include a thick silt and clay unit present throughout the Keyport area which is informally termed the Clover Park unit. Throughout most of the Keyport area, the Clover Park unit is about 100 feet thick with its top near sea level and is regional in extent. While the Clover Park unit generally behaves as a regional aquitard, at least one location was encountered (at Area 8) where it has been thinned significantly by erosion. Both above and below the Clover Park unit are multiple water-bearing zones separated by other aquitards. Those water-bearing zones above the Clover Park unit are collectively called the "shallow aquifer" and those below are called the "deep aquifer."

Almost all of the water wells in the area are completed in the glacial deposits above bedrock. Approximately 25 water wells within one-half mile of NUWC Division, Keyport were identified from state and county records. Most domestic wells tap the upper aquifer system. The well that supplies NUWC Division, Keyport (BW-5), as well as the two public utility district (PUD) water wells that supply much of the town of Keyport and the surrounding area, are completed in the deep aquifers below the Clover Park aquitard. Four older base wells (now abandoned) were also screened in the lower aquifers.

The various strata encountered at this site are as follows:

- Artificial fill was identified at each of the five terrestrial Areas.

- Organic-rich silty or sandy marsh/tide flat deposits underlie the fill at Areas 2 and 3.

- Estuary or beach sand was identified below these deposits at OU 1.

- Vashon recessional outwash is uncommon or forms only a thin veneer on till except at Area 3 where it is up to several feet thick.

- Vashon till was identified at Areas 3 and 5. Till appears to be localized in extent and forms lenticular deposits.

- Vashon advance outwash was identified at all Areas. At Area 2, all or much of the Vashon glacial deposits have been eroded prior to deposition of the estuary or marsh sediment.

Nonglacial fluvial and other floodplain deposits are present at Area 2. At Areas 3, 5, and 8, these deposits may have been present but were probably eroded prior to Vashon deposition. At these Areas, it is probable that Vashon advance outwash extends down to the Clover Park unit.

Groundwater flow in the shallow aquifer at NUWC Division, Keyport generally follows surface topography (Figure 2-3). Groundwater near Area 2 flows northeasterly discharging to the shallow lagoon. Groundwater near Area 3 flows generally southward, discharging to the shallow lagoon and an adjacent marsh. A groundwater divide separates groundwater flowing toward Dogfish Bay from groundwater flowing toward Liberty Bay. This divide trends between OU 1 and Area 3 and is located northwest of Area 2. Net groundwater flow at Area 8 is toward Liberty Bay, although there are temporary flow reversals near the shore during high tides.

2.2 SURFACE WATER RESOURCES

Marine or brackish water bodies on and near the site consist of Liberty Bay, Dogfish Bay, the tide flats, a marsh, and the shallow lagoon. Freshwater bodies include two creeks feeding into the marsh pond, and two creeks in the vicinity of Area 2 that feed the lagoon; (Figure 2-4). Tidal fluctuations in Liberty Bay affect the shallow lagoon and groundwater around the lagoon to a small extent. Liberty Bay tidal fluctuations have a larger effect on shallow groundwater immediately adjacent to the bay. There is no known domestic or industrial use of surface water at NUWC Division, Keyport.

2.3 DEMOGRAPHICS

As of August 1994, over 3,600 people work at the station. Of these, 278 are military personnel, 2,817 are civilians, and approximately 500 are contractors. About 87 people (including 48 children) live on the NUWC Division, Keyport site; the residential area is located in the north-central portion of the site. Several areas onsite are used for recreation.

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The closest off-site residential area is the community of Keyport, to the northwest of the station with an estimated population of 35O. Keyport has a few small businesses, including a grocery store, motel, tavern, and marina. This marina and a short fishing pier are located on Liberty Bay at the town of Keyport. Some Keyport homes are located on the waterfront at Dogfish Bay and Liberty Bay.

Except for the small community of Keyport, most of the area surrounding the station has low density residences. The city of Poulsbo (population 4,850) lies about 2 miles northwest of Keyport, across Liberty Bay. There is considerable tourism in the Poulsbo area, mostly during the summer months. Poulsbo has three marinas, which are very popular in summer. A small residential area known as Lemolo lies directly across Liberty Bay from NUWC Division, Keyport. The Port Madison Indian Reservation (population 4,834) lies about one half mile northeast of the base across Liberty Bay. Silverdale (population 7,660) lies about 5.5 miles to the southwest of Keyport.

2.4 BIOLOGICAL RESOURCES

Land uses at NVWC Division, Keyport include industrial facilities, operation support areas, wetlands, tide lands, a lagoon, forest lands, and residential areas.

Recreational shellfish harvesting historically occurred in the tide flats. Due to occurrences of unpredictable nonpoint pollution events, the Washington Department of Health classified parts of Liberty Bay as "restricted" for commercial shellfish (bivalve) harvesting io 1991. ("Restricted" means that shellfish from such areas cannot be marketed directly but must first be relayed through an "Approved" growing area.)

In addition, the Bremerton-Kitsap County Health District has issued a Public Health Advisory and posted signs saying that shellfishing in Liberty Bay is not recommended due to inconsistent water quality. In 1987, NUWC Division, Keyport closed its own beaches on Liberty Bay to shellfish harvesting.

Dogfish Bay continues to be used for recreational fishing. Commercial and private clam and oyster beds are abundant in the Liberty Bay/Port orchard area. Many residents report good crabbing and smelt fishing near Keyport at certain times of the year. Commercial oyster beds owned by the Coast Oyster Company are located in Dogfish Bay. A small number of people fish recreationally in Liberty Bay. Commercial harvests of salmon are conducted by Suquamish Tribal members. The Suquamish Indian Tribe runs a fisheries enhancement program to raise chum and chinook salmon in and near Liberty Bay. The tribe depends on water from Liberty Bay and local streams in the area to support the fisheries program. In addition, the Suquamish Indian Tribe retains the right to harvest fishery resources for ceremonial, subsistence, and economic purposes in Dogfish Bay and Liberty Bay.

The shallow lagoon serves as a recreational area for row and paddle boating, sailing, and picnicking. It is also used for feeding and nesting by migratory and resident waterfowl. Waterfowl nest boxes and baskets have been installed to encourage nesting activity.

Approximately 60 acres of the Keyport facilities are forested. The forest primarily consists of Douglas fir, western hemlock (Tsuga heterophylla), western red cedar (Thuja plicata), white fir (Abies concolor), red alder, and big leaf maple (Acer macrophyllum). These trees serve as nesting and feeding habitat for various birds and mammals.

The wetlands on the base (south and west of both Areas 1 and 2) provide a habitat for nesting, feeding, and cover for various organisms such as amphibians, waterfowl, and small animals. The wetlands are also valued for their aesthetic, recreational, and educational qualities. Walking trails are located within and around some of the wetlands, providing recreational bird-watching opportunities. These wetlands provide a valuable function in storm and flood water storage, water quality protection, groundwater recharge/discharge, biological habitat, aesthetic qualities, and recreational activities. The wetlands were delineated by Wiltermood Associates (1992).

The following species occasionally observed at the NUWC Division, Keyport facility are federally listed as threatened or endangered in the State of Washington:

- Bald eagle - listed as threatened. A bald eagle has occasionally been seen at the facility, specifically in the vicinity of Area 1 and the shallow lagoon. An active nest is located approximately 1.5 miles south of the facility along the shoreline of Port Orchard.

- Marbled murrelet - listed as threatened.

- Peregrine falcon - listed as endangered.

3.O SITE HISTORY AND ENFORCEMENT ACTIVITIES

3.1 SITE HISTORY

The Keyport property was acquired by the Navy in 1913 and first used as a quiet-water range for torpedo testing. The first range facility was located in Port Orchard inlet to the southeast of the site. The first building was constructed in 1915. During and soon after World War I, some minor additions were made to the base. The largest expansion in activities and acquisition of additional property occurred during World War II.

During the early 1960s, the role of the base was expanded from torpedo testing to include manufacturing and fabrication operations, such as welding, metal plating, carpentry, and sheet metal work. More expansion took place in 1966, including the building of a new torpedo shop. In 1978, the facility changed names from Naval Torpedo Station Keyport to Naval Undersea Warfare Engineering Station Keyport in recognition that the functions had broadened to include various undersea warfare weapons and systems engineering and development activities. In 1992, the facility again changed names to NUWC, Division Keyport. Operations currently include engineering, fabrication, assembly, and testing of underwater weapons.

3.2 REGULATORY HISTORY

In September 1984 the Navy conducted an Initial Assessment Study, performed under the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify areas of possible environmental contamination resulting from past methods of storage, handling, and disposal of hazardous substances at NUWC Division, Keyport (SCS Engineers 1984). Subsequent studies, documented in a Current Situation Report (SCS Engineers

1987), evaluated these and other areas to determine locations of potential or significant contamination that may require remedial action and should be studied further. As a result of these studies and recommendations by the Navy, six specific Areas were recommended for further investigation in the RI/FS. These six Areas are:

- Area 1 - Keyport Landfill
- Area 2 - Van Meter Road Spill/Drum Storage Area
- Area 3 - Otto Fuel Leak Area
- Area 5 - Sludge Disposal Area
- Area 8 - Plating Shop Waste/Oil Spill Area
- Area 9 - Liberty Bay

In 1988, under its Installation Restoration Program, the Navy began the RI/FS process to evaluate the six areas of potential concern identified in the earlier studies. In October 1989, the site was officially listed on the NPL. In response to the NPL designation, the Navy, the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) entered into a Federal Facilities Interagency Agreement (FFA) in July 1990. The FFA established a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at NUWC Keyport. The FFA listed the six NPL subsites at NUWC Division, Keyport identified by the Navy for inclusion in the RI/FS.

The final RI and FS reports were submitted in october 25 and November 15, 1993, respectively (URS 1993a-d). A Proposed Plan for the cleanup of the six Areas was prepared by the Navy, EPA, and Ecology and distributed to the public; three public meetings were held and public comment was taken on the Proposed Plan through May 1, 1994. Because of lack of acceptance of the preferred alternative for the Area 1 Landfill by a segment of the public, withdrawal of concurrence on the preferred alternative by Ecology, and an inability to reach a consensus on the appropriate action, Area 1 was separated from the other Areas into its own operable Unit (OU 1) in order to allow the other Areas (OU 2) to proceed to ROD. Area 1 will have its own ROD when the appropriate remedial action is determined.

4.O HIGHLIGHTS OF COMMUNITY PARTICIPATION

Since 1986, the Navy has conducted a number of activities designed to involve the community in the remedial process. Some of these activities are summarized below:

1986 . Public bus tour of Site upon announcement of nomination to the NPL
1988 . First Technical Review Committee (TRC) meeting held. TRC includes representatives from federal, state, and local governmental agencies, tribes, and community organizations
1991 . Fact Sheet on the progress of the RI/FS distributed to public
. TRC Meetings (2)
. Public open House held at NUWC, including bus tours, displays, and Fact Sheet
. Keyport-Poulsbo Independence Day Celebration: RI/FS Displays and Fact Sheets distributed
1992 . TRC meeting
. Kitsap Mall Business Fair RI/FS Displays
. Keyport-Polsbo Independence Day Celebration: RI/FS Displays and Fact Sheets distributed
. Fact Sheet updating RI/FS progress distributed to public
. TRC Work Shop held on human health and ecological risk
. Public Availability Session (open House) held at NUWC, including bus tours, displays, and Fact Sheets
1993 . Public Availability Session (open House) held at NUWC, including bus tours, displays, Fact Sheets, and presentation of informational video on NUWC RI/FS
. Navy participation with staff and displays in Open House held by the citizens environmental watchdog organization and EPA Technical Assistance Grand (TAG) and Washington State Department of Ecology Public Participant Grand recipient Olympic View Environmental Review Council (OVER-C)
. TRC Meetings (4)
. NUWC Street Fair: RI/FS displays presented, Fact Sheets distributed, and presentation of informational video on NUWC RI/FS
. CoastWeeks tour of NUWC coordinated by OVER-C given by NUWC staff
. Fact Sheet on RI/FS and Risk Assessment results distributed

The RI, FS, and Proposed Plan for the NUWC Division, Keyport Site were finalized and made available to the public in October 25, 1993, November 15, 1993, and January 24, 1994, respectively (URS 1993a-d; 1994). These documents were made available to the public in both the administrative record located at the Navy Engineering Field Activity Northwest, Naval Facilities Engineering Command, in Poulsbo, Washington, and in information repositories maintained at the Kitsap Regional Library in Bremerton, Washington, the Poulsbo Branch Library in Poulsbo, Washington, the Public Utilities District office in Poulsbo, Washington, and at the NUWC Division, Keyport Public Affairs office in Keyport, Washington. The Notice of availability of the RI, PS, and Proposed Plan was published in the Bremerton Sun newspaper on January 21, 1994 (the comment period was extended at the request of several members of the public). A public comment period was held from January 24, 1994 through May 1, 1994. In addition, public meetings were held on February 17, April 21, and April 28, 1994. Three meetings were necessary to adequately present the proposed plan and answer public questions. At these meetings, representatives from the Navy, EPA, and Ecology answered questions about each area and the remedial alternatives under consideration.

As discussed in Section 3.2, following the public comment period on the Proposed Plan, the site was organized into two OUs. A response to the comments received during this period that were relevant to OU 2 is included in the Responsiveness Summary, which is Appendix A of this Record of Decision. Public comments relevant to OU 1 (including those received prior to the separation of OU 1 and OU 2) will be addressed in the Responsiveness Summary of the OU 1 ROD. In general, public comments were favorable to the proposed plan regarding OU 2. This decision document presents the selected remedial actions for OU 2 of the NUWC Division, Keyport Site, in Keyport, Washington, chosen in accordance with CERCLA, as amended by SARA and, to the extent practicable, the National Contingency Plan and complies with applicable or relevant and appropriate federal, state, and local laws and regulations. The decision for this site is based on the administrative record.

5.0 SCOPE AND ROLE OF OPERABLE UNITS

As discussed in Section 3.2, following the public comment period on the Proposed Plan, the site was organized into two OUs. These are:

- OU 1: Area 1 - Keyport Landfill
- OU 2: Area 2 - Van Meter Road Spill/Drum Storage Area
  Area 3 - Otto Fuel Leak Area
  Area 5 - Sludge Disposal Area
  Area 8 - Plating Shop Waste/Oil Spill Area
  Area 9 - Liberty Bay

This ROD addresses the Areas in OU 2. OU 1 will be addressed in a separate ROD to be completed at a later date.

6.0 REMEDIAL INVESTIGATION AND FEASIBILITY STUDY METHODS

This section presents the methods used to conduct the RI and FS. The RI includes the baseline risk assessment, which comprises the human health risk assessment and the ecological risk assessment.

6.1 RI DATA COLLECTION

RI sampling at OU 2 was conducted in several episodes during two phases, as outlined below:

Phase I

- Summer 1989 — Marine sediment sampling of the shallow lagoon (near Areas 2 and 3), sediment and shellfish sampling of Liberty Bay (Area 9).
- Spring/Summer l990 — Soil vapor survey (Area 2); terrestrial soil borings (Areas 2, 3, 5, 8); subsurface soil and root-zone soil sampling (Area 2, 3, 5, 8); stream sediment sampling (Area 2); installation of groundwater monitoring wells (Areas 2 and 3); slug testing of groundwater wells, water level measurements.
- Spring/Summer 1991 — Terrestrial soil borings (Areas 2, 5, 8), subsurface soil sampling (Areas 2, 5, 8), surface soil and root-zone soil sampling (Areas 2, 3, 5); stream sediment sampling (Area 2); installation of one groundwater monitoring well (Area 2), groundwater sampling (Areas 2, 3, 8); water level measurements; fish and invertebrate sampling in the shallow lagoon (near Areas 2 and 3); surface water sampling (the shallow lagoon and Area 9).
- Summer 1991 — Air sampling including emission flux and ambient monitoring for volatile organic compounds (VOCs) and methane; high-volume filter sampling of inorganics and particulates (Area 2).

- January 1992 — Groundwater resampling, with flltering for metals (Area 2); surface water sampling (the shallow lagoon and Area 9).

Phase II

- Summer 1992 — Terrestrial soil borings (Areas 2 and 8); subsurface soil sampling (Areas 2, 8); installation of groundwater monitoring wells (Area 8) and beach well points/piezometers (Area 8); groundwater sampling (Areas 2 and 8); marine sediment and shellfish sampling the shallow lagoon (near Areas 2 and 3) and Liberty Bay (Area 9).

6.2 RI DATA EVALUATION AND SCREENING

Results of the chemical analyses were evaluated and screened. First, chemical concentrations were compared to background screening values (BSVs). Background samples were collected for terrestrial soil, stream sediment, groundwater, and freshwater seeps and for marine surface water, sediment, and fish and shellfish tissue to assess the concentrations of naturally occurring or widespread anthropogenic chemicals in the environment at the site. Background samples were selected from representative locations distant or upgradient from the areas under study. BSVs were calculated to provide a single number for each matrix to which samples could be compared. Because most synthetic organic compounds do not occur naturally in the environment, only inorganic chemicals were compared to BSVs (i.e., the BSVs for organic compounds were assumed to be zero).

Second, chemical concentrations exceeding BSVs were compared to corresponding regulatory limits (i.e., to chemical-specific values from regulations that are directly applicable or relevant and appropriate [ARAR] to the environmental medium sampled). Table 6-1 shows the ARARs to which results from each medium at each Area in OU 2 were compared.

A chemical-specific ARAR of particular concern to the State of Washington is the Washington Model Toxics Control Act (MTCA) Method B Cleanup levels. Method B levels are set using a risk assessment approach that takes into consideration chemical toxicity, degree of exposure to the chemicals, and combined health effects of multiple chemicals. Method B levels are based on a carcinogenic risk for each chemical of 1O-6 and a cumulative carcinogenic risk of 10-5 or, for non-carcinogens, a hazard index (HI) of one.

Finally, chemical concentrations exceeding BSVs were also evaluated for their impacts to human health and ecological risk in the baseline risk assessment. This methodology followed CERCLA guidance and is described below in Sections 6.3 and 6.4. The baseline risk assessment first identified a relatively large group of potential chemical risk contributors (chemicals of potential concern [COPCs]), and then, following further analysis, identified the major chemical contributors to risk (the so called "risk drivers"), if any, in each medium at each Area.

The evaluation of the nature and extent of contamination at each Area (summarized below in Sections 7.1.3, 8.1.3, 9.1.3, 10.1.3, and 11.1.3) focuses on those chemicals that either exceed ARARs or were identified as risk drivers.

6.3 HUMAN HEALTH RISK ASSESSMENT

The purpose of the risk assessment is to provide an evaluation of the actual or potential threat to human health from chemical releases at various areas of the NUWC Division, Keyport facility assuming no action is taken to remediate the areas. Specific objectives include the following:

- Evaluation of data and identification of compounds or chemicals of potential concern (COPCs)
- Identification of potential human receptors and exposure pathways
- Quantification of exposure
- Characterization of human health risks to current and future receptors

The risk assessment provides a quantitative and qualitative description of current and future receptor groups, identifies the contaminants of greatest toxicologic concern, and evaluates the environmental pathways for the most important exposures. It characterizes current and future land uses that may result in health effects.

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Applicable or Relevant and Appropriate Requirements (ARARs)

- Groundwater quality was compared to surface water quality criteria and MTCA surface water cleanup levels because the groundwater discharges into water bodies and could potentially cause ARAR exceedences in surface water.

Sources:

a Puget Sound Air Pollution Control Agency Criteria for Toxic Air Contaminants
b Safe Drinking Water Act, Maximum Contaminant Levels (40 CFR 141)
c State of Washington, Maximum Contaminant Levels (WAC 246-290-310)
d Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201)
e EPA Surface Water Quality Criteria, 1991
f State of Washington Sediment Management Standards (WAC 173-204)
g Washington Model Toxics Control Act (MTCA) Cleanup Regulation, Method B, WAC 173-340.

6.3.1 Potential Contaminant Identification Methods

Extensive sampling was performed during the RI. Media sampled include soil vapor, soil, groundwater, surface water, sediments, and air. Chemicals detected in samples were screened by comparing analytical data with background levels (for inorganic chemicals) and with risk-based screening concentrations as identified by EPA, Region 10. For groundwater, the risk-based screening concentrations designated by EPA represents a 10-6 risk for carcinogenic effects and a hazard quotient (HQ) of 0.1 for noncarcinogenic effects. For soils, the risk-based screening concentrations are 10.7 for carcinogenic effects and an HQ of 0.1 for noncarcinogenic effects. Chemicals identified as being of potential concern (COPCs) as a result of this screening process were carried through subsequent steps of the human health risk assessment.

6.3.2 Exposure Assessment Methods

An exposure assessment was conducted to characterize the exposure setting and receptors at risk at NUWC Division, Keyport, to identify exposure pathways, and to quantify exposure. Potential receptors and exposure pathways selected for evaluation in the risk assessment, as appropriate, include the following:

- Current and Future Workers - ingestion of chemicals in soil; inhalation of volatiles and particulates; ingestion of chemicals in groundwater

- Current and Future Residents - ingestion of chemicals in soil, groundwater, homegrown produce, surface water, marine sediment and fish/shellfish; inhalation of volatiles during household use of groundwater

- Current and Future Visitors (recreational land use) - ingestion of chemicals in surface water, marsh and marine sediment, and fish/shellfish

- Current and Future Subsistence Users - ingestion of chemicals in fish/shellfish

Risks were calculated for both average exposures and for a reasonable maximum exposure (RME). The RME corresponds to the highest plausible degree of exposure that may be anticipated at a site.

In this risk assessment, quantification was not performed for any dermal contact scenarios, based on guidance received from EPA Region 10 (Cirone 1990), because of inadequate toxicological constants for dermal exposure. However, since the time this guidance was given, better toxicological constants for dermal exposure have become available and quantification of dermal contact scenarios has become commonplace in CERCLA human health risk assessments. Because of this, EPA evaluated the effect of not considering the dermal contact exposure route and concluded that, because of the low dermal absorption of the contaminants at OU 2, the incremental risk posed by this exposure route would be very small and would not affect the conclusions of the risk assessment.

6.3.3 Toxicity Assessment Methods

A toxicity assessment was conducted for the COPCs to quantify the relationship between the magnitude of exposure and the likelihood or severity of adverse effects (i.e., dose response assessment). Toxicity values are developed separately for carcinogenic effects (cancer slope factors) and noncarcinogenic health effects (reference doses). Toxicity values are derived from either epidemiological or animal studies, to which uncertainty factors are applied. The primary sources for toxicity values used are the EPA's Integrated Risk Information System (IRIS) database and Health Effects Assessment Summary Tables (HEAST).

Currently, EPA does not provide toxicity data for lead because of unique considerations related to the toxicology of this element. As an alternative to the traditional risk assessment approach, lead concentrations at the site can be compared with EPA recommended acceptable lead levels of 200 mg/kg in soils, 15 µg/L in groundwater, and 1.5 µg/m3 in air. The RME lead concentrations observed in soil, water, and air for all Areas in OU 2 are well below these levels.

6.3.4 Risk Characterization Methods

The risk characterization integrates the information developed in the toxicity assessment and exposure assessment to develop carcinogenic and noncarcinogenic risks. Cancer risks are probabilities that are expressed in scientific notation. An excess lifetime cancer risk of 1x10-6 indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site. The NCP recommends an acceptable target cancer risk range of 10-6 to 10-4 for CERCLA sites.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the hazard quotient. By adding the HQs for all contaminants within a medium and across all media to which a given population may reasonably be exposed, the hazard index (HI) can be generated. If the HI is less than 1, it indicates that noncarcinogenic health effects are unlikely. If the HI is greater than 1.0 it indicates that adverse noncancer health effects are possible.

6.3.5 Uncertainties

It is often difficult to directly compare the relatively high level of certainty inherent in some scientific disciplines, such as chemistry and mathematics, with that of biological and environmental systems. Since risk assessment is based on a mixture of sciences with varying levels of certainty, it stands to reason that the final estimate of the risk assessment is only as certain as the least certain link in the chain leading to the estimate. It is important to emphasize that the baseline risk assessment is primarily a decision-making tool for use in assessing the need for remedial action. The results of risk assessments are presented in terms of the potential for adverse effects based on a number of very conservative assumptions. The tendency to be conservative is an effort to err on the side of the protection of health.

The uncertainties in each component of the risk assessment process are compounded in the overall calculation to yield final estimates with wide uncertainty ranges. For example, if an estimate of the average daily dose for a compound ranges a factor of 10 above and below the point estimate used in the exposure assessment, then the uncertainty range for the final estimated health effect may be at least that large.

The sources of uncertainty may be site-related or associated with the assumptions and procedures used during the risk assessment. If limited data are available, one sample with an extreme concentration (high or low) may bias the exposure estimates. With a small data set that cannot meaningfully be evaluated statistically, it is very difficult to identify and eliminate anomalous results.

The 95 percent upper confidence limit (UCL) estimate for the reasonable maximum exposure concentrations was based on an assumption of a normal distribution and used the existing untransformed data sets. These assumptions could introduce uncertainty, although estimates based on t-distribution are not considered seriously affected by slight deviations from normality. Such effects are greater as the level of precision increases and as the sample count decreases.

Sample quantitation limits for some chemicals, particularly in groundwater, were quite high. Underestimation of human health risks due to inadequate sample quantitation limits may potentially have occurred for groundwater at Area 2 (arsenic, beryllium, antimony, polynuclear aromatic hydrocarbons [PAHsl) and groundwater at Area 8 (PAHs). No significant underestimation of human health risks due to inadequate sample quantitation limits is believed to have occurred at Areas 3, 5, or 9, or in media other than identified above at Areas 2 and 8.

Specific sources of uncertainty are described below.

- Bis(2-ethylhexyl)phthalate was detected in shellfish tissue. However, this chemical was also detected in all background tissue samples.

- A variety of chemicals believed to be carcinogens were detected during the RI. A number of these do not have slope factors (e.g., lead and chromium) and therefore do not contribute to the quantification of total cancer risk. This may result in an underestimate of the cancer risk at NUWC Division, Keyport.

- A variety of chemicals detected during the RI do not have inhalation RfDs (e.g., trichloroethene, vinyl chloride, cadmium, lead) and therefore do not contribute to the quantification of total HI. This may result in an underestimate of the noncancer risk at NUWC Division, Keyport.

- When risks are summed across chemicals, it is assumed that the chemical-specific risks are independent and additive. In actuality, these risks may interact to produce an effect that is less than additive (antagonism) or an effect that is more than additive (synergism). Unfortunately, data on chemical interactions are lacking for most chemical mixtures. In the absence of mixture-specific toxicity data, the assumption of additivity is a standard approach. This may result in overestimation or underestimation of risk.

- Propylene glycol dinitrate (PGDN) is only one component of Otto fuel. A second component, 2-nitrodiphenylamine, is present in smaller proportion than PGDN and is reportedly more toxic than PGDN. Samples were analyzed for 2-nitrodiphenylamine with a high pressure liquid chromatograph (HPLC) method; during data validation, all HPLC data were rejected. Therefore, no information is available on the concentrations of 2-nitrodiphenylamine in the environment at NUWC Division, Keyport. This lack of data may result in an underestimation of risk.

Cancer and noncancer risks are summed in the risk characterization process to estimate potential risks associated with the simultaneous exposure to multiple chemicals. In the case of carcinogens, this gives carcinogens with a Class B or Class C weight-of-evidence the same weight as carcinogens with a Class A weight-of-evidence. It also equally weights slope factors derived from animal data with those derived from human data. Uncertainties in the combined risks are also compounded because RfDs and cancer slope factors do not have equal accuracy or levels of confidence and are not based on the same severity of effect. These factors may result in an overestimation or underestimation of risk.

Uncertainties in any phase of the risk analysis are reflected and compounded in the risk estimates. The actual degree of uncertainty is difficult to define precisely without a more quantitative approach. The methods and assumptions employed in this risk assessment are conservative, and ranges of risk estimates incorporated are more likely to capture the "true" risks than point estimates will indicate.

6.4 ECOLOGICAL RISK ASSESSMENT

The purpose of the ecological risk assessment is to provide a baseline evaluation of the potential threat to the terrestrial and marine environments from chemical releases at various areas of NUWC Division, Keyport. Specific objectives include the following:

- Evaluation of data and identification of COPCs
- Identification of potential receptor populations and exposure pathways
- Characterization of effects to exposed organisms
- Evaluation of risks to receptor organisms and habitats

Important ecological indicators used in this risk assessment for the marine environment include water, sediment, tissue, and habitat quality. Indicators for the terrestrial/freshwater environment include soil quality, earthworm toxicity, algal toxicity, and habitat quality.

6.4.1 Contaminant Identification Methods

For inorganics, COPCs were identified by comparing analytical data to background levels, and those that exceeded background reference values were mained for evaluation of potential risks. All organic compounds detected were retained as COPCs. COPCs in each media were compared to federal and state regulatory criteria and standards (e.g., federal water quality criteria and Washington State Sediment Management Standards) and to available toxicological effects data from the literature. Toxicity tests to receptor organisms habiting in area soils and aquatic sediments were also conducted.

6.4.2 Exposure Assessment Methods

The level of COPCs actually or potentially reaching organisms depends on physical, chemical, and biological characteristics of the contaminant, the organism, and the environment. Exposure characterization included the identification of populations in areas potentially exposed to COPCs and the determination of exposure point concentrations to selected receptor organisms. For the aquatic environment, several species of shellfish in the marine sediments and mussels and sculpins in the shallow lagoon were used to evaluate bioaccumulation and potential food chain transfers. Exposure modeling for receptors in the terrestrial environment included the vole, mallard duck and Canada goose.

6.4.3 Toxicity Assessment Methods

Measured or modeled exposure concentrations were compared to toxicological effect concentrations to characterize risks to the organisms. For the terrestrial environment, soil concentrations of COPCs are compared to toxicological reference values (TRVs). For the marine environment, water, sediment, and tissue concentrations of COPCs are compared to relevant TRVs including federal and state water quality criteria, the Washington State Sediment Management Standards and other sediment guidelines, and various tissue reference values.

6.4.4 Risk Characterization Methods

All of the above processes of regulatory comparison, toxicity tests, modeling, and evaluation of habitat characteristics were considered in a "weight-of-evidence" approach. The goal of this approach was to reach conclusions regarding the level of risk posed to the marine and terrestrial environments.

6.4.5 Uncertainties

As in the human health risk assessment, the uncertainties in each component of the ecological risk assessment process are compounded in the overall calculation to yield final estimates with wide uncertainty ranges. Specific sources of uncertainty in each step of the assessment are listed below.

- Data Evaluation

  - The initial selection of COPCs for terrestrial habitat was considered conservative. Only those inorganic COPCs whose reasonable maximum exposure (RME) concentrations were below background levels were ejected as COPCs; all remaining detected chemicals were retained as COPCs and evaluated further.

  - Risk-based detection limits for marine sediments were not always achieved for semivolatile chemicals. Evaluation at one-half the detection limit resulted in HQ values greater than 1, particularly for Phase I samples; these results can only be interpreted to mean that the quantitation limits were not sufficient to indicate an absence of risk. Based on chemical results obtained for Phase II sampling with lower detection limits, most organic compounds are probably not present at levels above risk-based criteria.

- Toxicity Evaluation

  - Chemical-specific toxicity information varies widely depending on the kinds of organisms and exposure media that may be of concern. For many of the COPCs, toxicity information that could be used to assess potential ecological risks was not available for other chemicals within the same structural compound class (e.g., PAHs). Because the ecological risk assessment is intended to be a screening-level process, the lowest toxicity values within the structural compound class were used as surrogate values. For some compound classes, the use of such surrogate values may be highly conservative and result in an overestimation of risk.

  - For some chemicals, sufficient information was not available to determine surrogate toxicity values. Although these substances were carried through the exposure analysis, the missing toxicity information precluded interpretation of that exposure, and resulted in an underestimation of potential risk.

  - In general, chemical-specific or surrogate toxicity values are more widely available for aquatic receptors and mammals than for birds. These limitations result in greater emphasis on assessment of risks to aquatic and mammalian receptors, and an underestimation of risks to avian receptors.

  - For mammals and birds, toxicity values were often available for only one kind of a receptor within a phylogenetic class. This toxicity data has been extrapolated directly to other wildlife species. Because the lowest literature toxicity reference value was generally selected, this may result in an overestimation of risk.

  - Preferably, toxicity values representing ecologically significant endpoints at the chronic no-observed-effects levels (NOELs) or lowest-observed-effects levels (LOELs) were selected. However, in some cases it was necessary to apply safety factors to extrapolate from other endpoints (e.g., lethal dose for 50 percent of the exposed population [LD-50] to a NOEL). The extrapolation of toxicity values from one endpoint to another was based on published equations that may not be directly applicable to the specific organisms or chemicals in this evaluation.

  - Toxicity values obtained from the literature to develop TRVs are based on oral doses of pure chemicals. Exposure to chemicals in natural environments is modified because chemicals are often associated with other media, such as soil, or are incorporated into different organisms, such as plants and small mammals. It is generally assumed that chemicals in soil, plants, and prey will not be absorbed as readily through the digestive tract as will pure chemicals. The exposure models used in this screening level assessment assume that the chemical is in the most readily available form and there is 100 percent absorption into the body; therefore, the model probably overestimates actual exposure.

  - Certain chemicals can toxicologically interact, having either synergistic or antagonistic effects on the toxicity of the individual chemical. Interactions of COPCs were not evaluated in the assessment, so neither the magnitude nor direction of these interactions is understood.

  - The TRVs used in the risk evaluation contain many water and sediment criteria that were developed to protect a wide range of organisms. Some of these TRVs may be overly conservative when applied to specific organisms inhabiting the Keyport area.

- This study included bioassay tests for relatively few stations that were intended to be representative of large areas. The results of these bioassays were an important factor in risk characterization. The degree to which these results are representative of their respective areas introduces uncertainty into conclusion regarding risk.

- The equilibrium partitioning model for evaluating sediment quality utilizes partitioning theory to relate the sediment concentration to the equivalent free chemical concentration in porewater. Sediment toxicity can only be evaluated for those chemicals with corresponding water quality criteria. It is assumed that water quality criteria would protect benthic organisms when applied to the predicted porewater concentrations for sediments. There is uncertainty with respect to the octanol-water partitioning coefficient (K-ow) associated with the specific chemical and used to calculate the organic carbon partitioning coefficient (Koc). Chemical-specific Kow values are experimentally determined quantities and the techniques used for deriving the coefficients vary in their specificity and accuracy.

- To assess surface water toxicity to freshwater aquatic biota, EPA chronic ambient water quality criteria/LOELs were used as TRVs when available. EPA (USEPA 1992) is currently reviewing total inorganics criteria for water quality to address the correlation between inorganics that are measured and those that are biologically available.

- Exposure Evaluation

    - The exposure modeling approach used in the risk assessment contains many assumptions that could affect the estimated levels of exposure used to evaluate potential risks. For example, the amount of chemical accumulating in plants was estimated at 1 percent of the reasonable maximum exposure (RME) soil concentration. In addition, modeled receptors were conservatively assumed to obtain lOO percent of their diets from the study areas.

    - Risk from chemical exposure to terrestrial receptors was based on RME exposure estimates. RME exposure point concentrations were calculated using the 95 percent UCL on the arithmetic mean. These estimates of exposure do not account for spatial variability in chemical concentrations in soil. For example, the exposure point concentration may be high but may result in a single elevated hit from a sample population. For animals with localized home ranges, such as the vole, a discontinuous distribution of chemicals in soil would mean that only certain members of the population would potentially be exposed. Consequently, population level effects may be considerably overestimated when using average chemical concentrations.

    - As previously stated, the scope of this approach does not allow exposure modeling to be performed for all species known to inhabit or visit NUWC Division, Keyport. To accommodate this uncertainty, a very conservative approach was used for the selected species. Therefore, the tendency is to overestimate, rather than underestimate, site risks.

    - The bioaccumulation modeling used in the characterization of marine risks entailed uncertainty of two types: 1) uncertainty due to limitations inherent in the model (e.g., number and types of variables, mathematical formulation), and 2) uncertainty in parameter values (e.g., sampling error, inference from other species or methods). These factors result in uncertainty in the estimates of tissue concentrations of COPCs in certain receptors, which affects the reliability of the hazard quotients calculated and related risk conclusions.

As in the human health risk assessment, uncertainties in any phase of the risk analysis are reflected and compounded in the risk estimates. The actual degree of uncertainty is difficult to define precisely without a more quantitative approach. The methods employed in this risk assessment are conservative, however, and ranges of risk estimates incorporated are more likely to capture the "true" risks than point estimates will indicate.

6.5 FEASIBILITY STUDY

The Baseline Risk Assessment evaluated the chemicals detected for the risk they pose to potential human and environmental receptors. The RI Report evaluated the sample results to identify specific media and locations where chemicals were detected at concentrations exceeding chemical-specific criteria of appropriate environmental regulations (i.e., applicable or relevant and appropriate requirements [ARARs]). Chemicals identified as posing significant risk in the Baseline Risk Assessment or that exceed an ARAR may justify remedial action at a site or any of its individual Areas.

The FS identifies remedial action objectives (RAOs) for cases where action may be justified based on the conclusions of the Baseline Risk Assessment and the chemical-specific ARARs comparisons. The RAOs are designed to prevent exposures to chemicals that drive the baseline risk estimates or exceed ARARs. Remediation goals are established based upon the RAOs.

The FS then develops and evaluates a range of possible remedial action alternatives for technical feasibility and ability to attain the RAOs. The remedial alternatives are evaluated with respect to evaluation criteria specified in CERCLA.

6.5.1 Remedial Action Objectives

The results of the RI and risk assessment were used to determine the need for remedial action. The following general RAOs have been established:

- Prevent human exposures to carcinogenic chemicals resulting in cumulative risks above the 1O-4 to 10-6 risk range.
- Prevent human exposures to noncarcinogenic chemicals resulting in a noncancer HI greater than 1.
- Prevent exposures to chemicals resulting in significant ecological risks.
- Prevent exposures to chemicals above ARARs. Principal chemical-specific ARARs for OU 2 are:
    - The Model Toxics Control Act (MTCA), 173-340 Washington Administrative Code (WAC), which establishes cleanup levels for groundwater, soil and surface water based on human health risk. The cumulative sum of the individual chemical risks may not exceed 1 x 10-5 incremental cancer risk and an HI of 1 for noncancer risk.
    - The national drinking water regulations, Code of Federal Regulations (4O C.F.R. §§141, 142, and 143) and the State Board of Health drinking water regulations, 246-290-310 WAC, which establish federal and state drinking water standards applicable to public water supplies.
    - The Water Quality Standards for Surface Waters of the State of Washington, 173-201A WAC, which establish state standards for surface water and incorporates federal ambient water quality criteria.
    - The Sediment Management Standards, 173-204 WAC, which establish state standards for marine sediments.

6.5.2 Remediation Goals

For cases where cleanup actions are needed, cleanup standards can be derived from the objectives listed above. These standards are referred to as remediation goals and represent concentration levels in specific media that satisfy the RAOs.

Remediation goals have been derived for each Area as follows:

- Soil remediation goals based on results of the human health risk assessment and MTCA cleanup levels.
- For Areas with potential drinking water exposures, groundwater remediation goals based on results of the human health risk assessment, drinking water standards, and MTCA cleanup levels.
- For Areas where RAOs include protection of downgradient surface water, groundwater remediation goals based on results of the ecological and human health risk assessments, surface water criteria, and MTCA cleanup levels.

6.5.3 Development and Evaluation of Alternatives

A full range of remediation processes was initially identified. These initial process options were evaluated and screened based on effectiveness, implementability, and cost. After screening, the most promising processes were developed into Area-specific alternatives that were then subjected to a detailed analysis in the FS.

The alternatives developed for each Area were compared to each other with respect to nine specific evaluation criteria that have been used in assessing and selecting a preferred remedy. These nine criteria are:

1. Overall protection of human health and the environment.

2. Compliance with ARARs.

3. Long-term effectiveness and permanence.

4. Reduction of toxicity, mobility, and volume through treatment.

5. Short-term effectiveness.

6. Implementability.

7. Cost.

8. State acceptance (preferences).

9. Community acceptance (preferences).

The first two criteria are considered "threshold factors," because CERCLA requires that the selected remedy must satisfy these criteria. The remaining criteria are considered "balancing" or "modifying" factors and are used to select the preferred alternative from those that satisfy the threshold criteria.

7.0 SUMMARY OF INVESTIGATION FOR AREA 2

This section presents a summary of the RI/FS for Area 2.

7.1 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site characteristics, including a discussion of the geologic and hydrologic characteristics and the nature and extent of contaminants.

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7.1.1 Site Description

Area 2 is composed of three distinct areas: Van Meter Road spill area, Building 957 drum storage area, and Building 734 drum storage area (Figure 7-l). The spill area and the Building 734 area are just north of a small perennial creek that flows east-northeast and discharges into the shallow lagoon. The Building 957 area is presently paved and fenced; it is used as a scrap recycling yard, including metal grinding activities.

The Van Meter Road spill occurred in 1976 at a paved area northwest of where the road crosses the creek. Plating shop wastes (estimated quantity: 2,000 to 5,000 gallons) corroded through an unlined tank truck and spilled overnight onto the pavement and flowed toward the creek. After the spill was discovered, material remaining on the surface was washed into the creek (SCS Engineers 1984).

The two storage areas were active from the 1940s through the 1960s, during which time neither area was paved. Drums were stored at these areas until they were recycled or reused. Drums not completely empty were allowed to drain onto the ground; leakage was also prevalent. SCS Engineers (1984) reported that approximately 4,000 to 8,000 gallons of wastes were discharged in these two areas. Virtually any chemical, solvent, fuel, or oil used at NUWC Division, Keyport that arrived in 55-gallon drums may have been placed in these storage areas (SCS Engineers 1984).

7.1.2 Geology and Hydrology

Five geologic units were identified above the Clover Park unit at Area 2. Figures 7-2 and 7-3 present geologic cross sections. The water table underlies Area 2 at a depth of 4 to 8 feet below ground surface (bgs). The shallow aquifer is present within geologic Units 2A through 2H. The more permeable layers are near the top and base of the aquifer. A less permeable horizon of sand and silt (Unit 2G) separates the two more permeable zones. It is likely that the more permeable zones at the top and base of the aquifer are connected hydraulically. The shallow aquifer is underlain by the Clover Park aquitard (Unit 2J) which separates it from the deep aquifer. The most permeable and coarse-grained portion of the shallow aquifer is the sand and gravel Unit 2F, which is laterally discontinuous.

Based on dry-season water level data, the groundwater flow direction at Area 2 is northeast toward the shallow lagoon (roughly parallel with the creek) (Figure 7-4). The average horizontal gradient in the Building 957 area is 0.032. The calculated linear groundwater velocity ranges from 7 to 510 ft/yr, averaging 56 ft/yr. Vertical head differences between the upper and lower parts of the aquifer are minor, which indicates minimal vertical flow.

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7.1.3 Nature and Extent of Contaminants

Media sampled at Area 2 during the RI include air, soil vapor, soil. stream sediment, and groundwater. Marine media in the shallow lagoon (downstream from Areas 2 and 3) are discussed in Section 8.0. The nature and extent discussion considers only those chemicals that are major contributors to human health or ecological risks, or that exceed one or more ARARs. These chemicals are considered to be chemicals of concern and are listed in Table 7-1 with a summary of results.

- Soil

Arsenic and beryllium were detected in surface and root-zone soil at concentrations exceeding MTCA Method B cleanup levels (see Section 6.2) and are major contributors to human health risk. Nonetheless, fewer than half the samples taken exceeded background soil concentrations; of those that did, none exceeded background by a large amount (i.e., by more than a factor of three). The sources and extent of these inorganic chemicals are unclear as there are no observed trends in lateral distribution.

Vinyl chloride was detected in Area 2 subsurface soil and is a major contributor to human health risk. Nonetheless, this volatile organic compound (VOC) was detected in only 1 of 21 samples (boring SB2-14 in Figure 7-5) at a low concentration (0.018 mg/kg) relative to the analytical detection limit (0.012 mg/kg). The source of this chemical is unclear as there is no observable trend in spatial distribution. However, vinyl chloride is a degradation product of trichloroethene and dichloroethenes, which were also detected in the same borehole (Figures 7-6 and 7-7), but at relatively low concentrations (up to 0.43 mg/kg).

Five PAHs were detected in root-zone or subsurface soil at concentrations exceeding MTCA Method B levels. Most of these chemicals were detected in a single root-zone soil sample just east of the Building 957 area and may be attributable to past drum handling activities at this location.

- Stream Sediment

In stream sediment at Area 2, no chemicals were major contributors to human health or ecological risk. No ARARs currently exist for freshwater sediment.

- Groundwater

Manganese was detected in groundwater at concentrations exceeding background and Washington State MCLs in four samples. These exceedences are from three shallow downgradient wells on the eastern side of the Building 957 area.

Trichloroethene and vinyl chloride were detected in groundwater at concentrations exceeding drinking water standards (maximum contaminant levels [MCLs]) and MTCA Method B levels (Figures 7-5 and 7-6). Trichloroethene was detected in a well at the upgradient (southwest) corner of the Building 957 area; vinyl chloride was detected in a well downgradient of this area. Although 1,2-dichloroethene did not exceed regulatory levels, it was detected in two downgradient wells and is a probable degradation product of trichloroethene. The presence of VOCs in shallow groundwater within and downgradient of the Building 957 area indicates that the former drum storage area may be a source. This conclusion is supported by the results of the soil vapor survey, which indicate that VOCs exist under much of the pavement surrounding Building 957.

- Air

Chemical results from air sampling media did not exceed local background concentrations, did not exceed any ARARs, and were not major contributors to human health or ecological risk.

Table 7-1
Area 2 - Major Risk Contributors and ARAR-Exceeding Chemicals

Chemical	Number of Samples	Number of Detections Above Background	Background Concentration	Range of Detects Above Background: Minimum	Range of Detects Above Background: Maximum	Major Risk Contributor: Human Health	Major Risk Contributor: Ecological	Exceeds ARAR
SURFACE SOIL (0-2 inches)								
Inorganic Chemicals (mg/kg)								
Arsenic	6	2	6.06	10.6	16.6	*		*
Beryllium	6	2	0.94	1.0	1.1	*		*
ROOT-ZONE SOIL (2-15 inches)								
Inorganic Chemicals (mg/kg)								
Arsenic	13	2	6.06	6.2	17.7	*		*
Beryllium	4	2	0.94	1.60	1.65	*		*
Semivolatile Organic Compounds (mg/kg)								
Benzo(a)anthracene	4	1	NV	0.20	0.20			*
Benzo(a)pyrene	4	1	NV	0.21	0.21			*
Benzo(b)fluoranthene	4	1	NV	0.53	0.53			*
Benzo(k)fluoranthene	4	1	NV	0.96	0.96			*
Chrysene	4	1	NV	0.28	0.28			*
SUBSURFACE SOIL (>15 inches)								
Volatile Organic Compounds (mg/kg)								
Vinyl chloride	21	1	NV	0.018	0.018	*		
Semivolatile Organic Compounds (mg/kg)								
Benzo(a)pyrene	10	1	NV	0.22	0.22			*
GROUNDWATER								
Inorganic Chemicals (ug/L)								
Manganese	12	4	684	950	2.500	*		*
Volatile Organic Compounds (ug/L)								
Trichloroethene	24	3	NV	24	36			*
Vinyl chloride	24	2	NV	3.0	4.0	*		*

NV = No Value
ARAR - applicable or relevant and appropriate requirement
NOTE: Major risk contributors identified as follows:
Human Health: Chemical contributes at least 1 in 100,000 excess cancer risk or 0.1 hazard quotient to combined RME risk for scenarios with unacceptable risk, as evaluated in Human Health Risk Assessment.
Ecological: Identified in Ecological Risk Assessment as a risk driver.

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7.2 SUMMARY OF SITE RISKS

The following sections summarize human health and ecological risks.

7.2.1 Human Health Risks

This section presents a summary of contaminant identification, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis for Area 2.

- Initial Contaminant Identification

As a result of preliminary risk-based screening conducted for Area 2 samples, the following are judged to be human health risk COPCs at Area 2:

  - Air: acetone, benzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, methylene chloride, propylene, toluene, 1,2,4-trichlorobenzene, xylenes

  - Soil: arsenic, beryllium, chromium, cobalt, lead, mercury, vinyl chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, phenanthrene, and PGDN

  - Stream Sediment: arsenic, beryllium, chromium, cobalt, lead, PGDN

  - Groundwater: manganese, trichloroethene, vinyl chloride

- Exposure Assessment

Sources of COPCs include a 1976 plating waste spill on Van Meter Road and near a stream that flows into the shallow lagoon, and leakage or emptying of wastes from drums containing assorted fuels, organic chemicals, and pesticides near Buildings 734 and 957.

Liquid contamination was discharged directly to the soil surface and subsequently either infiltrated and adsorbed to the soil, was released in liquid form as runoff, or was transported with eroded soil particles. Current site workers as well as future construction workers and residents could be exposed to COPCs in soil via incidental ingestion and dermal contact scenarios.

Particulate transport of COPCs could result in an inhalation hazard to current and future workers at Area 2. In a future residential scenario, most of the ground surface would be covered with pavement (streets, sidewalks), houses, or plantings (lawn, shrubs). However, to be conservative, risks to future residents from fugitive dust emissions are evaluated in this risk assessment.

After the 1976 plating waste spill, COPCs were washed into the stream. This activity, in addition to runoff from the drum storage and disposal areas, may have carried hazardous constituents into the surface water, where they settled into stream sediment and may have been carried out to the shallow lagoon. PGDN and a subset of metals in soils were detected in stream sediment. Infiltration of rain water into this site may have carried hazardous constituents to shallow groundwater which subsequently drains to the stream and the lagoon. In a future scenario, residents (particularly children) may be exposed to COPCs in stream sediment while playing in the stream.

Future residents at Area 2 may ingest COPCs in groundwater or may be exposed by inhalation during household use of water or by dermal contact.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.1.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Tables 7-2 through 7-4 summarize the risk characterization results for Area 2.

Current Land Use. The excess RME cancer risk for current workers at Area 2 using RME assumptions is 5 x 10-6. The major exposure pathway contributing to this cancer risk is ingestion of chemicals in soil (arsenic - 4 x 10-6). The RME HI is low. No current residential or recreational exposure scenarios have been postulated for Area 2.

Table 7-2
Summary of Risk Results
Area 2 - Current Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Current Workers				
Inhalation of airborne chemicals - particulates	2E-8	6E-9	2E-7	7E-8
Inhalation of airborne chemicals - volatiles	2E-8	7E-9	5E-5	5E-5
Ingestion of chemicals in soil	5E-6	1E-6	0.02	0.01
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	5E-6	1E-6	0.06	0.05

Table 7-3
Summary of Risk Results
Area 2 - Future Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Future Residents				
Ingestion of chemicals in drinking water (shallow aquifer)	8E-5	1E-5	5	2
Inhalation of volatiles during household use of water	5E-5	9E-6	-	-
Ingestion of chemicals in soil	3E-5	2E-6	0.1	0.03
Inhalation of airborne chemicals - particulates	4E-8	7E-9	0.0002	0.0001
Inhalation of airborne chemicals - volatiles	3E-8	7E-9	9E-5	7E-5
Ingestion of chemicals in homegrown produce	8E-5	9E-6	0.2	0.09
Ingestion of chemicals in freshwater sediment (creek)	1E-5	8E-7	0.04	0.01
Ingestion of chemicals in surface water while swimming (lagoon)	-	-	1E-6	8E-7
Ingestion of chemicals in marine sediment (lagoon)	4E-6	2E-7	0.02	0.003
TOTAL	3E-4	3E-5	5	2
Future Workers				
Inhalation of airborne chemicals - particulates	9E-9	4E-9	6E-5	5E-5
Inhalation of airborne chemicals - volatiles	2E-8	7E-9	5E-5	5E-5
Ingestion of chemicals in soil	3E-6	1E-6	0.01	0.01
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	3E-6	1E-6	0.05	0.05
Future Visitor				
Ingestion of chemicals in surface water while swimming (lagoon)	-	-	1E-6	8E-7
Ingestion of chemicals in marine sediment (lagoon)	4E-6	2E-7	0.02	0.003
TOTAL	4E-6	2E-7	0.02	0.003

Note on scientific notation: Throughout this and similar tables, scientific notation is used to express very small numbers. An example of scientific notation is "2E-5." This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

Table 7-4

Summary of Major Contributions to Cancer Risk for Future Residents at Area 2a

Chemical	Groundwater Ingestion (Shallow)	Volatiles Inhalation During Household Use	Total - Groundwater	Soil Ingestion	Inhalation of Particulates	Inhalation of Volatiles	Ingestion of Produce	Total-Soil	Freshwater Sediment Ingestion (creek)	Surface Water Ingestion (lagoon)	Marine Sediment Ingestion (lagoon)	Total - All Media
RME Case												
Arsenic	NA	NA	NA	2E-5	5E-9	NA	4E-5	6E-5	6E-6	NA	4E-6	7E-5
Benzo(a)pyrene	NA	NA	NA	3E-6	3E-11	NA	3E-6	6E-6	NA	NA	NA	6E-6
Beryllium	NA	NA	NA	8E-6	2E-10	NA	5E-6	1E-5	4E-6	NA	NA	2E-5
Trichloroethene	1E-6	2E-6	3E-6	NA	NA	NA	NA	NA	NA	NA	NA	3E-6
Vinyl chloride	8E-5	5E-5	1E-4	2E-8	4E-14	NA	3E-5	3E-5	NA	NA	NA	2E-4
TOTAL (RME)	8E-5	5E-5	1E-4	3E-5	4E-8	3E-8	8E-5	1E-4	1E-5	NA	4E-6	3E-4
Average Case												
Arsenic	NA	NA	NA	1E-6	9E-10	NA	5E-6	6E-6	4E-7	NA	2E-7	6E-6
Benzo(a)pyrene	NA	NA	NA	2E-7	7E-12	NA	4E-7	6E-7	NA	NA	NA	6E-7
Beryllium	NA	NA	NA	6E-7	3E-11	NA	7E-7	1E-6	4E-7	NA	NA	1E-6
Trichloroethene	1E-7	3E-7	4E-7	NA	NA	NA	NA	NA	NA	NA	NA	4E-7
Vinyl chloride	1E-5	9E-6	2E-5	2E-9	8E-15	NA	3E-6	3E-6	NA	NA	NA	2E-5
TOTAL (Average)	1E-5	9E-6	2E-5	2E-6	7E-9	7E-9	9E-6	1E-5	8E-7	NA	2E-7	3E-5

a Includes all chemicals that individually contribute an excess RME cancer risk of 1 x 10-6 or greater to total RME cancer risk of 1 x 10-4 or greater.

NA = Not applicable; chemical is not a major risk contributor in this pathway.

Note on scientific notation: Throughout this and similar tables, scientific notation is used to express very small numbers. An example of scientific notation is "2E-5." This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

Future Land Use. The total excess cancer risk (RME) for future residents at Area 2 is 3 x 10-4, which is in excess of EPA target levels. The major contributors to this risk are chemicals in groundwater, soil, and sediment. Exposure pathways contributing significantly to cancer risks to future residents at Area 2 are ingestion of chemicals in drinking water (vinyl chloride, trichloroethene), inhalation of volatiles during household use of groundwater (vinyl chloride, trichloroethene), ingestion of chemicals in soil (arsenic, beryllium, benzo[a]pyrene), ingestion of chemicals in homegrown produce (arsenic, vinyl chloride, beryllium, benzo[a]pyrene), ingestion of chemicals in freshwater sediment (arsenic, beryllium), and ingestion of chemicals in marine sediment (arsenic)(Table 7-3). The average cancer risk for future residents at Area 2 is 3 x 10-5. The noncancer HI (RME) for future residents at Area 2 is 5. The major pathways contributing to the noncancer risk are ingestion of chemicals in drinking water (manganese - 5) and ingestion of chemicals in homegrown produce (arsenic - 0.2).

The RME excess cancer risk for future workers at Area 2 is 3 x 10-6. This is due primarily to ingestion of arsenic (2 x 10-6) and beryllium (9 x 10-7) in soil. The noncancer HI for future workers is below EPA's target risk level.

For future visitors to the shallow lagoon, the cancer risk (RME) is 4 x 10-6. This is due almost entirely to ingestion of arsenic in marine sediment. The noncancer HI for future visitors is below EPA's target risk level.

7.2.2 Ecological Risks

- Initial Contaminant Identification

As a result of the initial ecological risk screening conducted for Area 2 samples, the following are judged to be ecological risk COPCs at Area 2:

  - Soil: cadmium, lead, and zinc

  - Stream sediment: copper

- Exposure Assessment

Because the portion of Area 2 that encompasses Building 957 drum storage area is paved and fenced, plant and wildlife exposures are limited to the adjacent soils at the edge of the pavement. The soils were disturbed (i.e., do not have distinct soil horizon structure relative to background soils) during construction of the paved lot. The Building 734 drum storage subarea is unpaved and dominated by trees. The Van Meter Road subarea is paved.

Plants and soil invertebrates would have the greatest exposure to the COPCs. Small mammals, such as the Townsend's vole (Microtus townsendi) may come into contact with COPCs in the soil directly or through ingestion of contaminated vegetation. This organism feeds on succulent greens and creates runways beneath the leaf litter.

A small perennial creek traverses Area 2 and discharges to the shallow lagoon. The riparian habitat along the creek drainage is dominated by an overstory of red alder (Alnus rubra) and an understory of salmonberry (Rubus spectabilis), blackberry (Rubus spp.), and horsetail (Equisetum arvense). Additional plant species include willow (Salix spp.), rush (Juncus spp.), hawthorne (Crataegus spp.), red elderberry (Sambucus racemosa), Indian plum (Osmaronia cerasiformis), fireweed (Epilobium angustifolium), false lily-of-the-valley (Maianthemum dilatatum), and piggy-back plant (Tolmiea menziesii).

The riparian habitat associated with the creek provides cover, perch sites, and food for local wildlife. Nesting cavities were noted in several snags along the creek. Black-capped chickadees (Parus atricapillus) and Steller's jays (Cyanocitta stellerii) have been observed. Species that may visit the site include Cooper's hawk (Accipiter cooperii) and sharp-shinned hawk (Accipiter straitus) as well as kinglets (Regulus calendula), warblers (Vermivora celata), and towhees (Pipilo erythrophthalmus). Garter snakes (Thamnophis ordinoides) also may be present in the area. Consumption of fish by raptors was not evaluated for this Area; the stream is small and fish populations were not observed during the RI field work.

Because the creek that traverses Area 2 flows into the shallow lagoon, Area 2 COPCs could potentially be transported in water and sediments via the creek to the lagoon. Populations potentially exposed in the lagoon are discussed below

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.2.3) were combined with the results of the exposure assessment to arrive at the risk characterization. The ecological risk assessment concluded that direct exposures to soil and the ingestion of prey species lower on the food chain do not pose significant risks to terrestrial or aquatic organisms living in the stream at Area 2.

7.3 NEED FOR REMEDIAL ACTION

The results of the risk assessment indicate that there may be risks to hypothetical future residents posed by exposure to soils and groundwater at Area 2. Trichloroethene and vinyl chloride are the principal chemicals causing risk. These compounds also exceeded drinking water standards in some of the groundwater samples. Occurrence of these contaminants is limited to the upper aquifer in the portion of Area 2 south of the creek (former Building 957 drum storage area). No significant ecological risks or current health risks were identified at Area 2.

Because of the risk posed to future residents, RAOs were developed. Based on the RI and risks assessment results, RAOs for Area 2 focus on preventing human health exposures to trichloroethene and vinyl chloride in soil and groundwater by pathways such as ingestion of groundwater, inhalation of volatiles while showering, or ingestion of soil or vegetables grown in the soil. Remediation goals included restoration of the groundwater to drinking water quality for VOCs such as trichloroethene and vinyl chloride, which were identified as target compounds for evaluation of alternatives.

Although arsenic and beryllium in soil and manganese in groundwater contributed to the overall human health risk, they were present at concentrations similar to background levels established in the RI. RAOs were not included for these elements because they do not present significant additional risks compared with the background concentrations in adjacent areas.

7.4 DESCRIPTION OF ALTERNATIVES

A full range of remediation technologies was identified, screened, and evaluated in the FS. The alternatives developed and analyzed for Area 2 are described in the following sections. Table 7-5 summarizes and compares the main elements of each alternative. Table 7-6 summarizes the ARARs evaluation for the alternatives that was performed in the FS. Table 7-7 shows the FS cost estimates for the alternatives.

7.4.1 Alternative 1 - No Remedial Action

The no-action alternative was included in the range of alternatives evaluated in the FS, as required by the National Contingency Plan (NCP). It includes no specific response actions to reduce contaminants, control their migration, or prevent exposures. The no-action alternative serves as a baseline from which to judge the performance of the action-oriented alternatives.

7.4.2 Alternative 2 - Limited Action

This alternative would control exposures to target compounds through the use of institutional controls. Groundwater sampling would be used to monitor conditions and determine if additional actions are needed in the future.

These actions would prevent risks to human health by prohibiting future residential use of the property, particularly ingestion of drinking water from the shallow aquifer. It is possible to use institutional controls to prevent the risks posed by this site because current drinking water supplies are not threatened and the low contaminant concentrations and low frequency of detection of contaminants in the groundwater indicate low potential for off-Area migration. Area 2 does not pose risks warranting action for other land use scenarios studied in the baseline risk assessment, including human and ecological receptors for current conditions.

Alternative 2 would rely on natural attenuation mechanisms to restore the site, with the intent of minimizing environmental disturbance and short term impacts compared with those that would occur if more aggressive remediation actions were employed. Target compounds in the aquifer (groundwater and associated saturated soil) would be gradually removed by natural degradation and flushing processes as groundwater passes through the contaminated zone at naturally-occurring flow rates, and VOCs in the vadose zone soils would decline as they biodegrade or vaporize and diffuse into the atmosphere. Groundwater sampling would be used to monitor the progress of these natural processes to ensure that risks do not unexpectedly increase and to determine when institutional controls may be discontinued. The institutional controls would be maintained to prevent potable use of the aquifer until remediation goals were met.

Table 7-5
Alternatives Evaluated in the FS for Area 2

Response Action	Alternative 1 No Remedial Action	Alternative 2 Limited Action	Alternative 3 Soil Vapor Extraction and Institutional Controls	Alternative 4 Source Treatment and Removal with Aquifer Flushing	Alternative 5 Dewater Aquifer and Soil Vapor Extraction	Alternative 6 In-situ Steam Stripping
Institutional controls - long term		*	*	if needed	if needed	if needed
Monitoring - long term		*	*	if needed	if needed	if needed
Soil vapor extraction in vadose zone			*	*	*	
Dewatering system and groundwater cutoff walls				*	*	
Soil vapor extraction in dewatered zone					*	
Excavate Unit 2B and treat/dispose off-site				*		
Aquifer flushing system				*		
Treat extracted groundwater				*	*	
Discharge extracted groundwater				*	*	
In-situ steam stripping of vadose and saturated zones						*
Demolish existing structures to gain access to soils for cleanup						

Table 7-6
Evaluation of ARARs for Area 2 Alternatives

Act or Regulation	Citation	Requirement	Alternative 1	2	3	4	5	6
Chemical-Specific ARARs								
Safe Drinking Water	42 CFR 142 WAC 246-290-310	Maximum contaminant levels (MCLs) for public water supplies.	*	*	*	*	*	*
MTCA	WAC 173-340	Cleanup standards for groundwater.	*	*	*	*	*	*
Location-Specific ARARs								
Clean Water	40 CFR 230 40 CFR 320 40 CFR 330	Wetlands dredge and fill permit; mitigate unavoidable impacts.			*	*	*	*
Clean Water	Executive Order 11990; 40 CFR 6	Wetlands preservation: avoid unnecessary alteration and mitigate impacts.		*	*	*	*	*
Endangered Species	50 CFR 402	Conserve endangered species habitat.	*	*	*	*	*	*
Action-Specific ARARs								
MTCA	WAC 173-340-440	Deed restrictions and survey requirements.		*	*	*	*	*
MTCA	WAC 173-340-360 WAC 173-340-410	Specifies monitoring and institutional controls.		*	*	*	*	*
Clean Air	40 CFR 52 PSAPCA Reg I	Control fugitive dust emissions from construction activities.			*	*	*	*
Water Wells	WAC 173-160	Standards for monitoring or extraction wells.		*	*	*	*	*
Clean Water	40 CFR 122.26	Stormwater discharge permit for construction activities.			*	*	*	*
Clean Water	40 CFR 122 40 CFR 403 WAC 173-216	Effluent discharge permit for treated groundwater or condensate to POTW.			*	*	*	*
RCRA; Dangerous Waste	40 CFR 261-263 40 CFR 268 WAC 173-303	Characterization, transportation, treatment, and disposal requirements for excavated soil; land disposal restrictions.			*	*	*	
RCRA; Dangerous Waste	40 CFR 261-263 40 CFR 268 WAC 173-303	Characterization, transportation, treatment, and disposal requirements for treatment system residuals; land disposal restrictions.			*	*	*	*
Air Quality	PSAPCA Reg III	Control toxic emissions from stripper or soil vapor extraction system.			*	*	*	*
Safe Drinking Water	40 CFR 144	Underground injection control permit for aquifer flushing system.				*		

* Indicates that the requirement is applicable or relevant and appropriate to the actions and circumstances of the alternative.

Table 7-7
Estimated Costs of Area 2 Alternatives

Evaluation Factor (Cost)		Alternative 1 No Remedial Action	2 Limited Action	3 Soil Vapor Extraction and Institutional Controls	4 Source Treatment and Removal with Aquifer Flushing	5 Dewater Aquifer and Soil Vapor Extraction	6 In-Situ Steam Stripping
Initial Capital Investment			$0.02 million	$1.1 million	$5.1 million	$5.1 million	$8.3 million
Operating and Maintenance Cost	Years 1-2	0	$0.06 million	$0.3 million	$0.5 million	$0.5 million	$0.08 million
	Year 3	0	$0.06 million	$0.06 million	$0.5 million	$0.06 million	$0.06 million
	Years 4-5	0	$0.03 million	$0.03 million	$0.5 million	$0.03 million	$0.03 million
	After 5 years	0	0	0	$0.4 million	0	0
Life-cycle period for Present Worth, years		0	30	30	10	5	5
Present Value of O&M Costs	3% net discount rate	0	$0.02 million	$0.8 million	$3.8 million	$1.1 million	$0.3 million
	5% net discount rate	0	$0.02 million	$0.7 million	$3.5 million	$1.1 million	$0.2 million
	10% net discount rate	0	$0.02 million	$0.7 million	$2.8 million	$1.0 million	$0.2 million
Life-Cycle Cost	3% net discount rate	0	$0.03 million	$1.8 million	$8.9 million	$6.3 million	$8.6 million
	5% net discount rate	0	$0.02 million	$1.8 million	$8.6 million	$6.2 million	$8.5 million
	10% net discount rate	0	$0.02 million	$1.8 million	$7.9 million	$6.2 million	$8.5 million

Monitoring and institutional controls would be applied to the zone of contamination, which is defined by the trichloroethene/vinyl chloride plume in the upper aquifer underneath the paved area that currently surrounds Building 1018. This pavement covers a square area (200' x 200') bounded by wetlands to the north and south. Available data indicate the plume and coincides roughly with the extent of the paved area; however, additional sampling would be needed to define the exact extent. The depth of the plume is about 20 feet. A regular groundwater monitoring program would be established to monitor this plume for trends in contaminant concentrations and off-site migration. Institutional controls would include security measures such as currently enforced at the base, Navy land use restrictions while the base remains in operation, and deed restrictions if the base should be closed or the Navy should transfer the property to another owner.

7.4.3 Alternative 3 - Soil Vapor Extraction and Institutional Controls

Alternative 3 would be the same as Alternative 2 with the addition of vapor extraction technology to remove VOCs from the unsaturated soil zone. This alternative would reduce and control exposures to target compounds by the following response actions:

- Treat vadose soil within the contaminated zone by soil vapor extraction to remove possible sources of chlorinated solvents and other VOCs.
    - Treat extracted air and vapors to thermally destroy VOCs prior to discharge into the atmosphere.
    - Treat condensate resulting from the soil vapor extraction process and discharge treated effluent into the county sanitary sewer system leading to a public-owned treatment works (POTW).
    - Manage incidental excavated material (e.g., trench spoils) by off-site disposal (estimated volume: 1,400 cubic yards).
    - Implement environmental monitoring.
    - Implement institutional controls.

Vapor extraction would reduce or eliminate target compounds from the vadose zone, thus controlling possible migration of these contaminants into the aquifer by leaching or vapor diffusion mechanisms. The vapor extraction system would cover the same areal extent as described in Alternative 2 for institutional controls. Implementation would require removal of some pavement and excavation of soil for the trenches. Target compounds in the aquifer (groundwater and associated saturated soil) would be gradually removed by the same natural degradation and flushing processes as discussed for Alternative 2. Treatment of the vadose zone soil would assure that possible VOC sources above the saturated zone do not contribute on-going inputs of target compounds into the aquifer that would prolong its natural restoration.

This alternative was designed to apply a minimum degree of remediation technology that might be needed to assist and speed up the natural cleansing of the aquifer, with the intent of minimizing environmental disturbance and short term impacts compared with those that would occur if more aggressive remediation actions were employed.

As in Alternative 2, the risks posed by the site would be prevented by the use of institutional controls that preclude potable use of the aquifer. Groundwater sampling would be included to monitor the progress of natural restoration and determine when institutional controls could be stopped. The rationale and features of monitoring and institutional controls are the same as for Alternative 2. Institutional controls would be maintained until remediation goals were met.

7.4.4 Alternative 4 - Source Treatment and Removal with Aquifer Flushing

Alternative 4 would be similar to Alternative 3, except that aquifer flushing and soil removal actions would be added to further speed the restoration of the groundwater. This alternative would involve the following response actions:

- Excavate and remove an organic-rich geologic soil unit (Unit 2B) within the contaminated zone; backfill with clean material (estimated volume: 11,000 cubic yards).
    - Demolish existing structures and pavement as needed to gain access for excavating soil.
    - Install a groundwater cut-off wall to separate the clean backfill from the remainder of the contaminated zone (i.e., Unit 2F).
- Extract groundwater to lower the water table and dewater the aquifer within the contaminated zone to allow excavation of the soil in Unit 2B which is normally below the water table.

   - Treat extracted groundwater and discharge treated water into the county sewer system.
   - Install groundwater cut-off walls to reduce the volume of extracted groundwater and prevent dewatering of the adjacent wetlands and ecosystem damage that might occur while dry.

- Install aquifer flushing system to remove target compounds from saturated soil in Unit 2F.

   - Install groundwater extraction and reinjection trenches.
   - Treat extracted groundwater prior to reinjection into the aquifer or discharge into the county sewer.

- Use vapor extraction to treat vadose soil within the contaminated zone above Unit 2F to remove possible sources of chlorinated solvents and other VOCs.

- Manage excavated material by off-site disposal (estimated volume: 2,200 cubic yards).

- Implement environmental monitoring.

- Implement institutional controls.

This alternative would employ remedial actions to clean up target compounds throughout the full depth of the contaminated zone in the upper aquifer. It includes a groundwater extraction and recharge system to enhance the rate of aquifer restoration compared with that expected for natural processes in Alternatives 2 and 3. However, aquifer flushing would likely not be effective in a reasonable time frame for restoring the groundwater associated with Unit 2B soils, because these soils exhibit high natural organic content compared with other soils at Area 2, and therefore would adsorb target compounds more strongly than the other soils. Because of this, Alternative 4 included excavation and removal rather than aquifer flushing of geologic Unit 2B.

Because part of Unit 2B lies below the water table, this alternative includes groundwater pumping to lower the water table and allow excavation of this soil under relatively dry conditions. Groundwater cut-off walls would be included as part of the dewatering system mainly to protect wetlands near Area 2 and to reduce the volume of extracted groundwater and the corresponding treatment costs.

Treatment of the vadose zone by soil vapor extraction would be used for the same purposes as described for Alternative 3. The vapor extraction system would be smaller than that assumed for Alternative 3, because part of the vadose soils would already be remediated during the excavation and removal of Unit 2B.

As in Alternative 3, the risks posed by the site would be prevented by the use of institutional controls that preclude potable use of the aquifer. Groundwater sampling would be used to monitor the progress of aquifer flushing and determine when institutional controls could be discontinued. The general rationale and features of monitoring and institutional controls would be the same as for Alternative 2.

7.4.5 Alternative 5 - Dewater Aquifer and Soil Vapor Extraction

Alternative 5 involves the same actions as Alternative 3, except soil vapor extraction would be applied to the saturated zone soils as well as the unsaturated zone. Treatment of the saturated zone would be done to improve the time frame for groundwater restoration. This alternative would involve the following response actions:

- Extract groundwater to lower the water table and dewater the aquifer within the contaminated zone to allow soil vapor extraction treatment of the soil zone which is normally below the water table.

   - Treat extracted groundwater and discharge treated water into the county sewer system.
   - Install groundwater cut-off walls to reduce the volume of extracted groundwater and prevent dewatering of the adjacent wetlands and ecosystem damage that might occur while dry.

- Use vapor extraction to treat vadose soil within the contaminated zone above Unit 2F to remove possible sources of chlorinated solvents and other VOCs.

- Manage incidental excavated material by off-site disposal (estimated volume: 4,200 cubic yards).

- Implement environmental monitoring.

- Implement institutional controls.

These actions constitute a cleanup strategy for Area 2 in which soil vapor extraction is used to treat the target compounds throughout the full depth of the contaminant zone in the upper aquifer. Soil vapor extraction is not effective for removing contaminants from below the water table due to slow mass transfer rates across the air/water interface at the water table. This limitation would be overcome under this alternative by pumping groundwater to lower the water table and allow the soil vapor extraction system to pull air through the portion of the plume which is normally saturated with water.

Treatment of the vadose zone by soil vapor extraction would be used for the same purposes as described for Alternative 3. The vapor extraction system would cover the same areal extent as in Alternative 3. The vapor extraction system would be sized larger than that assumed for Alternative 3, because it would extend deeper (into the saturated zone soils) and vapor rates would be higher to treat the additional soil volume.

As in Alternative 3, the risks posed by the site would be prevented by the use of institutional controls that preclude potable use of the aquifer. Groundwater sampling would be used to monitor the progress of vapor extraction and determine when institutional controls could be discontinued. The general rationale and features of monitoring and institutional controls are the same as for Alternative 2. Depending on treatment efficacy, it might be necessary to continue institutional controls after the vapor extraction system is turned off. Institutional controls would be maintained until remediation goals were met (either by vapor extraction or by subsequent natural attenuation processes).

7.4.6 Alternative 6 - In-Situ Steam Stripping

This alternative features the use of a mobile in-situ steam stripping process to remove and treat target compounds throughout the contaminated zone in the upper aquifer. This technology has the potential for restoring the aquifer in a short time frame. Alternative 6 would involve the following response actions:

- Treat soil within the contaminated zone by in-situ steam stripping to remove possible sources of chlorinated solvents and other VOCs.

  - Demolish existing structures and pavement as needed to gain access for the steam stripping process.
  - Treat extracted air for reuse in the process.
  - Recycle or dispose of residual condensate resulting from the steam stripping process.

- Implement institutional controls.

- Implement environmental monitoring.

The in-situ steam stripping process can effectively strip and treat VOCs from both the vadose zone and the saturated zone, so no additional remediation technologies would be needed. The stripping process would be applied over the same areal extent as the vapor extraction system in Alternative 3.

The mobile steam stripping unit consists of a hooded auger fitted with cutting blades and steam/air inlets that can accomplish batch-wise in-situ mixing of subsurface soil to facilitate steam stripping of organic compounds from a contaminated zone. The stripping unit is capable of treating soil and groundwater to the full depth of the upper aquifer. The entire contaminant zone would be treated in sequential batches by moving the extraction unit from one spot to another in an overlapping grid pattern.

The system includes a vacuum pump to extract the air and stripped vapor from the treatment zone under the hood. The extracted air stream would be treated to remove VOCs and then recycled to the soil stripping zone. The vapor treatment system would produce small volumes of condensed vapors which might be amenable to off-site solvent recycling or otherwise would be sent to an off-site treatment, storage, and disposal facility. The treated air would be recycled to the treatment zone along with steam to feed the stripping process.

The stripping process might not be fully effective for restoring groundwater to drinking water quality. In this event, the residual risks posed by the site would be prevented by the use of institutional controls that preclude potable use of the aquifer. Groundwater sampling would be used to monitor the progress of natural attenuation and determine when institutional controls could be discontinued. The general rationale and features of the monitoring and institutional controls would be the same as for Alternative 2. Institutional controls would be maintained until remediation goals were met.

7.5 COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives were assessed in comparison with the nine evaluation criteria specified by CERCLA. The following sections summarize the comparative analysis of the alternatives with respect to the nine criteria, as discussed in the FS.

7.5.1 Overall Protection of Human Health and the Environment

All of the alternatives, with the exception of the no-action alternative, would provide adequate protection of human health and the environment by eliminating, reducing or preventing risk through the use of treatment technologies or institutional control measures. Because the no-action alternative is not protective of human health for future residents, it is not considered further in this analysis as an option for Area 2.

Alternative 2 would rely on institutional controls to prevent exposures until natural processes restore the aquifer, and would monitor restoration progress by continued groundwater sampling. Institutional controls would also be required for Alternative 3, because contaminants would not be completely removed from the site in this alternative. Although the remaining alternatives are designed to achieve remediation goals within reasonable time frames, this might not happen due to practical constraints or treatment performance limitations, and residual contamination might remain above cleanup levels. If residual contamination remains after treatment, institutional controls would be required for ultimate protection under these alternatives as well.

The exposures of concern at Area 2 are due to domestic use of groundwater by future residents. The institutional controls would prevent these exposures by excluding residential use of the site and precluding potable well construction. Institutional controls would not prevent ecological exposures; however, no ecological risks were identified for Area 2.

7.5.2 Compliance with ARARs

All of the alternatives are expected to meet the respective requirements of federal and state environmental laws and regulations that have been identified as being applicable or relevant and appropriate to the circumstances of each alternative. Compliance with chemical-specific cleanup goals, such as drinking water standards and MTCA cleanup levels, would not be achieved in the groundwater in a short time frame for any of the alternatives, except perhaps Alternatives 5 and 6. Depending on treatment effectiveness, residual groundwater contamination might remain after treatment for these alternatives as well. Natural degradation mechanisms are expected to eventually reduce concentrations of the chemicals of concern below the groundwater cleanup goals. Until the groundwater cleanup goals are met, institutional controls would be used to prevent the exposures of potential concern, as required by MTCA (WAC 173-340-440).

Alternative 2 would rely completely on natural processes for reducing groundwater concentrations. The remaining alternatives would use treatment measures to accelerate the time frame for restoration of the groundwater to drinking water standards.

Subsurface barrier walls and in-situ treatment systems for Alternatives 3 through 6 would be designed to comply with all appropriate regulations for wetlands protection. Groundwater and soil vapor treatment systems for Alternatives 3 through 6 would be designed to satisfy appropriate effluent discharge and air emissions regulations. Soil excavated in Alternative 4 would be tested to determine if the material is a characteristic hazardous waste, and would be treated and managed as needed to comply with RCRA and state regulations for off-site land disposal.

7.5.3 Long-Term Effectiveness and Permanence

Alternative 2 includes no treatment actions, and would not permanently remove or destroy chemicals of concern except slowly by natural degradation processes. The remaining alternatives would accelerate the permanent reduction of risk at Area 2 by applying various degrees of treatment. In Alternative 3, soil vapor extraction would remove VOCs from the vadose zone soil to eliminate this as a potential ongoing source of groundwater contamination. Alternatives 4 through 6 would use additional treatment measures to remove VOCs from the saturated zone soils as well as the vadose soils. All the removed VOCs would be treated for permanent destruction with the possible exception of the soils excavated in Alternative 4. The VOC concentrations in the excavated soils are expected to be low enough that treatment would not be required by hazardous waste regulations prior to disposal in an off-site landfill.

Alternatives 5 and 6 would permanently reduce contaminants throughout the site and would have little if any long-term reliance on institutional controls because any residual risks would be small. Alternative 4 would have more reliance on institutional controls, because aquifer flushing to restore groundwater may not be as effective as the vapor extraction and steam stripping technologies used in Alternatives 5 and 6. Alternative

3 would have even more reliance on institutional controls because it would only treat contaminants in the vadose zone. Alternative 2 would rely completely on institutional controls for prevention of risks.

7.5.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 4, 5 and 6 would include in-situ technologies designed to treat contaminants throughout the entire plume to reduce toxicity. Alternatives 5 and 6 (soil vapor extraction coupled with aquifer dewatering and steam stripping, respectively) would achieve the most complete treatment in the shortest time frame. In comparison, aquifer flushing used in Alternative 4 would be slower and may not be as effective. Alternative 3 would provide quick and effective treatment using soil vapor extraction, but only for the soils above the water table. Alternative 2 does not include treatment technologies and hence would not satisfy the regulatory preference for remedies that use treatment as a principal element.

7.5.5 Short-Term Effectiveness

All the alternatives would quickly attain RAOs, because they all include institutional controls that can be readily implemented for short-term prevention of exposures. Alternatives 5 and 6 would achieve remediation goals in the shortest time frame (estimated less than 5 years), while Alternative 2 would take the longest time (a century or more). In Alternative 4, aquifer flushing would take longer to restore groundwater than the vapor extraction and steam stripping technologies used in Alternatives 5 and 6. Alternative 3 would take even longer than Alternative 4 because it would rely on natural groundwater flushing of the saturated zone. Alternative 2 may take longer for natural restoration than Alternative 3 because contaminants in the vadose zone would remain and could provide ongoing sources of groundwater contamination. Although intermediate cleanup times are expected for Alternatives 3 and 4, these alternatives involve aquifer flushing for which time frame estimates are difficult to make, and the cleanup duration for these alternatives may not be substantially shorter than that for Alternative 2.

Short-term risks to the community are not expected to be significant for any of the alternatives. Alternative 2 would avoid short-term impacts to the wetlands bordering Area 2 that may occur from construction activities to implement the other alternatives. Short-term environmental impacts are likely for Alternatives 4, 5 and 6 because these involve construction of subsurface barrier walls or use of in-situ steam stripping along the wetland boundaries. Alternative 3 would have less potential for impacting the wetlands because the soil vapor extraction trenches could be designed to minimize construction next to the wetlands.

7.5.6 Implementability

Alternative 2 would be the easiest to implement since institutional controls and groundwater monitoring would involve no significant technical or administrative difficulties. The remaining alternatives would require coordination with various regulatory agencies to satisfy substantive requirements of wetlands protection regulations; these concerns appear to be most important for Alternatives 4 through 6 because extensive construction activities would occur along the wetland borders. Alternatives 3 through 5 involve groundwater treatment which would require a permit to discharge treated effluent. Alternatives 3 through 6 would all require treatability tests or field pilot tests to verify performance and establish sizing criteria for remedial design. Alternative 4 appears to be the most complex to implement because several different technologies would be applied. Alternative 6 could be subject to potential delays due to the specialized equipment and services required for in-situ steam stripping.

7.5.7 Cost

Alternative 2 would have the lowest cost, with an estimated present worth of $0.2 million. The estimated present worth cost of the remaining alternatives ranges from $2 million for Alternative 3 to $9 million for Alternatives 4 and 6. Alternative 5 would have an intermediate cost, (present worth of $6 million).

7.5.8 State Acceptance

The State of Washington Department of Ecology concurs with the selected remedy for Area 2 of the NUWC Division, Keyport Operable Unit 2. Comments received from Ecology have been incorporated into this Record of Decision.

7.5.9 Community Acceptance

Community acceptance was not specifically addressed as part of the evaluation of the individual alternatives in the FS. Rather, this criterion was assessed in the context of the preferred alternative presented to the public in the proposed plan and the public meeting.

Based on comments received on the proposed plan during the public comment period, as summarized in Appendix

A, the selected remedy described below appears to be acceptable to the community.

7.6 SELECTED REMEDY FOR AREA 2

Based on consideration of CERCLA requirements, the detailed analysis of alternatives, and public comments, the Navy, EPA, and Ecology have determined that the most appropriate remedy for Area 2 is Alternative 2, which consists of institutional controls and groundwater monitoring (see Section 12.1 for rationale). The institutional controls will be used to exclude residential use of the site and prevent construction of domestic wells. The monitoring will be used to establish trends in groundwater chemical concentrations and determine when institutional controls could be discontinued.

The following sections describe additional details of the selected remedy for Area 2. The descriptions, details, and costs discussed below for the selected actions are based on currently available data and information. Changes may be made to the selected remedy as a result of new information developed during the remedial design process.

7.6.1 Monitoring

This section describes the principal elements of the groundwater monitoring that will be implemented for the selected remedy. After this ROD is signed, further details of the monitoring program will be developed by preparation of a sampling and analysis plan, with input from the community and review and concurrence by EPA and Ecology.

The chemicals of concern in Area 2 groundwater are trichloroethene and vinyl chloride. Groundwater contributed an excess cancer risk of 1.3 x 10-4 (almost entirely due to vinyl chloride) to a cumulative excess cancer risk of 3 x 10-4 estimated for future residents. Both vinyl chloride and trichloroethene were also detected above drinking water standards. The highest concentrations were those for trichloroethene at monitoring well 2MW-1 (24 to 36 µg/L).

Soil vapor survey data do not indicate the presence of contamination upgradient from 2MW-1; however, no monitoring wells were sampled upgradient of 2MW-1 to confirm the absence of upgradient sources. For this reason, the groundwater monitoring program will include installation and sampling of two new monitoring wells upgradient of 2MW-1. In addition, a well will be installed downgradient of Area 2 for investigative purposes. These three new wells are referred to herein as "investigative wells." The locations of these wells will be selected with the concurrence of EPA and Ecology. One round of samples will be collected from the investigative wells and analyzed for VOCs. Water table elevations will be measured seasonally for one year to determine seasonal variation. If the water table elevation has significant seasonal variations in the investigative wells (i.e., to the extent that the overall groundwater flow direction changes seasonally), an additional sampling round will be performed. The investigative sampling will be initiated within 15 months of the signing of this ROD. If the sampling results confirm expectations (i.e., no additional sources), no further sampling will be done for the investigative wells. If the sampling results indicate an additional source, the Navy will undertake further investigation, monitoring, or action with the concurrence of EPA and Ecology.

Initially, the long-term groundwater monitoring will consist of:

- Sampling of wells 2MW-1 and 2MW-3, plus a downgradient well.
- Annual sampling of the wells until the 5-year site review is performed.
- The groundwater samples will be analyzed for VOCs using standard EPA drinking water methods.
- Sampling of one or more of the investigative wells might be included, depending on the results of the investigative sampling described above.

The initial scope of the monitoring described above will be modified as the data are collected and evaluated. If concentrations increase or the plume expands, the need for additional wells, increased sampling frequency, or other actions will be evaluated. If concentrations decrease over time, the sampling frequency may be reduced.

The long-term groundwater monitoring data will be used to establish contaminant trends over time and assess whether institutional controls restricting groundwater use can be discontinued. For this purpose, the monitoring data will be compared with federal and state drinking water standards (Table 7-8). The analytical methods and details of how these evaluations are to be made will be documented in the sampling and analysis plan.

Table 7-8
Remediation Goals for Area 2 Groundwater

Chemical	Drinking Water MCL, µg/L Federal	State	MTCA B Cleanup Level, µg/L
Trichloroethene	5	5	5a
Vinyl chloride	2	2	0.023b

a Thc MTCA B Cleanup Level for trichloroethene is the same as the MCL, because the MCL is a sufficiently protective, health-based standard, as determined by the procedures described in Ecology's guidance memorandum (Kraege 1993).

b This goal is below practical quantitation limits of standard EPA analytical methods for drinking water. In such cases, the MTCA cleanup standard will be based on the PQL, as stipulated in WAC 173-340-700(6). The expected PQL, based on EPA Method 502.1. is 0.1 µg/L (Robb 1993). Expected PQLs are not always achieved, depending on the matrix effects of a particular sample.

Any decision to modify the monitoring scope or discontinue institutional controls based on the groundwater monitoring results will be subject to approval by EPA and Ecology, with input from the community.

7.6.2 Institutional Controls

Institutional controls will be implemented to prevent residential land use at Area 2, restrict construction activities, prevent construction of domestic wells, provide for long-term monitoring activities, and control physical access to the property. The institutional controls will apply to the part of Area 2 where the groundwater is impacted by VOCs above drinking water standards (i.e., MCLs and MTCA B cleanup levels). Based on current data, this would include the paved area at monitoring wells 2MW-1 and 2MW-3 (i.e., the former Building 957 drum storage area). The areal extent of the property subject to institutional controls will be established with concurrence from EPA and Ecology after the upgradient sampling data have been obtained and evaluated.

The following institutional controls will be implemented and maintained while the Navy owns the property:

- Physical access to the property will be controlled by continued use of existing base security measures, including fencing of the entire base, pass and identification procedures, guardhouses, and security patrols.

- Land use restrictions will be imposed to disallow residential development.

- Land use restrictions will be imposed to prevent construction of wells at Area 2 for drinking water, irrigation, or other domestic purposes.

- The physical access and land use restrictions will be initiated by issuing a NUWC Division, Keyport Instruction signed by the base Commander. This instrument will constitute orders to base military and civilian personnel to implement and maintain the access controls and restrictions. Implementation of the Instruction will include incorporation of its elements into the facility master plan and the capital improvements plan.

- The Instruction will also include provisions for conducting the long-term monitoring activities called for in this ROD.

- The Instruction will be prepared after this ROD is signed. Its content will be subject to review and approval by EPA and Ecology.

In the event the Navy sells or transfers the property, per 40 C.F.R. §373.1, in accordance with CERCLA section 120(h)(1), the Navy will include a notice that identifies that hazardous substances were stored on the properly and were released and disposed of on the property. This notice will identify the type and quantity of such hazardous substance and the time at which such storage, release, and disposal took place. This notification will occur even if the property is transferred to another federal agency.

In addition, per CERCLA section 120(h)(3) the deed will contain specified information regarding the hazardous substances and a covenant warranting that:

1. All remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of such transfer and,

2. Any additional remedial action found to be necessary after the date of such transfer will be conducted by the United States. When the Department of the Navy reports property as excess to the General Services Administration (GSA), it is responsible for informing GSA of all inherent hazards and for the expense and supervision of decontamination of the property (41 C.F.R. §§101-47.401-4).

The remedial actions necessary to protect human health and the environment at Area 2 are the following institutional controls, which will be implemented when the Navy transfers the property to a future owner:

- Restrictive covenants on the property will be recorded with the county register of deeds that are binding on the owner's successors and assignees, and that place limiting conditions on property conveyance, restrict land use, and require maintenance of physical access controls.

- The restrictive covenants for land use will disallow residential land use and control digging, maintenance, and construction activities at Area 2.

- The restrictive covenants for land use will prevent construction of wells at Area 2 for domestic and agricultural purposes.

- The restrictive covenants will require the owner to implement and maintain physical access controls equivalent to existing base security measures, which may be satisfied by fencing Area 2 and posting signs.

- Conveyance of the property will be subject to the conditions and obligations of this ROD, including long-term monitoring. The property restrictive covenants will require notification to environmental regulatory agencies (EPA, Ecology, or their designees) of any intent to transfer interest in the property, modify its land use, or implement construction activity, and require agency approvals for such actions.

- The location of Area 2 and survey bench marks will be recorded with the county register of deeds. The extent of the property subject to restrictive covenants will also be recorded.

7.6.3 Cost

The estimated life cycle cost of the selected remedial actions for Area 2 is shown on Table 7-9, based on a life cycle of 30 years and a net discount factor of 5 percent. Table 7-9 provides a breakdown of the major capital, operating, and maintenance cost items that contribute to the overall life cycle cost.

8.0 SUMMARY OF INVESTIGATION FOR AREA 3

This section presents a summary of the RI/FS for Area 3.

8.1 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site characteristics, including a discussion of the geologic and hydrologic characteristics and the nature and extent of contaminants.

8.1.1 Site Description

The Otto Fuel Leak Area is located between Buildings 106 and 499 adjacent to the shallow lagoon (Figure 8-1). Otto fuel is a torpedo propellant composed of three ingredients: PGDN, di-n-butyl sebacate, and 2-nitrodiphenylamine. Torpedo fuel testing is conducted in Building 106, including use of Otto fuel. Two Otto fuel wastewater drainlines exist beneath the ground at Area 3; these formerly connected Building 106 with a 1,000 gallon sump (currently inactive) and now connect to an active sump located south of Building 499.

Wastewater that accumulated in the former sump was periodically pumped out into portable tanks for treatment/disposal away from Area 3. Periodic pumpouts are also practiced for the currently active sump. The former sump has been inactive since 1984 when it was discovered to be leaking wastewater into the ground. Previously (in the late 1960s), a separate leak had been discovered in the drainline between Building 106 and the former sump. These known leaks, plus possible incidental spillage near the sumps from pumpout activities, are the sources of suspected contamination at Area 3 (SCS Engineers 1984, Sweet-Edwards 1985).

Table 7-9
Estimated Costs for Selected Remedial Actions, Area 2

A. CAPITAL COSTS	Estimated Cost, $
DIRECT CAPITAL COSTS:	
Monitoring Wells	12,000
INDIRECT CAPITAL COSTS:	
Engineering, legal, administration (20% of direct costs)	2,400
Contractor overhead and profit (25% of direct costs)	3,000
SUBTOTAL, INDIRECT COSTS:	5,400
TOTAL PROJECT CAPITAL COST:	
Total direct and indirect capital costs	17,400
Contingency (30%)	5,200
SUBTOTAL, PROJECT CAPITAL COSTS	22,600
B. OPERATING & MAINTENANCE COSTS	Annual Cost, $/yr
Monitoring, Years 1-3	62,300
Monitoring, After 3 yrs	31,100
Well Maintenance	700
C. LIFE CYCLE COST (30 years at 5% net discount rate)	Present Value, $
Present Value of Project Capital Cost	22,600
Present Value of O&M Cost	220,000
TOTAL PRESENT WORTH:	242,600

Note: The costs shown above were based on FS assumptions.

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The immediate vicinity of the sump areas is generally flat and grassy, with dense foliage along the nearby shoreline. The 17-acre shallow lagoon is approximately 30 feet south of the former sump. The shallow lagoon is separated from Liberty Bay by a causeway along its eastern edge; the causeway dampens and minimizes tidal influences and currents in the lagoon (Figure 8-2).

<u>8.1.2 Geology and Hydrology</u>

Five geologic units were identified above the Clover Park unit at Area 3. Figures 8-3 and 8-4 present geologic cross sections. The depth to the water table at Area 3 is 5 to 7 feet. Two water-bearing zones have tentatively been identified at Area 3 above the Clover Park aquitard. The upper shallow (water table) aquifer is present within geologic Units 3B and 3D. Unit 3B consists of wet to moist organic-rich silt and clay. The most permeable and coarse-grained portion of this aquifer is the sand-rich Unit 3D. All of the monitoring wells at Area 3 are completed in this unit. Unit 3F corresponds to the lower, partially confined aquifer; it is hydraulically connected to the upper aquifer at the easternmost part of the Area. Under most of Area 3, and especially the portion of concern (west of MW3-4), till of Unit 3E forms a very tight aquitard separating the water-bearing zones of Units 3D and 3F. Unit 3E is expected to greatly retard the downward flow of water.

Water elevations show that groundwater in the western portion of Area 3 flows southwestward toward the marsh area and the sewage pump station instead of toward the lagoon (Figure 8-5). Water in the lagoon also appears to locally recharge groundwater toward the marsh area and pump station. The pump station wet well extends to about 10 feet bgs, which is below the water table, and the pump periodically turns on. Therefore, any potential groundwater leakage into the wet well through cracked concrete or connecting pipe joints could affect the groundwater flow direction in Area 3. The average horizontal groundwater gradient at Area 3 is 0.025. The calculated linear velocity ranges from 11 to 95 ft/yr, averaging 33 ft/yr.

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<u>8.1.3 Nature and Extent of Contaminants</u>

Media sampled at terrestrial Area 3 during the RI include soil and groundwater. Media sampled in the shallow lagoon include marine surface water, marine sediment, and marine shellfish/fish tissue. The nature and extent discussion considers only those chemicals that are major contributors to human health or ecological risk, or that exceed one or more ARARs. These chemicals are considered to be chemicals of concern and are listed in Table 8-1 with a summary of results. However, no chemicals from terrestrial Area 3 surpass these criteria, although some in the lagoon do. In addition, PGDN is discussed because of nature and extent concerns and because it was the target chemical. As discussed in Section 6.3.5, other Otto fuel compounds and breakdown products were also analyzed, however, laboratory complexities did not allow the reporting of meaningful results for these ancillary compounds.

- Soil

PGDN was identified at up to 0.18 mg/kg in samples near the two Otto fuel sumps. The probable source of surface soil detections is incidental spillage of Otto fuel from sump pumpout or other ongoing operations. The likely source for subsurface detections (down to 16 ft bgs) is leakage from the inactive sump or pipes leading to it from Building 106.

- Groundwater

PGDN was identified at up to 3.9 µg/L in samples near the inactive Otto fuel sump. The likely source of these detections is leakage from this sump or pipes leading to it from Building 106. Concentrations detected in groundwater and soil are several orders of magnitude lower than those measured in an earlier study (Sweet-Edwards 1985). Disappearance is probably due to: 1) source control (i.e., leaks were stopped years ago), 2) flushing of PGDN out of the aquifer by groundwater flow and discharge to the shallow lagoon, and 3) attenuation by natural degradation processes.

- Marine Surface Water

In the shallow lagoon, thallium exceeded MTCA Method B surface water criteria. However, it was detected at the quantitation limit at an estimated concentration ("J" flagged) in only one of seven samples from the same sample station. Although PGDN did not exceed any criteria, it was detected in all nine samples at relatively low concentrations (up to 0.11 µg/L).

- Marine Sediment

In the shallow lagoon, two organic compounds (bis[2-ethylhexyl]phthalate and phenol) were identified above Washington State Sediment Management Standards. The phthalate ester was above this standard in 8 of 32 samples, and phenol exceeded it in only one sample near Area 3. These chemicals are readily biodegraded and are widespread in the marine environment of Puget Sound (PSEP 1991, URS 1993a). PGDN was not detected in any sediment sample.

- Marine Shellfish/Fish Tissue

In the shallow lagoon, no chemicals exceeded ARARs or were major contributors to human health or ecological risk. Although PGDN did not exceed any criteria, it was detected in one of two tissue samples at a low concentration (0.00041 mg/kg).

Table 8-1
Area 3 - Major Risk Contributors and ARAR-Exceeding Chemicals

Chemical	Number of Samples	Number of Detections Above Background	Background Concentration	Range of Detects Above Background Minimum	Range of Detects Above Background Maximum	Major Risk Contributor Human Health	Major Risk Contributor Ecological	Exceeds ARAR
MARINE WATER - SHALLOW LAGOON								
Inorganic Chemicals (µg/L)								
Thallium	7	1	33 U	33	33			*
MARINE SEDIMENT - SHALLOW LAGOON (<10 cm)								
Semivolatile Organic Compounds (mg/kg)								
bis(2-Ethylhexyl)phthalate	19	8	NV	0.19	4.2			*
MARINE SEDIMENT - SHALLOW LAGOON (≥10 cm)								
Semivolatile Organic Compounds (mg/kg)								
bis(2-Ethylhexyl)phthalate	13	5	NV	0.16	3.1			*
Phenol	14	1	NV	0.90	0.90			*

NV = No Value
U = Not Detected at that concentration
ARAR = applicable or relevant and appropriate requirement
Note: Major risk contributors identified as follows:
Human Health: Chemical contributes at least 1 x 10-5 excess cancer risk or 0.1 hazard quotient to combined RME risk for scenarios with unacceptable risk, as evaluated in Human Health Risk Assessment.
Ecological: Identified in Ecological Risk Assessment as a risk driver.

8.2 SUMMARY OF SITE RISKS

The following sections summarize human health and ecological risks.

8.2.1 Human Health Risks

This section presents a summary of contaminant identification, exposure assessment, toxicity assessment, and risk characterization for Area 3.

- Initial Contaminant Identification

As a result of the preliminary risk-based screening conducted for Area 3 samples, the following are judged to be human health risk COPCs:

  - Soil: PGDN
  - Groundwater: PGDN

- Exposure Assessment

Primary sources of contamination are leakage from an Otto fuel pipeline and underground sump. Soil and groundwater contamination have occurred as a result of these activities.

Although the sources identified above are subsurface, PGDN was detected in surface soil at Area 3. Current industrial workers as well as future workers and residents may be exposed to Otto fuel in soil via incidental ingestion and dermal contact.

Otto fuel in soil could be transported by particulates to the surrounding air. In a future residential scenario, most of the ground surface would be covered with pavement (streets, sidewalks), houses, or plantings (lawn, shrubs). However, to be conservative, risks to future residents from fugitive dust emissions are evaluated in this risk assessment. Because of the primarily subsurface nature of contamination at this site, surface runoff and particulate transport are expected to be minor exposure pathways. Infiltration to groundwater and subsequent groundwater migration could transport Otto fuel compounds to the shallow lagoon. Future residents are assumed to use shallow groundwater at Area 3 as a drinking water source, and therefore may be exposed to Otto fuel in groundwater.

Otto fuel was detected in shallow lagoon surface water, indicating possible transport from Area 3 groundwater. Future visitors and Area 3 residents may be exposed to Otto fuel while swimming in the shallow lagoon (ingestion, dermal contact), or playing along the shoreline (incidental ingestion, dermal contact). No fish/shellfish ingestion pathway is postulated for the shallow lagoon because no edible-size fish, crabs, or other organisms were found during a biological survey of the lagoon conducted during the RI. A small population of mussels found during the survey exist only on the concrete substrate along the northern shore of the lagoon near the causeway, and this small, restricted population would not provide a significant or sustainable shellfish gathering area.

- Risk Characterization

The toxic effects of PGDN on the representative receptor population (as discussed in Section 6.1.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Tables 8-2 and 8-3 summarize the risk characterization results for Area 3.

Current Land Use. PGDN is the only chemical of potential concern for current scenarios at Area 3. Risk to current workers at Area 3 from PGDN have not been quantified because of the lack of an RfD for this compound; however, they would be expected to be less than those calculated for the future residential scenario, discussed below.

Future Land Use. Excess cancer risks (RME) for future residents and future visitors to Area 3 are 4 x 10-6. Excess cancer risks to future workers are within or below EPA's target risk range. Noncancer risks to future residents, visitors, and workers are below EPA's target risk level. However, risks from exposure to PGDN are not included in this table because of the lack of an RfD for PGDN. A surrogate RfD has been calculated for PGDN by URS Consultants, Inc. (see Appendix F of the Human Health Risk Assessment [URS 1993c]). This RfD is highly uncertain and is not verified by EPA, and therefore the noncancer risks associated with PGDN were evaluated separately. Table 8-4 shows the PGDN risk quantification results for the future residential scenario at Area 3. The RME HQ for ingestion of chemicals in drinking water is 1, while the RME HI for ingestion of chemicals in soil is 0.005. These noncancer risk results do not exceed target levels. on these results, it is concluded that PGDN does not pose a significant noncancer risk at Area 3.

Table 8-2
Summary of Risk Results-a
Area 3 - Current Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Current Workers				
Inhalation of airborne chemicals - particulates	-	-	-	-
Ingestion of chemicals in soil	-	-	-	-
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	-	-	0.04	0.04

a Risks presented are exclusive of PGDN. Because of uncertainty in RfD, risk associated with PGDN are presented separately in Table 8-4.

Table 8-3
Summary of Risk Results-a
Area 3 - Future Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Future Residents				
Ingestion of chemicals in drinking water (shallow aquifer)	-	-	-	-
Ingestion of chemicals in soil	-	-	-	-
Inhalation of airborne chemicals - particulates	-	-	-	-
Ingestion of chemicals in surface water while swimming (lagoon)	-	-	1E-6	8E-7
Ingestion of chemicals in marine sediment (lagoon)	4E-6	2E-7	0.02	0.003
TOTAL	4E-6	2E-7	0.02	0.003
Future Workers				
Inhalation of airborne chemicals - particulates	-	-	-	-
Ingestion of chemicals in soil	-	-	-	-
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	-	-	0.04	0.04
Future Visitors				
Ingestion of chemicals in surface water while swimming (lagoon)	-	-	1E-6	8E-7
Ingestion of chemicals in marine sediment (lagoon)	4E-6	2E-7	0.02	0.003
TOTAL	4E-6	2E-7	0.02	0.003

a Risks presented are exclusive of PGDN. Because of uncertainty in RfD, risk associated with PGDN are presented separately in Table 8-4.

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5". This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

Table 8-4
Noncancer Risks for PGDN at Area 3
Future Residential Scenario

Exposure Pathway	RME HI	Average HI
Ingestion of chemicals in drinking water	1	0.3
Ingestion of chemicals in soil	0.005	0.001
Inhalation of airborne chemicals - particulates	1E-07	8E-08
Ingestion of chemicals in surface water while swimming (lagoon)	7E-05	5E-05

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5". This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

8.2.2 Ecological Risks

- Initial Contaminant Identification

As a result of the initial ecological risk screening conducted for Area 3 samples, the following are judged to be ecological risk COPCs:

  - Soil: PGDN
  - Surface water in the shallow lagoon: dicamba, 2,4-D, and PGDN
  - Sediment in the shallow lagoon: none
  - Shellfish and fish tissue in the shallow lagoon: copper and PGDN

- Exposure Assessment

Area 3 is located in a moderately industrialized portion of the facility. The area surrounding the Otto fuel sump leak is generally grassy. Garter snakes were commonly observed in the grassy area. Canada geese (Branta canadensis) also feed in this area. A dense stand of shrubs and immature trees occupies the southern edge of the site and the shallow lagoon is located approximately 20 feet downslope.

Plants, soil invertebrates, and Canada geese are considered most exposed to the COPCs. Canada geese may be exposed to COPCs via ingestion of grasses, soil, and surface water.

Because of potential Otto fuel contamination in subsurface soils and groundwater, the nearby shallow lagoon was evaluated as a likely area for potential marine biotic exposures. The shallow lagoon has approximately 17 acres of surface area.

Since COPCs were detected most frequently in the sediments, species living in close association with the sediments are likely to experience the greatest exposure. Common benthic invertebrates of the lagoon are clams including Macoma spp., spionid and capitellid polychaetes, and corophid and gammarid amphipods. Small, dense beds of mussels (Mytilus edulis) are present at the northeast end of the lagoon near the connection to Liberty Bay. Planktonic invertebrates present include harpacticoid copepods.

Fish seine surveys of the shallow lagoon were conducted in June 1991 to identify potential receptors and evaluate species abundance. Results of four seine trawls indicate a relatively diverse fish community in the lagoon. Other observations during the June 1991 fish seine survey suggest that the lagoon probably serves as a nursery area for small fish species, such as three-spine stickleback and bay goby. Demersal fish species that feed primarily on benthic invertebrates include the Pacific staghorn sculpin (Leptocottus armatus) and speckled sanddab. Water-column-feeding species include surfsmelt, Pacific herring, three-spine stickleback, and bay goby.

The lagoon also supports a diversity of waterfowl and shorebirds. Omnivorous waterfowl include the mallard and Canada goose. More carnivorous birds are the bufflehead, common goldeneye (Bucephala clangula), cormorant (Phalacrocorax spp.), and great blue heron (Ardea herodius). Bald eagles (Haliaeetus leucocephalus) and ospreys (Pandion haliaetus) have been seen in the lagoon area on occasion.

Vegetation of the lagoon includes attached algae such as Ulva sp. and Enteromorpha sp., and emergents such as bullrush (Scipus sp.).

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.2.3) were combined with the results of the exposure assessment to arrive at the risk characterization. The ecological risk assessment concluded that direct exposures to environmental media and the ingestion of prey species lower on the food chain do not pose significant risks to terrestrial or marine organisms at Area 3.

8.3 NEED FOR REMEDIAL ACTION

No significant human health or ecological risks were identified for exposure to chemicals at Area 3. In addition, no exceedences of ARARs were found. Based on consideration of CERCLA requirements, the baseline risk assessment, and public comments, the Navy, EPA, and Ecology have determined that the most appropriate remedy for Area 3 is no action. The evaluation of risks associated with Area 3 showed that no remedial actions are necessary for this portion of OU 2 to ensure adequate protection of human health and the environment.

Community acceptance was assessed in the context of the preferred alternative presented to the public in the proposed plan and the public meeting. Based on comments received on the proposed plan during the public comment period, as summarized in Appendix A, the preferred alternative of no action appears to be acceptable to the community.

It is not necessary to include Area 3 in the 5-year review of OU 2.

9.0 SUMMARY OF INVESTIGATION FOR AREA 5

This section presents a summary of the RI/FS for Area 5.

9.1 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site characteristics, including a discussion of the geologic and hydrologic characteristics and the nature and extent of contaminants.

9.1.1 Site Description

Area 5 is a former sludge disposal area of approximately 0.4 acre, which lies near the northern shoreline of NUWC Division, Keyport (Figure 9-1). The western half of the Area is covered by an asphalt parking lot while the remainder is a grassy hillslope where a small recreational area (exercise station) is located. A small picnic area consisting of several tables lies just south of Area 5. The Area is approximately 150 feet from Liberty Bay.

The sludges reportedly disposed at Area 5 originated from the sludge drying operations of the domestic and industrial wastewater biological treatment plant formerly located near Building 180. Metals that may be adsorbed in these biological sludges constitute the main chemicals suspected to be present at Area 5 (SCS Engineers 1984).

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9.1.2 Geology and Hydrology

Three geologic units were identified above the Clover Park unit at Area 5. Figure 9-2 presents a geologic cross section. The uppermost unit (Unit 5A) at Area 5 consists of 4 feet of silt, sand, and gravel fill; no conspicuous sludge material was identified in this unit. This fill unit appears to pinch out toward the south. Below the fill is till, comprising about 45 feet of very dense, fine-sandy silt, with little gravel (Unit 5E Vashon till). Underlying this till is more than 18 feet of very dense, fine to coarse sand with trace gravel (Unit 5F). The uppermost water-bearing zone at Area 5 is Unit 5F, the top of which is about 50 feet bgs and -40 feet mean sea level (MSL). This aquifer is confined by Unit 5E, which acts as an aquitard.

9.1.3 Nature and Extent of Contaminants

Media sampled at Area 5 during the RI include surface and subsurface soil. The nature and extent discussion does not consider any chemicals or include any tables because there are no chemicals of concern.

• Soil

No chemicals were identified that exceeded MTCA Method B or were major contributors to human health or ecological risks.

• Groundwater

No groundwater samples were collected at Area 5. It had been planned to install a shallow monitoring well at Area 5 during the RI; however, no well was installed because till, which acts as a confining layer, was encountered during drilling at an unexpectedly shallow depth (4 feet bgs).

As described in Section 9.1.2, a 45 foot thick till unit was encountered in a pre-RI well (well 5MW-8; SCS Engineers 1987) located approximately 75 feet north of Area 8. The till unit, described as medium gray, very dense, silt and fine sand with a trace of fine gravel, was encountered between 7 and 51 feet bgs at this well.

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9.2 SUMMARY OF SITE RISKS

The following sections summarize human health and ecological risks.

9.2.1 Human Health Risks

This section presents a summary of contaminant identification, exposure assessment, toxicity assessment, and risk characterization for Area.

• Initial Contaminant Identification

As a result of the preliminary risk-based screening conducted for Area 5 samples, the following were judged to be human health risk COPCs:

  ▸ Soil: chromium, lead, mercury

• Exposure Assessment

Hazardous constituents (primarily metals) in wastewater treatment plant sludges spread on the ground surface at this area may have leached and percolated/infiltrated into surface and subsurface soils. Site workers and future residents could be exposed to cadmium and lead in soils by incidental ingestion as well as through dermal contact.

Half of Area 5 is paved; the other half is covered with grass. Therefore, particulate transport via fugitive dust emissions is considered very unlikely. Future construction of industrial facilities at this location could expose construction workers to particulates in air.

In a future residential scenario, most of the ground surface would be covered with pavement (streets, sidewalks), houses, or plantings (lawn, shrubs). However, to be conservative, risks to future residents from fugitive dusts emissions were evaluated in the risk assessment.

Metals in surface soil could also be carried via surface runoff to Liberty Bay, where they could subsequently be deposited in marine sediment or ingested by marine biota. Future visitors and residents could be exposed to metals while swimming in Liberty Bay (ingestion and dermal contact), playing in the intertidal zone (ingestion of marine sediment, dermal contact), or fishing/shellfishing. Liberty Bay exposure pathways are discussed further in Section 11.2.1.

COPCs could be transported by infiltration and percolation to groundwater beneath Area 5, and future residents could ingest them in drinking water. This pathway is not expected to be significant, however. No shallow groundwater was encountered beneath Area 5; drinking water wells installed in this area would have to be installed below the till and would most likely be screened below the Clover Park unit (e.g., in the deep aquifer).

• Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.1.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Tables 9-1 and 9-2 summarize the risk characterization results for Area 5.

Current Land Use. Cancer and noncancer risks to current workers at Area 5 are within or below EPA's target risk range. No current residential or recreational exposure scenarios have been postulated for Area 5.

Future Land Use. Excess Cancer risks (RME) for future residents and future visitors to Area 5 are 2 x 10-5. These risks are a result of the shellfish ingestion pathway for pentachlorophenol (1 x 10-5), arsenic (3 x 10-6), and bis(2-ethylhexyl)phthalate (2 x 10-6) in Liberty Bay. Excess cancer risks to future workers are within or below EPA's target risk range. Noncancer risks to future residents, visitors, and workers are below EPA's target risk level.

9.2.2 Ecological Risks

- Contaminant Identification

As a result of the initial ecological risk screening conducted for Area 5 samples, the following are judged to be ecological risk COPCs:

  - Soil: lead

- Exposure Assessment

Area 5 is located in an industrialized portion of the facility, with approximately 0.2 acres of landscaped grassy hillside available for terrestrial wildlife exposure. The entire area is bordered by parking lots and roadways. Terrestrial receptors may include grasses, invertebrates, small mammals (although none were observed during the RI), occasionally visiting passerine-type birds, and Canada geese. Grasses, soil invertebrates, and Canada geese are considered most exposed to the COPCs. Canada geese may be exposed to COPCs via ingestion of grasses and soil.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.2.3) were combined with the results of the exposure assessment to arrive at the risk characterization. The ecological risk assessment concluded that direct exposures to soil and the ingestion of prey species lower on the food chain do not pose significant risks to terrestrial organisms at Area 5.

9.3 NEED FOR REMEDIAL ACTION

No significant human health or ecological risks were identified for exposure to chemicals at Area 5. In addition, no exceedances of state cleanup standards (MTCA) were found. Therefore no remedial actions appear to be warranted for this Area, and no remedial alternatives were considered. However, some uncertainty remains because downgradient groundwater has not been sampled. No groundwater samples were taken during the RI at Area 5 because no source of contamination was identified and the stratigraphy and hydrogeologic conditions were not conducive to collecting a sample at the Area.

Based on consideration of CERCLA requirements, the baseline risk assessment, and public comments, the Navy, EPA, and Ecology have determined that the most appropriate remedy for Area 5 is no action. The evaluation of risks associated with Area 5 showed that no remedial actions are necessary for this portion of OU 2 to ensure adequate protection of human health and the environment.

Confirmatory sampling will be conducted to confirm the absence of significant risks for Area 5 and verify that a no-action conclusion is appropriate. The confirmatory sampling will be done in response to a request by Ecology that further attempts should be made to sample groundwater at Area 5. Accordingly, an existing monitoring well near the site (MW-8) will be sampled (Figure 9-1).

Community acceptance was assessed in the context of the preferred alternative presented to the public in the proposed plan and the public meeting. Based on comments received on the proposed plan during the public comment period, as summarized in Appendix A, the preferred alternative (limited groundwater sampling to confirm no action) appears to be acceptable to the community.

If the groundwater sampling confirms that a no-action decision is appropriate, it will not be necessary to include Area 5 in the 5-year review of OU 2.

Table 9-1
Summary of Risk Results
Area 5 - Current Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Current Workers				
Ingestion of chemicals in soil	-	-	0.003	0.003
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	-	-	0.04	0.04

Table 9-2
Summary of Risk Results
Area 5 - Future Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Future Residents				
Ingestion of chemicals in soil	-	-	0.02	0.006
Inhalation of airborne chemicals - particulates	1E-9	3E-10	1E-8	8E-9
Ingestion of chemicals in homegrown produce	-	-	0.01	0.005
Ingestion of chemicals in surface water while swimming (Liberty Bay)	-	-	3E-6	2E-6
Ingestion of chemicals in marine sediment (Liberty Bay)	-	-	-	-
Ingestion of chemicals in fish/shellfish (Liberty Bay)	2E-5	6E-7	0.05	0.006
TOTAL	2E-5	6E-7	0.08	0.02
Future Workers				
Inhalation of airborne chemicals - particulates	4E-10	1E-10	4E-9	3E-9
Ingestion of chemicals in soil	-	-	0.003	0.003
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	4E-10	1E-10	0.04	0.04
Future Visitors				
Ingestion of chemicals in surface water while swimming (Liberty Bay)	-	-	3E-6	2E-6
Ingestion of chemicals in marine sediment (Liberty Bay)	-	-	-	-
Ingestion of chemicals in fish/shellfish (Liberty Bay)	2E-5	6E-7	0.05	0.006
TOTAL	2E-5	6E-7	0.05	0.006

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5". This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

10.0 SUMMARY OF INVESTIGATION FOR AREA 8

This session presents a summary of the RI/FS for Area 8.

10.1 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site characteristics, including a discussion of the geologic and hydrologic characteristics and the nature and extent of contaminants.

10.1.1 Site Description

Area 8 occupies about 1 acre on the eastern portion of NUWC Division, Keyport surrounding the plating shop (Building 72 in Figure 10-1). This Area was included in the RI/FS because of the following historical releases:

- Chromate spill: In the 1970s, chromate plating solution (estimated total of up to 75 pounds of chromate salts) was accidentally spilled just east of Building 72 and washed into nearby storm sewers, which then discharged the solution into Liberty Bay. SCS Engineers (1984) concluded that because the spill area was paved, no residual contamination was expected.

- Utility trench: In early 1988, it was discovered that plating wastes from Building 72 were accidentally discharging into a concrete utility trench along the western side of the plating shop. The trench extends southward across a concrete paved area and Hunnicutt Road to the top of the riprap seawall adjacent to Pier 1 on Liberty Bay. It is possible that plating wastes migrated through joints or cracks in the utility trench into the adjacent soil. The trench was cleaned and all trench sludge was removed in February 1988. The source of the discharges from Building 72 was eliminated at that time (Hirsch, 29 February 1988, personal communication).

- Oil release: In 1987, subsurface petroleum hydrocarbons were discovered in a geotechnical boring before construction of Building 1019. An underground concrete vault located beneath Building 181, which historically was used to store diesel and Bunker fuel oil, was suspected as the source of these compounds.

Prior to actual construction of Building 1019, field investigations were conducted to assess the nature and extent of these hydrocarbons, resulting in the removal and off-site disposal of oil, groundwater, and soil from an observation test pit (Riedel Environmental Services 1988, SCS Engineers 1987).

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In addition to these historical releases, the Navy discovered in 1991 (during the course of building and equipment renovation) that chromic acid had been seeping through the concrete floor of the chrome room in the eastern end of the plating shop. In addition, other plating solutions, especially cadmium, were found at the time to be seeping through the floor in other parts of the shop. These findings led to the initiation of a series of field investigations to characterize these and other possible chemical sources (e.g., waste sumps) and to develop a corrective action program to upgrade the plating shop to eliminate and control such releases (Hart Crowser 1991). Contaminated vadose zone soil on the east side of Building 72 (down to a few feet deep) was removed in May 1992, along with sumps, pipelines, and a drainage trench (Hart Crowser 1992) (Figure 10-1). This action resulted from identification of chromium contamination in soil and groundwater and the discovery of leaking sumps.

Area 8 is located in a heavily industrialized part of NUWC Division, Keyport and is bordered by Liberty Bay to the south and east (see Figure 10-1). The Area is virtually flat and almost entirely paved (concrete up to 10 inches thick) or covered by buildings. Stormwater drains into stone sewers, which discharge into Liberty Bay. An industrial pier (pier 1) extends from the eastern side of Area 8 into Liberty Bay. In addition to the plating shop, current land use at Area 8 includes the following:

- Building 1019 is used for plating and photoetching.

- Building 804 was used as an underground concrete fuel storage vault. The top of the vault was removed, and it now serves as a containment structure and foundation for two steel diesel fuel storage tanks.

- Building 181 is used to store plating chemicals. It is located above another concrete underground vault immediately north of the Building 804 vault discussed above.

Other buildings adjacent to Area 8 include the following:

- Building 82 is a large office building with a restricted area used for work on torpedoes.

- Building 85 is a desalination/restoration unit and includes a battery refurbishing area.

- Building 98 is restricted and is used for soldering circuit parts.

10.1.2 Geology and Hydrology

Five geologic units were identified at Area 8. Because the near-surface lithologies at Area 8 are very homogeneous, a detailed cross section is not presented. Figure 10-2 presents a site-wide geologic cross section which includes Area 8. Unit 8A is about 3 to 13 feet thick and consists primarily of silty, gravelly sand fill. Unit 8F (Vashon advance outwash) and Unit 8I (Qg3 unit) combined are about 165 feet thick and consist of dense, sand, gravel, and some silt. Units 8F and 8I are saturated and make up the shallow unconfined aquifer at Area 8. Unit 8J (Clover Park unit) is only about 16 feet thick in well MW8-15 and consists of sandy clay and silt with some gravel. This unit appears to have been eroded into a large channel which was filled by Units 8F and 8I. Unit 8J forms the aquitard below the shallow aquifer at Area 8, although some silt-rich layers in Units 8F and 8I would retard vertical flow. Unit 8K (Qg4 unit) forms a sand and gravel aquifer below the Clover Park unit, but was not investigated in detail in the RI.

A vertical head difference of 3 to 4 feet exists between the bottom and upper portions of the shallow aquifer, indicating a significant upward vertical gradient. Net horizontal groundwater flow in the shallow aquifer, based on wells screened near the water table, is eastward toward Liberty Bay, although high tide causes a temporary flow reversal (Figure 10-3). The average (net) groundwater gradient is 0.02 toward the bay. The calculated linear flow velocity ranges from approximately 9 to 5,200 ft/yr, averaging 470 ft/yr.

10.1.3 Nature und Extent of Contaminants

Media sampled at Area 8 during the RI include subsurface soil and groundwater, including seeps and piezometer water at the adjacent beach. The nature and extent discussion considers only those chemicals that are major contributors to human health or ecological risks, or that exceed one or more ARARs. These chemicals are considered to be chemicals of concern and are listed in Table 10-1 with a summary of results.

- Soil

Arsenic and cadmium in subsurface soil were identified as major contributors to human health risk and exceeded MTCA Method B levels. Although not exceeding MTCA levels or risk-based concentrations, six VOCs were also detected in soil. These VOCs were also detected in groundwater, as discussed below. The source of the inorganic chemicals detected at Area 8 is believed to be metal plating activities associated with Building 72. Cadmium was detected most frequently and in highest concentrations in the western half of Building 72; it was present at lower concentrations along the utility trench and east of the building. Concentrations are elevated to depths of at least 9 feet bgs under the building and remain elevated (above the BSV) at 48 feet bgs east of the building near the seawall. Elevated chromium concentrations, probably also related to metal plating waste, were also identified in the subsurface of Building 72 to depths of at least 9 feet bgs. Additional soil data were collected at Area 8 as part of a soil removal action (Hart Crowser 1991, 1992) which could not be used for risk assessment because it was not validated sufficiently for such purposes. Nonetheless, these data indicate elevated concentrations of chromium in vadose zone soils near the chrome room, making chromium a potential concern in soil.

Arsenic is not associated with plating operations that have taken place at Area 8. Its low frequency of detection above BSV and small margin of exceedance of BSV suggest that its detection in Area 8 soil is probably related to background.

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Table 10-1
Area 8 - Major Risk Contributors and ARAR-Exceeding Chemicals

Chemical	Number of Samples	Number of Detections Above Background	Background Concentration	Range of Detects Above Background Minimum	Range of Detects Above Background Maximum	Major Risk Contributor Human Health	Major Risk Contributor Ecological	Exceeds ARAR
SUBSURFACE SOIL (>15 inches)								
Inorganic Chemicals (mg/kg)								
Arsenic	36	3	6.06	7.0	12.9	!		!
Cadmium	36	25	0.32 U	0.42	184	!		!
GROUNDWATER								
Inorganic Chemicals (µg/L)								
Antimony	33	1	14	36.5	36.5	!		!
Arsenic	25	2	12	23	68	!		!
Cadmium	34	12	2.5	3.4	1,780	!		!
Chromium, Hexavalent	33	20	10 U	1.0	5,000	!		!
Copper	34	8	3.0	3.5	78.5			*
Lead	34	2	1.0	1.0	17.5			*
Manganese	33	5	684	1,200	5,380	!		!
Nickel	34	19	3.0	5.8	3,550	!		!
Thallium	31	2	2.0	1.1	40			!
Zinc	34	5	18.6	102	394			!
Volatile Organic Compounds (µg/L)								
Benzene	51	3	NV	10	28	!		!
Bromodichloromethane	42	2	NV	2.0	2.0	!		!
Carbon Tetrachloride	42	1	NV	8.4	8.4	!		!
Chloroform	42	6	NV	1.0	10.8	!		!
1,1-Dichloroethane	42	11	NV	1.0	100			!
1,2-Dichloroethane	42	3	NV	2.0	5.0	!		!
1,2-Dichloroethane (total)	39	24	NV	1.0	71	!		!
1,1-Dichloroethane	42	23	NV	1.0	94	!		!
Tetrachloroethene	42	9	NV	2.0	130	!		!
1,1,1-Trichloroethane	41	31	NV	2.0	2,500	!		!
1,1,2-Trichloroethane	42	1	NV	89	89	!		!
Trichloroethene	39	31	NV	1.0	3,100	!		!

NV = No Value
U = Not Detected at that concentration
ARAR = applicable or relevant and appropriate requirement
* Groundwater quality was compared to surface water quality criteria (where more stringent than groundwater criteria) because the groundwater discharges into water bodies and could potentially cause ARAR exceedances in surface water.

Note: Major risk contributors identified as follows:
Human Health: Chemical contributes at least 1 x 10-5 excess cancer risk or 0.1 hazard quotient to combined RME risk for scenarios with unacceptable risk, as evaluated in Human Health Risk Assessment.
Ecological: Identified in Ecological Risk Assessment as a risk driver.

• Groundwater

Ten inorganic chemicals in groundwater exceeded MCLs or MTCA Method B levels. The inorganic contaminant plume is depicted in Figure 10-4. Cadmium was detected in shallow wells, which define a plume extending from the western portion of Building 72 eastward with decreasing concentrations. Total and hexavalent chromium detections indicate a generally similar pattern, except the chromium plume appears centered near the eastern part of Building 72. Hexavalent chromium concentrations generally decline toward the east and southeast. This is consistent with a source of hexavalent chromium near the chrome room in Building 72 and conversion of hexavalent chromium to trivalent chromium as it moves downgradient in groundwater. Several other metals (cobalt, copper, nickel, zinc) detected at this Area have somewhat similar distributions with declines in concentration in groundwater toward Liberty Bay to the east and southeast.

Twelve VOCs exceeded MCLs or MTCA Method B levels. The most frequently detected organic compounds in samples from shallow wells and seeps were trichloroethene; 1,1,1-trichloroethane; 1,2-dichloroethenes; and 1,1-dichloroethene. These compounds form a plume that extends from the eastern and southern sides of Building 72 to the intertidal zone of Liberty Bay. Three of these four compounds were also detected in groundwater samples from the intermediate-depth well (MW8-16) at lower concentrations, which is screened at 45 feet bgs. None were found in the deepest well above the Clover Park unit. The principal source of these compounds is believed to be solvents used in Building 72. It is possible that some of the VOCs might also originate from historical use of solvents in adjacent buildings.

Petroleum hydrocarbons and aromatic compounds were detected in groundwater samples from locations around Buildings 181 and 804. More mobile petroleum constituents (light fractions) have been detected as far northeast as shallow well MW8-14. Viscous petroleum hydrocarbons were visible in two wells and two borings near Buildings 181 and 804. The source of these compounds is believed to be the former fuel storage vaults at these two buildings.

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Because Area 8 groundwater discharges into Liberty Bay, there is a potential for migration of chemicals in the groundwater to the marine environment. Contaminants exceed surface water quality criteria in some of the Area 8 beach seep samples (see Figure 10-3), but no exceedences were identified in Liberty Bay surface water.

• Dense Non-Aqueous Phase Liquids (DNAPLs)

The chlorinated VOCs detected in soil and groundwater are DNAPL-related chemicals because in pure form they can exist as liquids that are immiscible with and denser than groundwater. Because DNAPL-related chemicals were detected, the potential for occurrence of DNAPLs was evaluated using EPA guidance (USEPA 1992). This guidance involves a three-step evaluation which considers historical site use and site characterization data, and then combines these in a decision matrix. Results of this assessment indicate:

- DNAPL presence is likely based on site history, because TCE and 1,1,1-TCA have been used as degreasing solvents in the plating shop.

- Available site characterization data do not indicate that the presence of DNAPLs is likely. However, the site characterization field program was not extensive enough to rule out the possibility that DNAPLs could be present.

- The overall likelihood of DNAPL presence is "moderate to high" based on the decision chart in the guidance document. The potential for DNAPL presence cannot be ruled out without conducting additional field investigations.

10.2 SUMMARY OF SITE RISKS

The following sections summarize human health and ecological risks.

<u>10.2.1 Human Health Risks</u>

This section presents a summary of contaminant identification, exposure assessment, toxicity assessment, and risk characterization for Area 8.

• Initial Contaminant and Identification

As a result of the preliminary risk-based screening conducted for Area 8 samples, the following are judged to be human health COPCs at Area 8:

- Soil: arsenic, cadmium, chromium, lead, mercury, tin

- Groundwater: antimony, arsenic, benzene, bromodichloromethane, cadmium, carbon tetrachloride, chloroform, hexavalent chromium, cobalt, 1,2-dichloroethane, 1,2-dichloroethene, 1,1-dichloroethene, lead, manganese, nickel, tetrachloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene

- Sediment: lead, mercury

- Shellfish Tissue: lead, mercury

- Exposure Assessment

Current land use at Area 8 is industrial. In addition to the plating shop (Building 72), Buildings 1019, 804, and 181 are considered within Area 8. Workers are primarily indoors during the work day. An occupational daily RME period was assumed to be 8 hours.

A future residential land use scenario was postulated at Area 8; this is a hypothetical scenario for evaluating worst-case exposure conditions. An alternative scenario of continued industrial use of this Area in the future has also been evaluated. The future residential land use scenario includes domestic groundwater use from on-site shallow wells. In fact, it may be unlikely that shallow aquifer wells would be actually installed at Area 8 because of its proximity to Liberty Bay and the risk of salt water intrusion. If on-site groundwater were to be used, it would likely be drawn from a deeper, more sustainable aquifer. The risk estimates derived from the assumption of shallow groundwater usage may be highly conservative.

Future residents of the town of Keyport and visitors to the Area may use Liberty Bay and the beach adjacent to Area 8 for recreation. Uses of Liberty Bay are discussed in Area 9, below.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.1.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Tables 10-2 through 10-6 summarize the risk characterization results for Area 8. More detailed risk characterization information is provided in Appendix G of the human health risk assessment (URS 1993c).

Current Land Use. Cancer and noncancer risks to current workers at Area 8 are within or below EPA's target risk range. No current residential or recreational exposure scenarios have been postulated for Area 8.

Future Land Use. The total RME excess cancer risk for future residents at Area 8 is 1 x 10-3, which is in excess of EPA target levels. The primary pathways contributing to this risk are ingestion of chemicals in drinking water (5 x 10-4), inhalation of volatiles during household use of water (5 x 10-4), ingestion of chemicals in homegrown produce (2 x 10-5), and ingestion of chemicals in soil (9 x 10-6). The average cancer risk for future residents is 1 x 10-4. Chemicals contributing to the excess cancer risk at Area 8 are summarized in Table 10-4.

The total HI (RME) for future residents at Area 8 is 34, which is in excess of EPA target levels. Residents may be exposed to noncancer chemicals of concern primarily via ingestion of chemicals in drinking water (HI = 30), and through ingestion of homegrown produce (HI = 4). Table 10-5 summarizes chemicals contributing to the high HI for future residents at Area 8. Table 10-6 identifies the potential noncancer health effects for a future resident at Area 8, and apportions the HQs among target organs.

As shown in Table 10-6, individual target organs with HIs above 1 are the kidney and liver. However, because the noncancer health effects of benzene, chromium, and nickel are not well known and contribute a potential HI of 7, any of the listed organs could be adversely affected from prolonged exposure to COPCs through the two exposure pathways.

Both cancer and noncancer risks to future workers and visitors are within or below EPA's target risk range.

Table 10-2
Summary of Risk Results
Area 8 - Current Land Use

Pathway	Cancer Risk		Hazard Index	
	RME	Average	RME	Average
Current Workers				
Inhalation of airborne chemicals - particulates	4E-9	1E-9	2E-9	1E-9
Ingestion of chemicals in drinking water (deep aquifer)	-	-	0.04	0.04
TOTAL	4E-9	1E-9	0.04	0.04

Table 10-3
Summary of Risk Results
Area 8 - Future Land Use

Pathway	Cancer Risk		Hazard Index	
	RME	Average	RME	Average
Future Residents	5E-4	5E-5	30	10
Ingestion of chemicals in drinking water (shallow aquifer)	5E-4	8E-5	0.1	0.06
Inhalation of volatiles during household use of water	9E-6	6E-7	0.2	0.04
Ingestion of chemicals in soil	7E-8	1E-8	2E-8	2E-8
Inhalation of airborne chemicals - particulates	2E-5	3E-6	4	1
Ingestion of chemicals in homegrown produce	-	-	4E-6	2E-6
Ingestion of chemicals in surface water while swimming (Liberty Bay)	-	-	-	-
Ingestion of chemicals in marine sediment (Liberty Bay)	-	-	-	-
Ingestion of chemicals in fish/shellfish (Liberty Bay)	1E-3	1E-4	30	10
TOTAL				
Future Workers				
Inhalation of airborne chemicals - particulates	4E-9	1E-9	2E-9	1E-9
Ingestions of chemicals in drinking water (deep aquifer)	-	-	-	0.04
TOTAL	4E-9	1E-9	0.04	0.04
Future Visitors				
Ingestion of chemicals in surface water while swimming (Liberty Bay)	-	-	3E-6	2E-6
Ingestion of chemicals in marine sediment (Liberty Bay)	-	-	-	-
Ingestion of chemicals in fish/shellfish (Liberty Bay)	-	-	-	-
TOTAL	-	-	3E-6	2E-6

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5." This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

Table 10-4

Summary of Major Contributions to Cancer Risk for Future Residents of Area 8a

Chemical	Groundwater Ingestion (Shallow)	Volatiles Inhalation During Household Use	Total-Groundwater	Soil Ingestion	Inhalation of Particulates	Ingestion of Produce	Total - Soil	Surface Water Ingestion	Marine Sediment Ingestion	Shellfish Ingestion	Total - All Media
RME Case											
Arsenic	2E-4	NA	2E-4	9E-6	3E-9	2E-5	3E-5	NA	NA	NA	2E-4
Benzene	3E-6	1E-5	1E-5	NA	NA	NA	NA	NA	NA	NA	1E-5
Bromodichloromethane	1E-5	NA	1E-5	NA	NA	NA	NA	NA	NA	NA	1E-5
Carbon tetrachloride	1E-5	4E-5	5E-5	NA	NA	NA	NA	NA	NA	NA	5E-5
Chloroform	4E-7	2E-5	2E-5	NA	NA	NA	NA	NA	NA	NA	2E-5
1,2-Dichloroethane	7E-6	2E-5	3E-5	NA	NA	NA	NA	NA	NA	NA	3E-5
1,1-Dichloroethene	2E-4	2E-4	4E-4	NA	NA	NA	NA	NA	NA	NA	4E-4
Tetrachloroethene	NA	3E-6	3E-6	NA	NA	NA	NA	NA	NA	NA	3E-6
1,1,2-Trichloroethane	9E-6	3E-5	4E-5	NA	NA	NA	NA	NA	NA	NA	4E-5
Trichloroethene	1E-4	2E-4	3E-4	NA	NA	NA	NA	NA	NA	NA	3E-4
TOTAL (RME)	5E-4	5E-4	1E-3	9E-6	3E-9	2E-5	3E-5	NA	NA	NA	1E-3
Average Case											
Arsenic	2E-5	NA	2E-5	6E-7	5E-10	3E-6	4E-6	NA	NA	NA	2E-5
Benzene	3E-7	2E-6	2E-6	NA	NA	NA	NA	NA	NA	NA	2E-6
Bromodichloromethane	1E-6	NA	1E-6	NA	NA	NA	NA	NA	NA	NA	1E-6
Carbon tetrachloride	1E-6	6E-6	7E-6	NA	NA	NA	NA	NA	NA	NA	7E-6
Chloroform	5E-8	4E-6	4E-6	NA	NA	NA	NA	NA	NA	NA	4E-6
1,2-Dichloroethane	8E-7	5E-6	6E-6	NA	NA	NA	NA	NA	NA	NA	6E-6
1,1-Dichloroethene	2E-5	3E-5	5E-5	NA	NA	NA	NA	NA	NA	NA	5E-5
Tetrachloroethene	NA	5E-7	5E-7	NA	NA	NA	NA	NA	NA	NA	5E-7
1,1,2-Trichloroethane	9E-7	5E-6	6E-6	NA	NA	NA	NA	NA	NA	NA	6E-6
Trichloroethene	1E-5	3E-5	4E-5	NA	NA	NA	NA	NA	NA	NA	4E-5
TOTAL (Average)	5E-5	8E-5	1E-4	6E-7	5E-10	3E-6	4E-6	NA	NA	NA	1E-4

a Includes all chemicals that individually contribute an excess RME cancer risk of 1 x 10-6 or greater to total RME cancer risk of 1 x 10-4 or greater.
NA = Not applicable; chemical is not a major risk contributor in this pathway.

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5". This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

Table 10-5
Summary of Major Contributions to Hazard Index for Future Residents of Area 8a

Chemical	Groundwater Ingestion (Shallow)	Volatiles Inhalation During HH Use	Total-Groundwater	Soil Ingestion	Inhalation of Particulates	Ingestion of Produce	Total-Soil	Surface Water Ingestion	Marine Sediment Ingestion	Shellfish Ingestion	Total - All Media
RME Case											
Antimony	1	NA	1	NA	NA	NA	NA	NA	NA	NA	1
Arsenic	0.7	NA	0.7	0.04	NA	0.1	0.1	NA	NA	NA	0.8
Benzene	0.5	NA	0.5	NA	NA	NA	NA	NA	NA	NA	0.5
Cadmium	20	NA	20	0.1	NA	4	4	NA	NA	NA	20
Carbon tetrachloride	0.2	NA	0.2	NA	NA	NA	NA	NA	NA	NA	0.2
Chromium	6	NA	6	0.06	NA	0.03	0.09	2E-6	NA	NA	6
Manganese	0.1	NA	0.1	NA	NA	NA	NA	NA	NA	NA	0.1
Nickel	0.7	NA	0.7	NA	NA	NA	NA	NA	NA	NA	0.7
Tetrachloroethene	0.1	NA	0.1	NA	NA	NA	NA	NA	NA	NA	0.1
1,1,1-Trichloroethane	0.1	0.1	0.2	NA	NA	NA	NA	NA	NA	NA	0.2
Trichloroethene	2	NA	2	NA	NA	NA	NA	NA	NA	NA	2
TOTAL (RME)	30	0.1	30	0.2	2E-8	4	4	3E-6	NA	NA	34
Average Case											
Antimony	0.5	NA	0.5	NA	NA	NA	NA	NA	NA	NA	0.5
Arsenic	0.2	NA	0.2	0.009	NA	0.04	0.05	NA	NA	NA	0.3
Benzene	0.2	NA	0.2	NA	NA	NA	NA	NA	NA	NA	0.2
Cadmium	6	NA	6	0.02	NA	1	1	NA	NA	NA	7
Carbon tetrachloride	0.1	NA	0.1	NA	NA	NA	NA	NA	NA	NA	0.1
Chromium	2	NA	2	0.01	NA	0.01	0.02	1E-6	NA	NA	2
Manganese	0.04	NA	0.04	NA	NA	NA	NA	NA	NA	NA	0.04
Nickel	0.2	NA	0.2	NA	NA	NA	NA	NA	NA	NA	0.2
Tetrachloroethene	0.03	NA	0.03	NA	NA	NA	NA	NA	NA	NA	0.03
1,1,1-Trichloroethane	0.04	0.06	0.1	NA	NA	NA	NA	NA	NA	NA	0.1
Trichloroethene	0.7	NA	0.7	NA	NA	NA	NA	NA	NA	NA	0.7
TOTAL (Average)	10	0.06	10	0.04	2E-8	1	1	2E-6	NA	NA	11

a Includes all chemicals that contribute an RME hazard quotient of 0.1 or greater.

Note on scientific notation: Throughout this and similar tables scientific notation is used to express very small numbers. An example of scientific notation is "2E-5". This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

Table 10-6
Area 8 - Apportioning Hazard Quotients Among Target Organs for
Future Residential Scenario

Chemical	HQ	Target Organ Primary	Secondary	Tertiary	Blood	CNS	Heart	Kidney	Liver	Skin	None
Antimony	1	Heart	Blood		1		1				
Arsenic	0.7	Skin	Blood	CNS	0.7	0.7				0.7	
Benzene	0.5	--	--								0.5
Cadmium	20	Kidney						20			
Carbon Tetrachloride	0.2	Liver							0.2		
Chromium	6	--	--								6
Manganese	0.1	CNS				0.1					
Nickel	0.7	--	–								0.7
Tetrachloroethene	0.1	Heart					0.1				
1,1,1-Trichlorothane	0.1	CNS	Heart	Skin		0.1	0.1			0.1	
Trichloroethene	2	Liver	Kidney					2	2		
Total	30				2	0.9	1	20	2	0.8	7

a Target organs from IRIS (IRIS 1993)
HI = Harzard Index
CNS = Central Nervous System

10.2.2 Ecological Risks

- Initial Contaminant Identification

The surface of this Area is paved with concrete and asphalt; screening for contaminants of concern was not conducted, as there are no potentially exposed organisms.

- Exposure Assessment

Area 8 is located in a heavily industrialized portion of the base and is totally covered with concrete or buildings. As a result, terrestrial wildlife habitat is insignificant and was not evaluated.

Elevated concentrations of metals and organics in the groundwater of Area 8 enter Liberty Bay as groundwater flows east toward the bay during low tide. Potential receptor organisms may include marine life in the nearshore tide zone where groundwater may mix with water in Liberty Bay. These receptors are discussed in Area 9.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.2.3) were combined with the results of the exposure assessment to arrive at the risk characterization. The general lack of wildlife habitat at Area 8 because of industrialization precludes any meaningful assessment of organism, community, or ecosystem risks from chemical contamination. The existing physical impacts to the terrestrial habitat override any potential chemical impacts.

Based on the RI data, ecological risk assessment for current conditions indicated that shallow groundwater from Area 8 discharging to Liberty Bay has not caused significant risk to organisms. Elevated concentrations of some metals and VOCs were found in the groundwater and in seeps near the shoreline with Liberty Bay; however, concentrations of the same chemicals in the three closest sediment samples (within 300 feet) did not indicate concentrations exceeding sediment standards. Semivolatile organic compounds (benzoic acid, phenol, and phthalates) were found above sediment standards at some stations farther out in Liberty Bay; however, these compounds are not thought to be related to releases from Area 8. As Area 8 groundwater continues to discharge into Liberty Bay, the groundwater contaminants could lead to future risks in the marine environment.

10.3 NEED FOR REMEDIAL ACTION

The baseline risk assessment found risks to human health were below EPA's acceptable levels for current exposure scenarios. On the other hand, the results indicate that chemicals in soils and groundwater at Area 8 pose unacceptable risks to future residents. Exposure pathways driving risk included ingestion of groundwater, inhalation of volatiles during household use of groundwater, and ingestion of homegrown vegetables. In addition, several VOCs and metals in groundwater were detected above drinking water standards, and metals in soil exceeded MTCA cleanup standards. No ecological risks were identified due to lack of significant habitat at Area 8.

Based on the RI and risk assessment results, groundwater remediation alternatives were evaluated for metals (e.g., cadmium, chromium) and VOCs (e.g., trichloroethene and 1,1-dichloroethene) with the goal of preventing ingestion of these compounds above drinking water standards or acceptable human health risk levels. Because contaminants in Area 8 groundwater could cause future impacts or human health risks in Liberty Bay, RAOs developed for groundwater also included protection of sediments and surface water quality offshore of Area 8.

RAOs developed for soil were based on preventing direct contact and ingestion exposures above acceptable human health risk levels, and protection of groundwater and surface water quality. The principal contaminants addressed by these objectives are metals and VOCs.

Petroleum contamination also exists at Area 8 in the vicinity of the former underground storage vault under Building 181. This contamination is being remediated under the underground storage tank (UST) program rather than CERCLA, and was therefore not included in the FS alternatives summarized below. The remediation is an independent action conducted under MTCA regulations (WAC 173-340-450). The petroleum releases involved heavy fuels oils that are viscous and not very mobile. The petroleum remediation will involve removal of the underground vault and associated petroleum-contaminated soil. These actions will be coordinated with phase 2 of the selected remedy for Area 8 (Section 10.6). Since these actions are identical with those of the selected remedy (i.e., building demolition, soil removal and off-site treatment/disposal), they are not expected to impact the implementability or effectiveness of the selected remedy.

10.4 DESCRIPTION OF ALTERNATIVES

A full range of remediation technologies was identified, screened, and evaluated in the FS. The alternatives developed and analyzed for Area 8 are described in the following sections. Table 10-7 summarizes and compares the main elements of each alternative. Table 10-8 summarizes the ARARs evaluation for the alternatives that was performed in the FS. Table 10-9 shows the FS cost estimates for the alternatives.

10.4.1 Alternative 1 - No Action

The no-action alternative was included in the range of alternatives evaluated in the FS, as required by the National Contingency Plan. It includes no specific response actions to reduce contaminants, control their migration, or prevent exposures. The no-action alternative serves as a baseline from which to judge the performance of the action-oriented alternatives.

10.4.2 Alternative 2 - Limited Action

This alternative would control exposures to chemicals of concern mainly through the use of institutional controls. In addition, the existing cover would be maintained over the site to prevent direct contact exposure to the underlying soils and control migration of soil contaminants by surface erosion processes. Sampling would be used to monitor conditions and determine if additional actions are needed in the future.

Table 10-7
Alternatives Evaluated in the FS for Area 8

Response Action	Alternative 1 No Remedial Action	Alternative 2 Limited Action	Alternative 3 Physical Containment	Alternative 4 Hydraulic Containment	Alternative 5 Vadose and Saturated Zone Soil Hot Spot Removal with Groundwater Interception	Alternative 6 Vadose Soil Hot Spot Removal with Groundwater Flushing	Alternative 7 On-Site Soil Treatment with Groundwater Interception	Alternative 8 Vadose Soil Removal and Saturated Zone Soil Hot Spot Removal with Groundwater Interception
Institutional controls		!	!	!	!	!	!	!
Monitoring		!	!	!	!	!	!	!
Circumferential groundwater cutoff wall			!					
Shortline groundwater cutoff wall					!	!	!	!
Shoreline groundwater interception wells				!	!	!	!	!
Aquifer flushing system						!		
Treat and discharge extracted groundwater				!	!	!	!	!
Removal of vadose zone hot spots and off-site disposal					!	!		
Removal of all vadose zone soil and off-site disposal								!
Dewatering system, removal of saturated soil hot spots, and off-site disposal					!			!
Immediate demolition of existing buildings & pavement					!	!	!	!
On-site treatment of vadose and saturated soil hot spots							!	
Off-site disposal of excess treated soil							!	
Maintain cover on the site (vegetated soil or pavement)				!	!	!	!	
Install interim impermeable cover (membrane/asphalt)			!					
Install final impermeable cover (RCRA type)			!					

Table 10-8
Evaluation of ARARs for Area 8 Alternatives

Act or Regulation	Citation	Requirement	Alternative 1	2	3	4	5	6	7	8
Chemical-Specific ARARs										
Safe Drinking Water	42 CFR 142 WAC 246-290-310	Maximum contaminant levels (MCLs) for public water supplies.	*	*	*	*	*	*	*	*
Water Quality	WAC 173-201A	Surface water quality standards.	*	*	*	*	*	*	*	*
Water Quality	WAC 173-204	Sediment management standards.	*	*	*	*	*	*	*	*
MTCA	WAC 173-340	Cleanup standards for soil, groundwater, and surface water.	*	*	*	*	*	*	*	*
Location-Specific ARARs										
Coastal Zone Management	16 USC 1451 WAC 173-14,16,2	Actions must be consistent with shoreline management program.			*	*	*	*	*	*
Action-Specific ARARs										
MTCA	WAC 173-340-440	Deed restrictions and survey requirements.		*	*	*	*	*	*	*
MTCA	WAC 173-340-360 WAC 173-340-410	Specifies monitoring and institutional controls.		*	*	*	*	*	*	*
Clean Air	40 CFR 52 PSAPCA Reg I	Control fugitive dust emissions from construction activities.			*	*	*	*	*	*
Water Wells	WAC 173-160	Standards for monitoring or extraction wells.		*	*	*	*	*	*	*
Clean Water	40 CFR 122.26	Stormwater discharge permit for construction activities.			*	*	*	*	*	*
Clean Water	40 CFR 122 40 CFR 403 WAC 173-216	Effluent discharge permit for treated groundwater or condensate to POTW.				*	*	*	*	*
RCRA; Dangerous Waste	40 CFR 261-263 40 CFR 268 WAC 173-303	Characterization, transportion, treatment and disposal requirements for excavated soil; land disposal restrictions.			*	*	*	*		*
RCRA; Dangerous Waste	40 CFR 261-263 40 CFR 268 WAC 173-303	Characterization, transportion, treatment and disposal requirements for treatment system residuals; land disposal restrictions.				*	*	*	*	*
RCRA; Dangerous Waste	40 CFR 264.310(b) WAC 173-303-665	Maintain integrity of cover over hazardous constituents left in place.		*	*	*	*	*	*	
Air Quality	PSAPCA Reg III	Control toxic emissions from stripper.				*	*	*	*	*
Safe Drinking Water	40 CFR 144	Underground injection control permit for aquifer flushing system.						*		

* Indicates that the requirement is applicable or relevant and appropriate to the actions and circumstances of the alternative.

Table 10-9
Estimated Costs of Area 8 Alternatives

Evaluation Factor		Alternative 1 No Remedial Action	Alternative 2 Limited Action	Alternative 3 Physical Containment	Alternative 4 Groundwater Interception
Initial Capital Investment		0	$0.12 million	$9.8 million	$3.3 million
Capital Investment for Final Cover		0	0	$1.1 million	$0.9 million
Operating and Maintenance Cost	Years 1-3	0	$0.25 million/yr	$0.47 million/yr	$1.1 million/yr
	Years 4-5	0	$0.08 million/yr	$0.34 million/yr	$0.96 million/yr
	After 5 years	0	0	$0.29 million/yr	$0.90 million/yr
Present Value of Final Cover Capital Costa	3% net discount rate	0	0	$0.45 million	$0.36 million
	5% net discount rate	0	0	$0.26 million	$0.21 million
	10% net discount rate	0	0	$0.07 million	$0.05 million
Present Value of O&M Costs (30 yr period)	3% net discount rate	0	$0.83 million	$6.3 million	$18.3 million
	5% net discount rate	0	$0.79 million	$5.1 million	$14.5 million
	10% net discount rate	0	$0.71 million	$3.3 million	$9.0 million
Life-Cycle Cost (Present Worth over 30 yrs)a	3% net discount rate	0	$0.95 million	$16.6 million	$22.0 million
	5% net discount rate	0	$0.91 million	$15.1 million	$18.0 million
	10% net discount rate	0	$0.83 million	$13.1 million	$12.4 million

Table 10-9 (Continued)
Estimated Costs of Area 8 Alternatives

Evaluation Factor		Alternative 5: Vadose and Saturated Zone Soil Hot Spot Removal with Groundwater Interception	Alternative 6: Vadose Soil Hot Spot Removal with Groundwater Flushing	Alternative 7: On-Site Soil Treatment with Groundwater Interception	Alternative 8: Vadose Soil Removal and Saturated Zone Soil Hot Spot Removal with Groundwater Interception
Initial Capital Investment		$33.7 million	$13.7 million	$16.5 million	$45.6 million
Capital Investment for Final Cover		$0.6 million	$0.6 million	$0.6 million	$0.6 million
Operating and Maintenance Cost	Years 1-3	$2.0 million/yr	$1.3 million/yr	$1.2 million/yr	$2.4 million/yr
	Years 4-5	$1.4 million/yr	$1.2 million/yr	$1.1 million/yr	$1.7 million/yr
	After 5 years	$1.3 million/yr	$1.1 million/yr	$1.1 million/yr	$1.7 million/yr
Present Value of Final Cover Capital Cost-a	3% net discount rate	$0.25 million	$0.25 million	$0.25 million	$0.25 million
	5% net discount rate	$0.14 million	$0.14 million	$0.14 million	$0.14 million
	10% net discount rate	$0.04 million	$0.04 million	$0.04 million	$0.04 million
Present Value of O&M Costs (30 yr period)	3% net discount rate	$28.2 million	$22.9 million	$21.2 million	$35.2 million
	5% net discount rate	$22.5 million	$18.1 million	$16.8 million	$27.9 million
	10% net discount rate	$14.4 million	$11.3 million	$10.4 million	$17.7 million
Life-Cycle Cost (Present Worth over 30 yrs)a	3% net discount rate	$62.1 million	$36.9 million	$38.0 million	$81.0 million
	5% net discount rate	$56.3 million	$31.9 million	$33.4 million	$73.6 million
	10% net discount rate	$48.1 million	$25.0 million	$26.9 million	$63.3 million

O&M = operation and maintenance

a The capital cost of the final cover is incorporated in the life-cycle cost assuming the final cover is implemented in the 30th year of the life cycle period.

Institutional controls would prevent risks to human health by controlling access and prohibiting future residential use of the property, including ingestion of drinking water from the shallow aquifer. It is possible to use institutional controls to prevent the risks posed by this site because current drinking water supplies are not threatened and the risks posed by the site are to future residents. Contaminants in Area 8 soil and groundwater do not pose risks warranting action for other land use scenarios studied in the baseline risk assessment, including human and ecological receptors for current conditions. Also, contaminants at Area 8 have not resulted in significant risks in Liberty Bay, based on the results of the RI and risk assessment for Area 9.

Under Alternative 2, institutional controls would be maintained while natural processes were allowed to gradually reduce site contamination. The following processes are likely to occur to reduce or immobilize contaminants: biodegradation of organic compounds, desorption and dissolution of organic and inorganic chemicals into groundwater with subsequent flushing into Liberty Bay and dispersion by tides, conversion of inorganics such as hexavalent chromium to less toxic forms, irreversible elemental fixation of metals such as cadmium and chromium into the chemical structure of the soil particles, and vaporization of volatile organic compounds into the atmosphere followed by photochemical degradation. These changes are expected to proceed very slowly (e.g., many decades may be needed for substantial improvement), and risks posed by metals in the vadose soils may never be significantly diminished by natural processes.

Sampling would be used to monitor the progress of these natural processes to ensure that concentrations do not unexpectedly increase and to determine if any institutional controls could be discontinued in the future. The monitoring and institutional controls would be applied to the zone of contamination, which includes the area under the plating shop and the land between the plating shop and Liberty Bay to the south and east. Additional sampling would be needed to establish the extent of the groundwater plume north and west of the plating shop.

A regular groundwater sampling program would be maintained to monitor this plume for trends in contaminant concentrations and off-Area migration (including possible downward migration). In addition, the FS assumed that seeps, surface water, and sediments would also be monitored in Liberty Bay near Area 8. Institutional controls would include security measures such as currently enforced at the base, Navy land use restrictions while the base remains in operation, and deed restrictions if the base should be closed or the Navy should transfer the property to another owner.

Alternative 2 would also include additional site characterization to verify the presence or absence of DNAPLs. This would involve soil gas surveys, cone penetrometer surveys, stratigraphy studies, vadose soil sampling, and saturated zone liquid sampling. If DNAPLs were confirmed, the need for and feasibility of additional response actions would be reevaluated.

10.4.3 Alternative 3 - Physical Containment

Alternative 3 focuses on prevention of exposures by using engineered controls to contain the chemicals of concern. This alternative would include the following actions:

- Install a groundwater barrier wall that encircles the contaminants to prevent migration into Liberty Bay.
- Install a low-permeability cover.
- Manage incidental excavated material (e.g., trench spoils) by off-site disposal.
- Implement environmental monitoring.
- Implement institutional controls.

Alternative 3 involves actions designed to control and prevent exposures of concern through containment and institutional controls, while incurring less disturbance of the site and short term impacts compared with alternatives using more aggressive cleanup actions. The actions are intended to address risks posed by the site while allowing existing operations and industrial site use to continue.

The containment wall and impermeable cover would be applied over the same areal extent as described in Alternative 2 for institutional controls. The cutoff wall would be placed as close to the shoreline as possible east and south of the plating shop. As discussed for Alternative 2, additional sampling would be needed to define the extent of the contaminant zone to the north and west of the plating shop.

Because a low-permeability stratigraphic unit was not encountered under a depth of 170 feet below the site, it would not be practical to key the groundwater cutoff wall into an aquitard. Therefore, the barrier would be designed as a hanging wall, with the bottom portion of the contaminant zone in open communication with the aquifer. The depth of the wall would be designed to extend below the bottom of the groundwater plume. An interim cover would be constructed, consisting of a flexible membrane barrier, a drainage layer, and an asphalt surface. Installation of the interim cover would require demolition of the existing pavement and excavation and grading of underlying surface soil so the finished cover would match existing topography.

A final cover would be implemented when and if the present industrial land use is no longer required (e.g., if the base were to be closed). Demolition of existing structures at Area 8 would be necessary to implement the final cover. The final cover would be a RCRA-type cover designed for long-term minimization of infiltration and maintenance expense.

The main benefit of the containment measures would be to limit the long-term migration of contaminants from Area 8 into Liberty Bay. The interim and final covers would also prevent direct contact with the soil and migration of contaminants via surface erosion. Because contamination would remain at the site, institutional controls would be required to prevent installation of potable wells, disturbance of the cover, and residential development. These restrictions would prevent risks to future residents. Monitoring would be included to demonstrate the effectiveness of the containment measures. Because of the containment measures, the scope of the monitoring would not need to be as extensive as in Alternative 2; accordingly, monitoring would only involve groundwater and seeps at Area 8. The rationale and features of institutional controls would be the same as discussed for Alternative 2.

<u>10.4.4 Alternative 4 - Hydraulic Containment</u>

Alternative 4 would include the actions of Alternative 2 plus a system to intercept groundwater leaving the Area and prevent its discharge into Liberty Bay. Specific actions under this alternative would be:

- Install groundwater interception wells along the shoreline.
- Treat and discharge groundwater.
- Maintain a cover on the site.
- Manage incidental excavated material by off-site disposal.
- Implement environmental monitoring.
- Implement institutional controls.

Alternative 4 is designed to achieve the same overall objectives as Alternative 3 by using hydraulic containment rather than physical containment to control migration of contaminants into Liberty Bay. The hydraulic containment system would consist of a series of groundwater extraction wells to collect groundwater before it enters the bay. With this approach, a low-permeability cover would not be needed to limit infiltration because any infiltration water would be intercepted by the extraction wells along with the other groundwater leaving the site. Limiting infiltration would not significantly reduce the pumping rates needed to intercept groundwater in this alternative.

As in Alternative 3, the actions in this alternative are intended to address risks posed by site contaminants while minimizing disruption of the site and existing operations. With these factors in mind, the hydraulic containment system would not include a groundwater cutoff wall. The absence of a cutoff wall would result in the need to use higher pumping rates to ensure groundwater capture, but would make installation of the hydraulic containment system easier to implement.

Extracted groundwater would be treated prior to discharge into the county sewer. The treatment train would consist of oil-water separation, chromium reduction, metals removal by precipitation, and air stripping to remove VOCs. The stripper offgas would be treated by activated carbon to remove the VOCs prior to release to the atmosphere. The spent carbon would be sent to an off-site facility for thermal regeneration and destruction of VOCs. The sludge from the metals precipitation step would be dewatered and sent to an off-site hazardous waste treatment and disposal facility. Treatability studies would be needed to verify performance and establish full-scale design parameters for these systems.

The hydraulic containment system would be designed to intercept groundwater passing through the same area of contamination as described in Alternative 2 for institutional controls. The extraction wells would be placed along the length of the shoreline east and south of the plating shop that corresponds to this zone of contamination. As discussed for Alternative 2, additional sampling would be needed to define the extent of the contaminant zone to the north and west of the plating shop. The depth of the wells would extend below the bottom of the groundwater plume.

Although a low-permeability cover is not required, this alternative would still involve maintenance of an interim cover and a final cover to prevent direct contact with soil contaminants and control migration by erosion of surface soils. The interim cover would consist of maintaining the existing buildings and asphalt and concrete pavements that presently cover site soils.

The final cover would be implemented in the future, as described for Alternative 3. The main difference is that, since an impermeable cover is not required for Alternative 4, the final cover would not be designed as a RCRA-type cap. Instead, the final cover would consist of a vegetated soil surface designed for erosion control.

The main benefits of Alternative 4 would be the same as those described for Alternative 3: to limit contaminant migration into Liberty Bay, prevent direct contact soil exposures, and control erosion. The rationale and features of institutional controls and environmental monitoring would be the same as discussed for Alternative 3, except that monitoring would be used to follow the progress of groundwater restoration by natural attenuation processes and determine if institutional controls could be discontinued in the future. Under Alternative 3, these natural processes would be impeded by the physical containment systems, and it is not expected that institutional controls could ever be discontinued.

10.4.5 Alternative 5 - Vadose and Saturated Zone Soil Hot Spot Removal with Groundwater Interception

The main feature of Alternative 5 is removal of contaminated soil from hot spots zones located both above and below the water table. It also includes a hydraulic containment system to prevent seepage of contaminated groundwater into Liberty Bay.

This alternative is intended to achieve an immediate reduction of site contamination, in addition to protecting human health and the environment by the following response actions:

- Excavate and remove soil hot spots (both vadose and saturated zone soils); backfill with clean material (estimated volume: 59,000 cubic yards).
  - Demolish existing buildings and pavement as needed to gain access to soils.
  - Construct structural groundwater barrier to create dewatering cells.
  - Extract groundwater to lower the water table within each dewatering cell to allow dry excavation below the water table.
- Install hydraulic containment system.
  - Install groundwater cutoff wall along the shoreline.
  - Install extraction wells on the upgradient side of the cutoff wall and pump to intercept groundwater leaving the site.
- Treat extracted groundwater and discharge treated water to the county sewer.
- Manage excavated material by off-site disposal.
- Maintain a cover on the site.
- Implement environmental monitoring.
- Implement institutional controls.

In contrast to Alternatives 3 and 4, this alternative envisions severe disruption of existing land use activities in order to allow access to contaminants for conducting more comprehensive remedial actions. Existing pavement and buildings would be demolished as needed to implement the remedy; this would interrupt the existing plating shop operations. Following the soil removal, it is envisioned that industrial land use could be resumed at the site. One likely land use would be a parking lot. The remedial actions in this alternative would not preclude construction of new buildings (e.g., within the soil removal areas).

Removal of soil hot spots would substantially reduce the volume and toxicity of metals and volatile organics contamination at the site, and eliminate risks to future residents from direct contact exposures in the excavated areas. In addition, the soil removal action would eliminate the major sources of groundwater contamination caused by leaching contaminants from the soil. Removing the major sources of groundwater contamination would help accelerate the restoration of the groundwater by the natural attenuation mechanisms discussed under Alternative 2. DNAPL characterization and evaluation would also be conducted as described for Alternative 2.

Because significant contamination is present in the saturated zone, this alternative includes excavation of hot spot soils from below the water table as well as soils from above the water table. Removal of saturated soils would involve dewatering prior to excavation. Following excavation of a dewatered cell, the cell would be backfilled with a low organic content sand to limit potential sorption of contaminants from groundwater. Additional sampling and analysis for metals and volatile organics would be needed to delineate the location and extent of hot spot zones to be excavated in this alternative. The excavation cells would be designed based on these hot spot zones, with the intent being to remove a high percentage of the overall site risk in a reasonable volume of soil (e.g., less than half the site area). Assuming that the soil contamination is widely dispersed, this alternative would not attempt to achieve all cleanup standards and remediation goals throughout the entire site through excavation alone. The hot spot zones assumed in the FS covered about half the site, and were extrapolated from the extent of the groundwater plume, with emphasis on the metals contamination. The assumed excavation depth, also based on the groundwater plume, was 60 feet.

The soil contamination at Area 8 is not derived from disposal of a RCRA-listed hazardous waste, but may be a characteristic hazardous waste. Batches of the excavated soil would be tested by EPA's toxicity characteristic leaching procedure (TCLP) to determine if they are characteristic hazardous wastes. Depending on the results, the material would be treated off-site as needed to comply with RCRA land disposal restrictions (40 C.F.R §268) prior to disposal. The TCLP results would also be used to determine whether a batch of soil must be disposed in a hazardous waste landfill or whether it could be accepted by a local solid waste landfill.

The hydraulic containment system for this alternative would differ from that in Alternative 4 by including a subsurface barrier wall between Area 8 and Liberty Bay to avoid pumping seawater and to minimize pump rates. The groundwater treatment and discharge systems would be the same as described for Alternative 4 except they would be sized to handle extracted groundwater from both the long-term interception and short-term dewatering systems.

This alternative would include maintenance of an interim and final cover, as described for Alternative 4, for the purposes of controlling erosion and preventing direct contact exposure to residual soil contamination left at the site. Maintenance of a cover would not be necessary for hot spot areas that were excavated and backfilled with clean material.

The main benefits of Alternative 5 would be similar to those described for Alternative 3: to limit the migration of contaminants into Liberty Bay, prevent direct contact soil exposures, and control erosion. In addition, the soil removal action would permanently reduce site contamination and minimize the quantity of contaminants that could ultimately seep into the bay. Depending on the effectiveness of the removal action, long-term operation of the hydraulic containment system might not be necessary. Because some residual contamination would be left at the site above acceptable risk levels, institutional controls and environmental monitoring would be required. The rationale and features of institutional controls and environmental monitoring would be the same as discussed for Alternative 4.

10.4.6 Alternative 6 - Vadose Soil Hot Spot Removal with Groundwater Flushing

This alternative would include the same actions as Alternative 5 except removal of soil hot spots from below the water table would be replaced by an aquifer flushing system. The aquifer flushing system would include a series of groundwater extraction and injection wells spaced across the site to circulate water through the aquifer and remove contaminants from the saturated soil zone. Alternative 6 would include the following response actions:

- Aquifer flushing system.
    - Install extraction and injection well network.
    - Extract and treat groundwater, and recycle treated water to the injection wells.
- Hydraulic containment system.
    - Install groundwater cutoff wall along the shoreline.
    - Install extraction wells on the upgradient side of the cutoff wall and pump to intercept groundwater leaving the site.
    - Treat extracted groundwater and discharge treated water to the county sewer.
- Excavate and remove soil hot spots (vadose zone soils only); backfill with clean material (estimated volume: 6,400 cubic yards).
    - Demolish existing buildings and pavement as needed to gain access to soils.
    - Manage excavated material by off-site disposal.
- Maintain a cover on the site.

- Implement environmental monitoring.

- Implement institutional controls.

This alternative is designed to achieve the same cleanup objectives as Alternative 5, but with different technology for the saturated zone. Aquifer flushing (pump and treat technology) is substituted for excavation of hot spots for removing contaminants from the saturated zone, because of the implementation difficulties associated with deep excavation below the water table. Removal of vadose zone hot spots and aquifer flushing are intended to permanently reduce contamination at the site and accelerate natural restoration of the aquifer by removing the major sources of groundwater contamination. As in Alternative 5, hydraulic containment is included to prevent contaminant migration into Liberty Bay, and maintaining a cover on the site would control erosion and prevent direct contact exposures to residual contaminants in vadose soils.

The features and rationale for most of the actions are identical to those discussed for Alternative 5, since most of the actions are the same. This includes the need for building demolition and disruption of operations at the site in order to excavate soils. Actions that differ from Alternative 5 are discussed below.

The aquifer flushing system would include several rows of extraction and injection wells (or trenches) spaced across the site. This network would cover the same areal extent as described for institutional controls in Alternative 2. As discussed for Alternative 2, additional sampling would be needed to define the extent of the contaminant zone to the north and west of the plating shop. The wells would be screened to a depth below the bottom of the groundwater plume. The network assumed in the FS included a total of 45 wells, screened to a depth of 70 feet.

The groundwater treatment train would be similar to that described for Alternative 5, except for the addition of an extra process (such as reverse osmosis) to further reduce the metals concentrations in the effluent. Lower metals concentrations would be needed to provide clean enough water for reinjection and effective flushing of metals from the aquifer, whereas higher metals concentrations would be acceptable for meeting the pretreatment limits expected for discharge to the county sewer.

Following treatment, most of the extracted groundwater would be reinjected for aquifer flushing, with the remainder of the treated effluent discharged to the county sewer system. The portion discharged to the sewer is needed for hydraulic containment (i.e., to control seepage into Liberty Bay) and would be equivalent to the groundwater extracted and discharged in Alternative 5.

<u>10.4.7 Alternative 7 - On-Site Soil Treatment with Groundwater Interception</u>

This alternative would include the same actions as Alternative 5 except that hot spot soil removal actions would be replaced by on-site soil treatment. Alternative 7 would include the following response actions:

- On-site treatment of soil hot spots (both vadose and saturated zone soils).

  - Demolish existing buildings and pavement as needed to gain access to soils.
  - Treat VOCs by thermal desorption.
  - Treat metals by chemical stabilization.

- Install hydraulic containment system.

  - Install groundwater cutoff wall along the shoreline.
  - Install extraction wells on the upgradient side of the cutoff wall and pump to intercept groundwater leaving the site.
  - Treat extracted groundwater and discharge treated water to the county sewer.

- Manage incidental excavated material by off-site disposal.

- Maintain a cover on the site.

- Implement environmental monitoring.

- Implement institutional controls.

This alternative was designed with the intention of limiting off-site soil disposal while providing protective measures equivalent in scope to those of Alternative 5. It differs from Alternative 5 mainly in that hot spots would be addressed by on-site treatment rather than by excavation and off-site disposal. Following on-site treatment, most of the treated soil would be left at the site rather than transported to an off-site landfill.

The features and rationale for most of the actions are identical to those discussed for Alternative 5 since many of the actions are the same. This includes the need for building demolition and disruption of operations at the site in order to gain access to treat soils, the need to maintain a cover on the site, and operation of a hydraulic containment system to prevent contaminant migration into Liberty Bay. Actions that differ from Alternative 5 are discussed below.

On-site treatment could be accomplished by either in-situ or ex-situ treatment methods. For ex-situ treatment the soils would be excavated using the dewatering methods described for Alternative 5, treated in mobile units located on the base, and then returned to Area 8 as backfill material. Hence treated soil would be left at the site regardless of whether in-situ or ex-situ treatment were used. In either case, treatment might result in an excess volume of soil that could not be left at the site without changing existing topography. Since this alternative envisions resuming industrial land use after completion of the remedial actions the existing topography would be retained and any excess material would be disposed off-site. Off-site disposal might also be used to avoid resuming chemically-stabilized soil to the zone below the water table.

On-site treatment would include thermal desorption for removing VOCs and chemical stabilization for immobilizing metals. Ex-situ soil washing to segregate contaminated fines from clean coarse material might also be used. Treatability studies would be conducted to determine performance and select the best treatment approach. The FS assumed the use of in-situ steam stripping for VOCs and in-situ stabilization for metals. The steam stripping process involves a mobile auger-driven unit to inject hot air and steam into the soil to vaporize and collect VOCs for treatment. The features and deployment of this process would be the same as previously described for Alternative 6 at Area 2 (see Section 7.4.6). This process would be used to strip VOCs from vadose soils, saturated soils, and groundwater. The equipment is capable of treatment to a depth of 60 feet. In-situ stabilization would also involve the use of auger-driven equipment. In this case, the auger system would mix the soil with injected chemicals to accomplish chemical fixation. Since the metals plume is shallower than the VOC plume, the FS assumed a treatment depth of 30 feet for chemical stabilization.

Thermal desorption treatment would be applied to VOC hot spots, with the areal extent determined based on the extent of VOCs in groundwater. Chemical stabilization would be applied to metals hot spots, with the areal extent determined based on the extent of the metals groundwater plume. Where the VOC and metals plumes overlap, thermal desorption would be applied first, followed by metals stabilization treatment. Additional sampling would be required to define these hot spots, particularly for VOCs. The hot spot zones assumed in the FS covered about half the site.

Monitoring would be included to demonstrate the effectiveness of the treatment measures. The monitoring would involve groundwater and seep sampling as discussed for Alternative 3.

The main benefits of Alternative 7 would be similar to those described for Alternative 5: to limit the migration of contaminants into Liberty Bay, prevent direct contact soil exposures, and control erosion. In addition, the soil treatment action would permanently reduce VOC contamination, restrict the mobility of metals, and thus reduce the quantity of contaminants that could ultimately seep into the bay. Depending on the effectiveness of treatment, long-term operation of the hydraulic containment system might not be necessary. Because residual contamination would be left at the site above acceptable risk levels, institutional controls would be required to prevent installation of potable wells, disturbance of the cover, and residential development. These restrictions would prevent risks to future residents. Because metals in chemically-stabilized soils would be left at the site, institutional controls would need to be maintained indefinitely.

10.4.8 Alternative 8 - Vadose Soil Removal and Saturated Zone Soil Hot Spot Removal with Groundwater Interception

Alternative 8 would include the same actions as Alternative 5, except that the extent of soil removal would be increased for vadose zone soil. The following actions would be included:

- Excavate and remove soil hot spots from the saturated zone; excavate and remove all vadose zone soils; backfill with clean material (estimated volume: 81,000 cubic yards).
    - Demolish existing buildings and pavement as needed to gain access to soils.
    - Construct structural groundwater barrier to create dewatering cells.
    - Extract groundwater to lower the water table within each dewatering cell to allow dry excavation below the water table.

- Install hydraulic containment system.

  - Install groundwater cutoff wall along the shoreline.
  - Install extraction wells on the upgradient side of the cutoff wall and pump to intercept groundwater leaving the site.

- Treat extracted groundwater and discharge treated water to the county sewer.

- Manage excavated material by off-site disposal.

- Implement environmental monitoring.

- Implement institutional controls.

This alternative is intended to meet RAOs in the shortest time frame. It differs from Alternative 5 mainly in that all the vadose zone soils would be excavated rather than just vadose soil hot spots. This would avoid the need for site characterization to define hot spots, and would ensure that all contaminant sources would be removed from the soils above the water table at Area 8. With all vadose soil contamination eliminated, a cover would not need to be maintained on the site, and institutional controls would not be needed to prevent soil-related exposures. Institutional controls would still be needed to restrict groundwater use because removal of saturated zone soil hot spots is not expected to completely restore groundwater to acceptable quality. Monitoring would be used to follow the progress of subsequent groundwater restoration by natural attenuation processes and determine when and if institutional controls could be discontinued in the future. Monitoring would include groundwater and seep sampling, as discussed for Alternative 3.

10.5 COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives were assessed in comparison with the nine evaluation criteria specified by CERCLA. The following sections summarize the comparative analysis of the alternatives with respect to the nine criteria.

10.5.1 Overall Protection of Human Health and the Environment

All of the alternatives, other than the no-action alternative, would provide adequate protection of human health and the environment by eliminating, reducing or preventing risk through the use of treatment, engineering controls, or institutional measures. Because the no-action alternative is not protective of human health for future residents, it is not considered further in this analysis as an option for Area 8.

Because contaminants would not be completely removed from the site in any of the alternatives, institutional controls would be required for ultimate protection under all the alternatives. Exposures of concern are those to future residents due to ingestion of soil or homegrown vegetables, and domestic use of groundwater. The institutional controls would prevent the potential exposures of concern to future residents by excluding residential use of the site, restricting future construction or disturbance of the site, and precluding potable well construction. Institutional controls would not prevent ecological exposures; however, no current ecological risks were identified for Area 8.

10.5.2 Compliance with ARARs

All of the alternatives are expected to meet the respective requirements of federal and state environmental laws and regulations that have been identified as being applicable or relevant and appropriate to the circumstances of each alternative. Compliance with chemical-specific cleanup goals, such as drinking water standards and MTCA cleanup levels, would not be achieved in all media in a short time frame for any of the alternatives, because residual contamination would remain at the site for all the alternatives. Because of the residual contaminants, institutional controls would be used to prevent the exposures of concern, as required by chemical-specific regulations (MTCA).

MTCA soil cleanup levels would be met in areas where soil hot spots are removed in Alternatives 5, 6 and 8, but these alternatives would not achieve cleanup of all contaminated soils at the site. Alternative 8 would achieve the greatest degree of cleanup because it involves removal of all vadose soils plus saturated zone hot spots, whereas Alternatives 5 and 6 only address hot spots in both zones. Alternative 5 would be more likely than Alternative 6 to achieve cleanup levels in the saturated zone because soil removal would probably be more effective than aquifer flushing. Alternative 7 may achieve cleanup levels for volatiles, depending on the removal efficiency of treatment, but would not achieve cleanup goals for metals since they would only be immobilized and not removed by chemical stabilization treatment. The remaining alternatives rely only on containment and institutional controls to prevent exposures.

Although Alternatives 5 through 8 include soil removal or treatment actions intended to attain cleanup levels for both the vadose and the saturated zone, these levels might not be achieved due to practical limitations of the technologies (see discussion in Section 10.5.6).

Groundwater cleanup levels are not likely to be achieved in a short time frame for any of the alternatives, because residual soil contamination would remain in all cases, and provide ongoing sources of groundwater contamination (see discussion in Section 10.5.5).

Surface water and sediment standards are not currently exceeded in Liberty Bay offshore Area 8, although surface water criteria have been exceeded in some of the seep samples. Alternatives 4 through 8 would provide equivalent assurance that surface water and sediment standards are met, since they all include a hydraulic containment system to intercept groundwater before it discharges into Liberty Bay. Alternative 3 may not be as protective, because the containment walls would not be keyed into an aquitard and may allow contaminants to escape by downward diffusion. Alternative 2 would not provide any engineered groundwater controls, but would rely on monitoring to determine when and if they are needed in the future.

Ths groundwater barrier walls and groundwater treatment systems for Alternatives 3 through 8 would be designed to comply with all appropriate regulations for shoreline management, effluent discharge, and air emissions control. Excavated soil would be managed in accordance with appropriate federal and state regulations for solid and hazardous wastes.

10.5.3 Long-Term Effectiveness and Permanence

Alternatives 5 through 8 would permanently reduce hazards posed by the contaminants in Area 8 vadose zone soils by their treatment or removal and off-site disposal. Alternative 8 would provide the best long-term effectiveness because it would clean up more soil than the hot spots addressed in the other alternatives. Residual quantities of VOCs and metals would remain in the groundwater and non-remediated soil zones, but the long-term risks of exposure to these contaminants in these media would be prevented by institutional controls. In addition, removal or treatment of hot spots would accelerate the natural restoration of the aquifer by eliminating long-term sources of groundwater contamination from the vadose and saturated soil zones, and would recluse the long-term migration of contaminants into the marine environment. Alternative 7 would provide less long-term effectiveness because chemically-stabilized metals would be left at the site after treatment rather than disposed in an off-site landfill. Alternatives 2 through 4 do not include any actions to permanently reduce site contamination.

The degree of permanence achieved by Alternatives 5 through 8 may be compromised by practical limitations of the technologies involved, which in particular may hamper their effectiveness for remediating contaminants in soils below the water table. Examples of potential limitations are discussed in Section 10.5.6, Implementability.

Alternatives 4 through 8 would also provide a groundwater interception system to control migration of contaminants into Liberty Bay. However, this groundwater control would rely on long-term pumping, treatment, and discharge of groundwater. Alternative 3 is designed to divert groundwater flow around Area 8 by encircling the contaminants with a subsurface barrier wall, and hence reduce contaminant migration into Liberty Bay. This approach

would avoid long-term reliance on groundwater pumping, but could allow downward migration and leakage of contaminants below the bottom of the barrier wall. The potential for such leakage would be reduced but not eliminated by the impermeable cover included in Alternative 3. These groundwater interception and containment measures would not reduce the onshore human health risks at Area 8, and may not be necessary for long-term attainment of RAOs offshore in Liberty Bay. Alternative 2 would monitor the groundwater and downgradient marine sediments to determine if Liberty Bay is adversely affected by Area 8 before deciding if groundwater control systems should be built.

If chlorinated solvents are present as DNAPLs, they may sink downward through the aquifer against the upward gradient that exists at the site, and could threaten drinking water resources in deeper aquifers. In addition, downward migration could spread the extent of the plume below the bottom of the cutoff walls and extraction wells of Alternatives 3 through 8, and circumvent their ability to contain or intercept groundwater and prevent discharge of VOCs into Liberty Bay. DNAPLs may be removed by the hot spot soil excavation or in-situ treatment technologies of Alternatives 5 through 8, but residual DNAPLs could still be left at the site in all the alternatives. If residual DNAPLs cause downward migration, this would be observed in the deeper monitoring wells which would trigger a re-evaluation of DNAPL investigations and DNAPL response actions.

10.5.4 Reduction of Toxicity, Mobility or Volume Through Treatment

Alternative 7 would treat soil to reduce toxicity and mobility by removing and destroying VOCs and by chemically stabilizing metals. Depending on the outcome of treatability studies, this alternative may also include soil washing that would reduce the volume of contaminated soil needing chemical stabilization.

Alternative 6 would employ a groundwater extraction and ex-situ treatment system to actively flush contaminants from the aquifer. The groundwater treatment system would remove VOCs by carbon adsorption for subsequent destruction during off-site thermal regeneration of the carbon, convert chromium to its less toxic trivalent form, reduce the volume of metals contamination by precipitating them as sludge, and reduce the mobility of the metals by chemical stabilization of the sludge prior to off-site disposal. Groundwater extraction and treatment in Alternatives 4, 5, 7, and 8 is included only for passive hydraulic containment, and would not result in significant reductions of toxicity, mobility, or volume through treatment.

Alternatives 5, 6, and 8 would also include treatment of VOCs and metals, as needed to meet hazardous waste regulations for off-site disposal. The volume of soil to be excavated for possible treatment would vary for each of these alternatives (Alternative 6 would remove the least and Alternative 8 the most soil). The excavated soil would be analyzed to determine treatment requirements. If treatment is not required for disposal, Alternatives 5 and 8 would not include treatment as a principal element of the remedy.

Alternatives 2 through 4 do not include treatment technologies as a principal element of the remedy, and thus would not satisfy the regulatory preference for treatment.

<u>10.5.5 Short-Term Effectiveness</u>

All of the alternatives would quickly achieve RAOs because they all would use institutional controls to prevent potential human exposures, and Area 8 does not appear to be causing current ecological risks based on existing data. For the purposes of controlling groundwater to prevent possible future risks in Liberty Bay, the groundwater interception system of Alternative 4 would be the quickest to implement, since it does not involve construction of a subsurface cutoff wall. The barrier wall control systems of Alternatives 3, 5, 6, 7, and 8 would take longer to implement, but could also be completed in a reasonably short time.

Remedial action objectives for Alternatives 2 through 4 would only be achieved by containment or institutional controls rather than active measures to prevent risks. Soil cleanup levels could be achieved in a relatively short time for the vadose zone hot spots that would be excavated in Alternatives 5 through 8. Alternatives 5, 7, and 8 include technologies for cleaning up the saturated zone that could be completed in a relatively short time. However, cleanup levels may not be attained throughout the site by the technologies alone because of practical limitations of the technologies.

Groundwater cleanup levels are not likely to be achieved in a short time frame for any of the alternatives, because residual soil contamination would remain in all cases, and provide ongoing sources of groundwater contamination. Alternative 8 would remove the most soil, and therefore would likely attain the greatest acceleration of natural groundwater restoration processes. Alternatives 5 and 7 would achieve intermediate improvement, since they would involve removal or treatment of hot spots in both the vadose and saturated zones. Alternative 6 is intended to clean up the entire groundwater plume by aquifer flushing, but it is not expected to be effective in removing metals from the soil in a short time frame. However, the removal of hot spots from the vadose zone in this alternative would improve the rate of groundwater restoration compared with Alternatives 2 through 4, none of which include any source treatment or removal actions. Physical containment (Alternative 3) would have no benefit with respect to drinking water quality, because the containment wall would be adjacent to the shoreline and there would be no usable aquifer downgradient of the site (i.e., groundwater cleanup levels would never be achieved).

Alternatives 5 through 8 would cause some short-term risks of exposure to workers and the community during excavation, treatment and hauling of soils removed from the vadose and saturated zones. These exposures would be less for Alternative 7 if treatability studies showed in-situ treatment should be used rather than ex-situ treatment. Some short-term impacts to Liberty Bay may result from Alternatives 3 through 8 because construction activities that disturb the soil near the shore could temporarily increase the mobility of contaminants. These impacts would be minimal for Alternative 4 which only involves construction of extraction wells rather than a groundwater interception system with a slurry wall.

<u>10.5.6 Implementability</u>

Technical constraints to implementation would be the least for Alternatives 2 and 3 because construction activities would be limited to installation of wells that would not conflict with existing facilities. Alternative 3 is designed to avoid immediate demolition of existing structures, but would require construction of a slurry wall and interim cover in the midst of existing buildings and underground utilities. The remaining alternatives would require immediate building demolition and possible relocation of utilities to provide unobstructed access to remediate the contaminated soils. There are practical military and economic constraints to demolition of the plating shop. The plating facility supports the military mission of the base. Disruption of plating operations by building demolition would have negative impacts to base operations. If demolition is required for remediation, its timing would need to be coordinated with the Navy's plans for a new plating facility in order to maintain plating capabilities unique to the base.

Although Alternatives 5 through 8 include soil removal or treatment actions intended to attain cleanup levels for both the vadose and the saturated zone, these levels might not be achieved due to practical limitations of the technologies. For example, Alternative 6 would use groundwater flushing to clean up the saturated zone, but this process is not expected to be effective for removing metals from the aquifer in a reasonable time frame. Alternative 7 may use augers to mix soil for in-situ treatment, but this equipment cannot reach beyond certain depths and might not be able to treat the entire zone of contamination. There is significant uncertainty regarding the technical feasibility of removing soil from below the water table, which is a principal action in Alternatives 5, 7, and 8. Because of the proximity to Liberty Bay and the need to excavate to considerable depths, shoring and dewatering requirements would be extensive and may be prohibitive. This issue would not affect the other alternatives.

Additional site characterization to verify the extent of contamination or define hot spots would be required to implement all of the alternatives other than Alternative 2. DNAPL characterization would involve the use of specialized equipment and services (cone penetrometer surveys) and would be difficult to implement while the plating shop is operational because of space constraints and the presence of numerous underground utility lines. Treatability testing would be needed for the slurry walls and treatment systems used in all the alternatives except Alternative 2. Delays could be experienced for Alternative 7 due to the specialized equipment and services needed for on-site soil treatment.

Alternatives 4 through 8 include treatment of extracted groundwater and thus would require coordination with other agencies to obtain a permit to discharge treated effluent. A discharge permit may be more difficult to obtain for Alternatives 5 and 8 because these would involve the highest effluent discharge rates and thus would have greater impact on the hydraulic capacity of the county sewer system and POTW. Alternatives 2 and 3 would avoid groundwater extraction and the need for a discharge permit.

10.5.7 Cost

Alternative 2 would have the lowest cost, with an estimated present worth of $0.9 million. Alternatives 3 and 4, which feature physical and hydraulic containment, have intermediate cost, with an estimated present worth of $15 million to $18 million. Somewhat higher costs are estimated for Alternative 6, which includes excavation of vadose hot spots and aquifer flushing ($32 million present worth), and for Alternative 7, which features on-site treatment ($33 million present worth). The highest costs would be incurred for Alternatives 5 and 7, which address contaminated hot spots in the saturated zone by shoring, dewatering, and excavating soils for off-site disposal (estimated present worth of $56 million to S74 million).

10.5.8 State Acceptance

The State of Washington Department of Ecology concurs with the selected remedy for Area 8 of the NUWC Division, Keyport Operable Unit 2. Comments received from Ecology have been incorporated into this Record of Decision.

10.5.9 Community Acceptance

Community acceptance was not specifically addressed as part of the evaluation of the individual alternatives in the FS. Rather, this criterion was assessed in the context of the preferred alternative presented to the public in the proposed plan and the public meeting.

Based on comments received on the proposed plan during the public comment period, as summarized in Appendix A, the selected remedy described below appears to be acceptable to the community.

10.6 SELECTED REMEDY FOR AREA 8

Based on consideration of CERCLA requirements, the detailed analysis of alternatives, and public comments, the Navy, EPA, and Ecology have determined that the most appropriate remedy for Area 8 is a combination of actions chosen from Alternatives 2 and 7 (see Section 12.2 for rationale). The selected remedy includes continued groundwater monitoring, sediment and tissue monitoring, institutional controls to restrict residential use of the site, and removal of vadose zone soil hot spots for off-site disposal. The excavated soil would be treated offsite as necessary to comply with land disposal regulations. The groundwater monitoring would be used to establish trends in groundwater chemical concentrations and determine when institutional controls could be discontinued. The groundwater data would also be compared with monitoring results for sediments and tissues to determine whether additional actions to protect the marine environment should be implemented at Area 8.

The following sections describe additional details of the selected remedy for Area 8. The descriptions, details, and costs discussed below for the selected actions are based on currently available data and information. Changes may be made to the selected remedy as a result of new information developed during the remedial design and construction processes. Such changes, in general, will reflect modifications resulting from the engineering design process.

10.6.1 Soil Removal and Disposal

The human health risk assessment determined that cadmium detected in the subsurface soil poses a noncancer health risk for future residents eating home-grown produce (HQ of 4). Cadmium and chromium were detected in subsurface soils at concentrations above state cleanup standards (MTCA Method B cleanup levels for soil ingestion). To reduce these risks, soil will be excavated and removed from hot spot areas within the vadose zone. The excavation of hot spots will remove the majority of contaminants that could otherwise be transported by groundwater into Liberty Bay and help to accelerate natural processes for restoring the aquifer. The hot spot removal will be concerned with metal contamination rather than VOCs, because no VOC sources were located by the soil sampling and if any residual VOCs are left in the vadose soils, they are more amenable to natural attenuation than metals. This is because VOCs can be vaporized, biodegraded, or leached out by rainfall, whereas leaching is the only mechanism applicable to metals.

The excavated soil will be transported for disposal in an off-site landfill. The contaminated soil is not a listed RCRA waste but may be a characteristic hazardous waste. The excavated material will be analyzed by the EPA toxicity characteristics leaching procedure (TCLP) to determine whether it is a restricted waste that requires treatment before being disposed. It is anticipated that some of the material may require chemical stabilization of the metals (cadmium, chromium) prior to disposal. Some of the soil may also require treatment to remove or destroy VOCs since these have been detected in the groundwater. The need for treatment will be determined based on the TCLP, results. Management of excavated material will be in accordance with federal and state hazardous waste regulations (40 C.F.R. §261, 40 C.F.R. §262, 40 C.F.R. §263, 40 C.F.R. §268, WAC 173-303).

Because the contaminants in Area 8 soil have led to groundwater contamination that poses unacceptable risk, the RAOs for the soil included protection of groundwater and surface water quality in addition to prevention of risks from soil ingestion pathways. Remediation goals relative to these RAOs are shown in Table 10-10, and are based on MTCA Method B cleanup levels for soil ingestion and groundwater protection. The soil concentration levels for groundwater protection were calculated by multiplying the corresponding MTCA groundwater cleanup level by a factor of 100, in accordance with WAC 173-340-740(3). Since Area 8 groundwater discharges into surface water, the MTCA groundwater cleanup level at the point of discharge is the more stringent of the MTCA B surface water cleanup level (defined in WAC 173-340-720[3][b][v]) and the MTCA B cleanup levels based on drinking water (defined in WAC 173-340-720[3][a]). For purposes of clarity, Table 10-10 shows soil cleanup levels for protection of both drinking water and surface water quality.

Although the MTCA B cleanup levels in Table 10-10 are the ultimate remediation goals for Area 8 soils, they will not be used for purposes of determining the location and extent of hot spots for the soil removal action. Instead, an action level equivalent to the MTCA B soil ingestion cleanup level has been selected to define hot spots for the soil removal based on the technical impracticability and the cost of dewatering and excavating the saturated zone soils or removing all the vadose zone soils that exceed the groundwater protection cleanup levels (as discussed in Section 12.2). Some of the groundwater protection cleanup levels are near or below background levels, and removal to such levels might result in excavating all the vadose soils at the site rather than hot spots. This would be impractical to implement and would have disproportionate costs relative to benefits because removing more than the hot spots would not achieve a substantial reduction in risk compared to the additional effort and cost that would be incurred. Institutional controls and monitoring will be implemented, as discussed in the next section, because the groundwater protection remediation goals will not be achieved by the soil removal action.

The use of the MTCA B soil ingestion levels as action levels for the soil removal is intended to accomplish the objectives of eliminating the risk from direct contact with soil, reducing the risk from eating homegrown produce, and accelerating the natural restoration of the groundwater. Table 10-10 identifies these action levels while accounting for background levels, and compares them to the maximum concentrations detected in Area 8 soils. Cadmium and chromium exceeded the MTCA B soil ingestion cleanup level due to noncancer effects, and thus will be used as target compounds for cleanup. Other chemicals 1 detected in the vadose soils did not exceed the soil ingestion cleanup levels except for arsenic. Arsenic was not selected as a target compound because the maximum concentration was only two times the background value, 90 percent of the soil results were less than the background value, and the locations where arsenic was detected above background are contiguous with the cadmium-, chromium-, and petroleum-contaminated areas of the site that will be excavated as part of the hot spot removal action and the UST soil removal action (the UST remediation is discussed in Section 10.3). A number of organic compounds were detected in soils, but none exceeded MTCA Method B cleanup levels (Table 10-10).

Table 10-10
Remediation Goals and Action Levels for Area 8 Soil

	Soil Remediation Goals, mg/kg					
Chemical	MTCA Method B Cleanup Level for Soil Ingestion-a	MTCA Method B Cleanup Level for Protection of Drinking Water-b,c	MTCA Method B Cleanup Level for Protection of Surface Water-b,d	RI Background Value for Soil (mg/kg)	Area 8 Soil Removal Action Level (mg/kg)	Maximum Result Detected in Soil (mg/kg)
INORGANICS						
Arsenic	1.4	0.005	0.014	6.1	6.1	12.9
Barium	5,600	100		89	5,600	125
Cadmium	80	0.5	0.8	0.32 U	80	193
Chromium (III)	80,000	1,600	16,000		80,000	
Chromium (VI)	400	8	5		400	
Chromium (total)		5		43		2,600
Copper	2,960	59	0.25	37	2,960	390
Lead		1.5	0.58			549
Mercury	24	0.2	0.0025	0.11 U	24	0.09
Nickel	1,600	10	0.79	91	1,600	427
Silver	240	4.8	0.12	1.1 U	240	2.8
Thallium	5.6	0.11	0.16	0.32 U	5.6	0.42
Tin	48,000	960			48,000	100
Zinc	24,000	480	7.7	60	24,000	718
Cyanide	1,600	32	0.1		1,600	3.5
VOLATILE ORGANIC COMPOUNDS						
Acetone	8,000	80				0.21
Benzene	35	0.5	7.1			ND
Carbon tetrachloride	7.7	0.034	0.44			ND
Chloroform	160	0.72	47			ND
1,1-dichloroethane	8,000	80				ND
1,1-dichloroethene	1.7	0.7	0.32			ND
1,2-dichloroethane	11	0.5	0.59			ND
1,2-dichloroethene(cis)	800	7				ND
1,2-dichloroethene (trans)	1,600	10	3,300			0.005
Ethylbenzene	8,000	70	690			7.3
Styrene	33	0.15				0.067
Tetrachloroethene	20	0.5	0.89			0.11
Toulene	16,000	100	4,900			0.24
1,1,1-trichloroethane	7,200	20	4,200			0.56
1,1,2-trichloroethane	18	0.5	4.2			ND
Trichloroethene	91	0.5	8.1			0.13
Xylenes	160,000	1,000				37

Table 10-10 (Continued)
Remediation Goals and Action Levels for Area 8 Soil

Chemical	Soil Remediation Goals, mg/kg MTCA Method B Cleanup Level for Soil Ingestion-a	MTCA Method B Cleanup Level for Protection of Drinking Water-b,c	MTCA Method B Cleanup Level for Protection of Surface Water-b,d	RI Background Value for Soil (mg/kg)	Area 8 Soil Removal Action Level (mg/kg)	Maximum Result Detected in Soil (mg/kg)
SEMIVOLATILE ORGANIC COMPOUNDS						
Butylbenzyl phthalate	16,000	320	130			0.083
Di-n-butyl phthalate	8,000	160	290			3.1
Di-n-octyl phthalate	16,000	32				0.085
Dimethyl phthalate	80,000	1,600	7,200			0.034
Bis(2-ethylhexyl) phthalate	71	0.6	0.59			0.45

a Value listed is the lower of the cancer or noncancer value.

b Value listed accounts for adjustment when an MCL or water quality standard is sufficiently protective to serve as the MTCA cleanup level (MTCA Implementation Memo No. 1; Kraege 1993). Value does not account for background or PQL adjustments.

c Value listed is the lowest value derived from: WAC 173-340-720(3)(a)(ii), 40 CFR 141, and WAC 246-290-310 (see Table 10-12).

d Value listed is the lowest value derived from: WAC 173-340-730(3)(a)(iii), 40 CFR 131.36, WAC 173-201A-040(3), and federal water quality criterion documents (as amended) (see Table 10-12).

ND = Chemical was detected in Area 8 groundwater but was not detected in soil samples.

The action level will be defined as a hazard index of 1, based on MTCA Method B soil ingestion exposure factors and toxicity factors for cadmium and chromium in effect at the time this ROD is signed. Table 10-11 lists the available soil data for cadmium and chromium, and shows the hazard index calculated for each sample location. The data listed in Table 10-11 include all samples collected for the RI and other studies conducted during the same time frame (Hart Crowser 1991, 1992).

Figure 10-5 plots the hazard indices and shows the location of hot spots based on the calculations listed in Table 10-11. Darkened symbols in Figure 10-5 indicate the sample locations where the hazard index was greater than 1, and are thus considered hot spots for the removal action. The hot spots will be removed by excavating the material within the vicinity of the darkened points in Figure 10-5, and then excavating outward horizontally and vertically until the action level is attained at the excavation surface (i.e., at the bottom and vertical surfaces of the excavation pit). The outward excavation will be accomplished in several stages, or passes, of excavation. After each pass of excavation, samples will be taken from the excavation surfaces and analyzed to determine compliance with the action level. The depth of excavation will be limited to the elevation of the water table regardless of whether cleanup levels are achieved. Once the action level is attained, the pit will be backfilled with clean material.

Because the extent of soil removal will be based on cleanup concentrations determined during excavation, the actual volume to be removed is presently unknown. It is anticipated that the volume will be equal to or less than that assumed for vadose zone hot spot removal in Alternative 5 of the FS (6,400 cubic yards). The volume in the FS was a conservative estimate derived from the extent of the groundwater plume. The actual soil volume that will be removed will be a function of the number of excavation passes at each hot spot location that are needed before analyses show that a clean surface has been attained compared with the action level. If the hot spots represent localized sources rather than widespread contamination, only a few excavation passes might be required at each location, and the total actual volume might be considerably less.

The soil removal will occur in two phases. The first phase will involve excavation of soil below the chrome room of the plating shop. This coincides with the hot spots at B-4 and B-5 shown within the eastern part of the plating building in Figure 10-2. The first phase excavation will not extend laterally beyond the limits defined by the walls of the chrome room. The first phase removal will commence within 15 months of the signing of this ROD. The second phase of soil removal will involve excavation of the remaining hot spots, including any portions of the hot spots at B-4 and B-5 that may extend laterally beyond the walls of the chrome room. The timing of the second removal phase depends on the Navy obtaining funding for construction of a new plating shop, because the plating facilities are needed to support base operations and the existing plating building must be demolished to provide access for the soil removal action. Flexibility in the timing of the second removal phase is included in this ROD because it is not legal to use federal funds appropriated for remedial actions to pay for the cost of a new plating facility. The Navy will implement the second phase of soil removal after completion of the first phase or no later than 1998 when the new plating facility is operational. This is dependent on funds being appropriated for the construction of the new facility. If funding for the new plating facility is not forthcoming such that the second phase soil removal is delayed beyond 1998, then other alternatives for engineered actions will be considered in concurrence with EPA and Ecology.

Table 10-11
Cumulative Noncancer Risk for Chromium and Cadmium in Area 8 Soils

Sample Designation	Sample Depth (feet)	Chromium Concentration (mg/kg)	Cadmium Concentration (mg/kg)	Chromium HQa	Cadmium HQa	Cumulative Risk (HIa)	HIa Above 1.0
ANAT-S-1	1	155	0.96	3.9e-01	1.2e-02	0.4	
ANAT-S-2	2.5	27.3	17.8	6.8e-02	2.2e-01	0.3	
ASDP-S-1	4-7	251	21.6	6.3e-01	2.7e-01	0.9	
AS-B-1	9.5	302	18.1	7.6e-01	2.3e-01	1.0	
AS-B-1R (replicate)	9.5	289	20.1	7.2e-01	2.5e-01	1.0	
AS-M-1	4.5-9.5	156	29.2	3.9e-01	3.7e-01	0.8	
AS-S-1	0-4.5	37.4	6.5	9.4e-02	8.1e-02	0.2	
BLT-E-B-2	8	52.6	45	1.3e-01	5.6e-01	0.7	
BLT-E-S-1	3	33.7	67	8.4e-02	8.4e-01	0.9	
BLT-M-B-2	6.5-7	198	193	5.0e-01	2.4e+00	2.9	*
BLT-M-S-1	0-3	45.2	126	1.1e-01	1.6e+00	1.7	*
BLT-W-B-2	5	93.4	40.5	2.3e-01	5.1e-01	0.7	
BLT-W-S-1	0-2	38.4	73.5	9.6e-02	9.2e-01	1.0	
B-14-S-1	1-1.5	20.8	2	5.2e-02	2.5e-02	0.1	
B-14-S-2	3-3.5	28.6	2.5	7.2e-02	3.1e-02	0.1	
B-15-S-1	0.5-1.5	46.2	54.7	1.2e-01	6.8e-01	0.8	
B-15-S-3	5.5-6	85	4.2	2.1e-01	5.3e-02	0.3	
B-16-S-1	0.5-1.5	40	35.7	1.0e-01	4.5e-01	0.5	
B-16-S-2	3-5	345	33.2	8.6e-01	4.2e-01	1.3	*
B-16-S-3	6.5-8	81.7	15	2.0e-01	1.9e-01	0.4	
B-17-S-1	1.0-1.5	86	130	2.2e-01	1.6e+00	1.8	*
B-17-S-2	3-4.5	166	184	4.2e-01	2.3e+00	2.7	*
B-17-S-3	7-8.5	129	36	3.2e-01	4.5e-01	0.8	
B-18-S-1	1-2	190	4.2	4.8e-01	5.3e-02	0.5	

Table 10-11 (Continued)
Cumulative Noncancer Risk for Chromium and Cadmium in Area 8 Soils

Sample Designation	Sample Depth (feet)	Chromium Concentration (mg/kg)	Cadmium Concentration (mg/kg)	Chromium HQa	Cadmium HQa	Cumulative Risk (HIa)	HIa Above 1.0
B-18-S-2	3-4	65.5	1.8	16.e-01	2.3e-02	0.2	
B-18-S-3	9-10.5	83.7	26.8	2.1e-01	3.4e-01	0.5	
B-19B-S-1	1-1.5	184	1.6	4.6e-01	2.0e-02	0.5	
B-19B-S-2	3.5-4	68.5	1.2	1.7e-01	1.5e-02	0.2	
B-1-S-3	6-6.8	23	1 U	5.8e-02	0.0	0.1	
B-1-S-5	11-11.5	14	1 U	3.5e-02	0.0	0.0	
B-1-S-7	16-16.8	22	3.4	5.5e-02	4.3e-02	0.1	
B-20/S-1(replicate of B-18-S-1)	1-2	196	3.2	4.9e-01	4.0e-02	0.5	
B-2-S-4	8.5-10	20	1 U	5.0e-02	0.0	0.1	
B-2-S-6	13.5-15	50	4.1	1.3e-01	5.1e-02	0.2	
B-2-S-9	21-21.7	53	11	1.3e-01	1.4e-01	0.3	
B-3-S-4	6-6.8	21	1 U	5.3e-02	0.0	0.1	
B-3-S-6	11-12.5	13	1 U	3.3e-02	0.0	0.0	
B-3-S-9	23.5-23.9	18	1 U	4.5e-02	0.0	0.0	
B-4-S-2	2.5-3	640	1.1	1.6e+00	1.4e-02	1.6	*
B-4-S-4	6-7	79	2	2.0e-01	2.5e-02	0.2	
B-5-S-1	1-1.5	2600	1.5	6.5e+00	1.9e-02	6.5	*
B-5-S-6	9-9.9	74	1	1.9e-01	1.3e-02	0.2	
B-5-S-7	12-12.8	110	1	2.8e-01	1.3e-02	0.3	
B-6-S-1	2.5-3.5	190	2.6	4.8e-01	3.3e-02	0.5	
B-6-S-4	10-10.7	81	1 U	2.0e-01	0.0	0.2	
B-7-S-2	2.5-3.5	260	2.1	6.5e-01	2.6e-02	0.7	
B-7-S-6	10-10.3	95	6.6	2.4e-01	8.3e-02	0.3	

Table 10-11 (Continued)
Cumulative Noncancer Risk for Chromium and Cadmium in Area 8 Soils

Sample Designation	Sample Depth (feet)	Chromium Concentration (mg/kg)	Cadmium Concentration (mg/kg)	Chromium HQa	Cadmium HQa	Cumulative Risk (HIa)	HIa Above 1.0
CHROME-B-3	8	21.8	0.01U	5.5e-02	0.0	0.1	
CHROME-M-1	4-6.5	76.1	2.4	1.9e-01	3.0e-02	0.2	
CHROME-S-1	0-4	34.9	19.9	8.7e-02	2.5e-01	0.3	
CHROME-S-1R (replicate)	0-4	34	17.2	8.5e-02	2.2e-01	0.3	
CSDP-S-1	4-5	63.7	5.1	1.6e-01	6.4e-02	0.2	
MW-10-S-4	8.5-9.3	18	1 U	4.5e-02	0.0	0.0	
MW-10-S-8	18.5-18.8	11	1 U	2.8e-02	0.0	0.0	
MW-11-S-3	6-7.5	73	18	1.8e-01	2.3e-01	0.4	
MW-11-S-7	16-16.8	24	6.4	6.0e-02	8.0e-02	0.1	
MW-12-S-10	23.5-24.4	30	3.4	7.5e-02	4.3e-02	0.1	
MW-12-S-3	6-7.5	64	15	1.6e-01	1.9e-01	0.3	
MW-12-S-7	16-17.2	91	3.5	2.3e-01	4.4e-02	0.3	
NSDP-WS	1.5	1610	9.2	4.0e+00	1.2e-01	4.1	
NSUMPT-B-1	5	134	13	3.4e-01	1.6e-01	0.5	
NSUMP-B-2	4	51.3	10.3	1.3e-01	1.3e-01	0.3	
NSUMP-B-2R (replicate)	4	45.8	3.69	1.1e-01	4.6e-02	0.2	
NSUMP-S-1	0-2	32.8	4.91	8.2e-02	6.1e-02	0.1	
SB8-15-1	13-14	29.1	4.5	7.3e-02	5.6e-02	0.1	
SB8-15-2	20-20.8	23.7	2.5	5.9e-02	3.1e-02	0.1	
SB8-15-3	30-31.5	33.1	1	8.3e-02	1.3e-02	0.1	
SB8-16-1	48-50	19.4	1	4.9e-02	1.3e-02	0.1	
SB8-16-FD1 (replicate)	48-50	32.9	1.9	8.2e-02	2.4e-02	0.1	
SB8-1-1	2-3	23.8	1.7	6.0e-02	2.1e-02	0.1	

Table 10-11 (Continued)
Cumulative Noncancer Risk for Chromium and Cadmium in Area 8 Soils

Sample Designation	Sample Depth (feet)	Chromium Concentration (mg/kg)	Cadmium Concentration (mg/kg)	Chromium HQa	Cadmium HQa	Cumulative Risk (HIa)	HIa Above 1.0
SB8-1-2	5-6	25.1	0.46 U	6.3e-02	0.0	0.1	
SB8-1-3	8-9	23	0.45 U	5.8e-02	0.0	0.1	
SB8-2-1	3-4	20.5	0.44 U	5.1e-02	0.0	0.1	
SB8-2-2	4-6	29.1	0.42 U	7.3e-02	0.0	0.1	
SB8-2-3	8-9	36.5	0.46 U	9.1e-02	0.0	0.1	
SB8-2-FD1 (replicate)	3-4	34.3	0.40 U	8.6e-02	0.0	0.1	
SB8-3-1	2-3	28.6	0.39 U	7.2e-02	0.0	0.1	
SB8-3-2	5-6	46	16.2	1.2e-01	2.0e-01	0.3	
SB8-3-3	8-9	20.5	5.1	5.1e-02	6.4e-02	0.1	
SB8-4-1	2-3	22.6	0.41 U	5.7e-02	0.0	0.1	
SB8-4-2	5-6	19.9	0.42	5.0e-02	5.3e-03	0.1	
SB8-5-1	2-3	25.8	.042 U	6.5e-02	0.0	0.1	
SB8-5-2	5-6	18.5	0.40 U	4.6e-02	0.0	0.0	
SB8-5-3	8-9	25.7	0.34 U	6.4e-02	0.0	0.1	
SELP-1-S-1	1	215	1.14	5.4e-01	1.4e-02	0.6	
SELP-2-S-2	4.5	29.2	5.5	7.3e-02	6.9e-02	0.1	
Soil Background Values (from RI)		42.6	0.32 U	1.1e-01	0.0	0.1	

a Hazard quotients (HQ) and hazard indices (HI) are relative to MTCA Method B exposure parameters and RfDs per the March 1994 Update of CLARC II. Cumulative risk (HI) for multiple target compounds is calculated using MTCA Level B formulas for direct contact exposures to soil.
* Indicated on HI above 1.0.
This table includes some data that have not been validated. The purpose of this table is for estimation of hot spot locations only.

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10.6.2 Monitoring

This section describes the principal elements of the monitoring that will be implemented for the selected remedy. After this ROD is signed, further details of the monitoring program will be developed by preparation of a sampling and analysis plan, with public input and review and concurrence by EPA and Ecology. The Navy may perform background sampling and analysis for comparison and determining the significance of monitoring results for inorganics. The sampling and analysis plan will specify methods for collecting, analyzing and interpreting background samples.

- Groundwater Monitoring

Groundwater monitoring will be conducted by sampling multiple monitoring wells in the water table aquifer at Area 8. Some of the wells will be screened in the uppermost portion of the aquifer to monitor horizontal migration, and some of the wells will be screened below the depth of known contamination to monitor for possible downward migration. Existing wells will be supplemented with new wells to implement the monitoring program.

The groundwater samples will be analyzed for VOCs and metals using standard EPA methods because these analytes were used in the plating shop and are present in the groundwater. The initial sampling rounds will also include analysis for semivolatile organic compounds (SVOCs) because of the petroleum releases from the former underground storage vault. SVOC analyses for subsequent rounds will depend on the results for the initial rounds.

The Navy has been conducting quarterly or monthly groundwater monitoring for these analytes since April of 1992. These monitoring results support a monitoring frequency of twice per year until the 5-year site review is performed. The sampling frequency for subsequent years will be adjusted as part of the 5-year review process. The scope of the monitoring program will continue to be amended as the data are gathered and evaluated. Any decision to modify the monitoring program will be made with EPA and Ecology concurrence and input from the community.

The groundwater monitoring data will be used to determine the effectiveness of the soil removal, establish contaminant trends over time, and assess whether institutional controls restricting groundwater use for drinking can be discontinued. For this purpose, the monitoring data will be compared with federal and state drinking water standards for metals and VOCs (Table 10-12). The analytical methods, number and locations of wells, and the details of how these evaluations are to be made will be documented in the sampling and analysis plan. Any decision to discontinue institutional controls on potable use of groundwater based on groundwater monitoring results will be subject to approval by EPA and Ecology with input from the community. Comparison of the groundwater data to drinking water standards may not be an appropriate measure for all institutional controls that may be implemented; the need to continue other institutional controls may depend on comparisons of monitoring data to other ARARs or risk-based levels besides drinking water standards.

The wells installed below the depth of known contamination will be used to assess possible downward migration. If the results for these wells show VOC concentrations are increasing or the edge of the plume is moving downward, the presence of DNAPLs may be indicated. If deeper aquifers appear to be threatened, the Navy will evaluate, in concurrence with EPA and Ecology, the need for further investigations to determine if DNAPLs are present and identify their locations. If further characterizations are carried out and DNAPLs are located, methods of DNAPL remediation will be considered by the Navy in concurrence with EPA and Ecology.

The groundwater monitoring data will also be compared with the long-term monitoring results for sediments and tissues (described in the next section) to establish whether migration of chemicals in the groundwater from Area 8 is causing impacts in the marine environment, and determine the need for groundwater control actions. These evaluations are discussed subsequently in the groundwater controls section.

Table 10-12
Remediation Goals for Area 8 Groundwater and Surface Water

		Drinking Water (µg/L)				Surface Water (µg/L)			
							State Water Quality Standards		
Chemicals	RI Background Value for Groundwater (µg/L)	MTCA Method B Formula Value	Federal MCL	State MCL	MTCA Method B Cleanup Level-b	MTCA Method B Formula Value-b	Ambient Marine-c,d	Fish Ingestion-a,c	MTCA Method B Cleanup Level
INORGANICS									
Arsenic	12	0.05	50	50	0.05	0.084	36	0.14	0.14
Barium	130	1,100 N	2,000	1,000	1,000				
Cadmium	2.5	8 N	5	10	5	20 N	8	170	8
Chromium (III)		16,000 N			16,000	160,000 N			160,000
Chromium (VI)	10 U	80 N			80	810 N	50		50
Chromium (total)	4 U		100	50	50				
Copper	3 U	590 N	1,300*		590	2,700 N	2.5		2.5
Lead	1 U		15*	50	15		5.8		5.8
Mercury	0.2 U	4.8 N	2	2	2		0.025	0.15	0.025
Nickel	3 U	320 N	100		100	1,100 N	7.9	4,600	7.9
Silver	29	48 N			48	16,000 N	1.2		1.2
Thallium	2 U	1.1 N	2		1.1	1.6 N		6.3	1.6
Tin		9,600 N			9,600				
Zinc	19	4,800 N			4,800	17,000 N	77		77
Cyanide	18	320 N	200		320	52,000 N	1	220,000	1
VOLATILE ORGANIC COMPOUNDS									
Acetone		800 N			800				
Benzene		1.5	5	5	5	43		71	71
Carbon tetrachloride		0.34	5	5	0.34	2.7		4.4	4.4
Chloroform		7.2	100f	100f	7.2	280		470	470
1,1-dichloroethane		800 N			800				
1,1-dichloroethene		0.073	7	7	7	1.9		3.2	3.2
1,2-dichloroethane		0.48	5	5	5	5.9		99	5.9

Table 10-12 (Continued)
Remediation Goals for Area 8 Groundwater and Surface Water

			Drinking Water (µg/L)				Drinking Water (µg/L)		
							State Water Quality Standards		
Chemical	RI Background Value for Groundwater (µg/L)	MTCA Method B Formula Value	Federal MCL	State MCL	MTCA Method B Cleanup Level-b	MTCA Method B Formula Value-b	Ambient Marine-c,d	Fish Ingestion-a,c	MTCA Method B Cleanup Level-b
Volatile Organic Compounds (continued)									
1,2-dichloroethene(cis)		80 N	70		70				
1,2-dichloroethene(trans)		160 N	100		100	33,000 N		140,000	33,000
Ethylbenzene		800 N	700		700	6,900 N		29,000	6,900
Styrene		1.5	100		1.5				
Tetrachloroethene		0.86	5		5	4.2		8.9	8.9
Toluene		1,600 N	1,000		1,000	49,000 N		200,000	49,000
1,1,1-trichloroethane		720 N	200	200	200	42,000 N		170,000	42,000
1,1,2-trichloroethane		0.77	5		5	25		42	42
Trichloroethene		4	5	5	5	56		81	81
Xylenes		16,000 N	10,000		10,000				
SEMIVOLATILE ORGANIC COMPOUNDS									
Butylbenzyl phthalate		3,200 N			3,200	1,300 N		5,200	1,300
Di-n-butyl phthalate		1,600 N			1,600	2,900 N		12,000	2,900
Di-n-octyl phthalate		320 N			320				
Dimethyl phthalate		16,000 N			16,000	72,000 N		2,900,000	72,000
Bis(2-ethylhexyl) phthalate		6.3	6		6	3.6		5.9	5.9

a Value listed is the lower of the cancer or noncancer value.
b Value listed accounts for adjustment when an MCL or water quality standard is sufficiently protective to serve as the MTCA cleanup level (MTCA Implementation Memo No. 1; Kraege 1993). Value does not account for adjustments due to background or practical quantitation limits.
c Value listed was derived from: 40 CFR 131.36, WAC 173-201A-040(3), and federal water quality criterion documents (as amended). If values conflicted, the value was selected in the following order of preference: 40 CFR 131.36 supercedes WAC 173-201A-040(3) which supercedes the federal criterion documents.
d Value listed is the lower of the chronic or acute standard for marine water.
e The standards for copper and lead are "treatment techniques." Copper and lead have action levels rather than MCLs. When applied to a purveyor of a public water supply, if the concentration measured at the tap exceeds the action level, this requires implementation of specified treatment techniques (40 CFR 261 Subpart I).
f Based on trihalomethanes.
N = Value listed is based on noncancer rather than cancer effects.
ND = Chemical was detected in Area 8 groundwater but was not detected in soil samples.

• Sediment and Tissue Monitoring

Long-term monitoring will include sampling sediments and tissues that may be impacted by groundwater discharges from Area 8. This monitoring is separate from the Area 9 confirmatory sediment sampling described in Section 11.3.

As natural restoration continues at Area 8, residual contamination may continue to be discharged into Liberty Bay for many years. Sediment and tissue monitoring will be done to assess whether these discharges accumulate over the long-term and cause impacts in Liberty Bay that may warrant implementation of groundwater control measures.

Initially, this monitoring will consist of:

- Sampling of a cluster of sediment stations in the intertidal zone adjacent to Area 8 north of Pier 1, or other places that are most likely to be affected by Area 8 groundwater.

- Sampling of bivalve tissues from stations in the intertidal zone adjacent to Area 8 north of Pier 1, or other places where bivalves are present and most likely to be affected by Area 8 groundwater.

- The sediment and tissue sampling locations will be specified in the sampling and analysis plan. The purpose of the sampling will be to assess possible future impacts attributable to Area 8, not to monitor throughout Area 9. Accordingly, the sampling locations will be selected to represent areas of greatest potential impact from Area 8 groundwater discharges.

- Bivalve species to be sampled will be specified in the sampling and analysis plan.

- Two rounds of sediment and bivalve sampling will be conducted prior to the 5-year review.

- The sampling results will be used to determine whether impacts occur in Liberty Bay that are related to contaminants from Area 8. Therefore, the samples will be analyzed for SVOCs and the following inorganic chemicals that have been used at the plating shop:

  Cadmium
  Chromium
  Copper
  Cyanide
  Gold
  Lead
  Nickel
  Silver
  Tin
  Zinc

- Analytical methods to be used will be specified in the sampling and analysis plan.

- The monitoring results will be evaluated as discussed in the groundwater controls section below.

The scope of the initial monitoring program will be amended as the data are gathered and evaluated. This may involve either expanding or reducing the number of samples or the sampling frequency, depending on the results. The need for continued SVOC monitoring will also be evaluated in the light of the groundwater monitoring results. The sediment and tissue monitoring will be continued until the groundwater complies with the surface water cleanup levels in Table 10-12 and the sediment results are satisfactory compared to the state Sediment Management Standards. Any decision to modify (e.g., addition of surface water monitoring) or discontinue the monitoring program will be subject to approval by EPA and Ecology, with input from the community.

• Groundwater Controls

This section describes how the Area 8 monitoring data will be used to determine whether groundwater control actions should be implemented at Area 8.

The data collected from the Area 8 sediment and issue monitoring program will be evaluated for human health risk using the same methodology and exposure assumptions as employed in the baseline risk assessment for Area 8. In addition, the sediment data will be evaluated for ecological risk by comparison with the Washington State Sediment Management Standards cleanup screening levels; the details of this evaluation will be specified in the sampling and analysis plan. The shellfish tissue data will also be evaluated for ecological risk using the methodology employed in the baseline risk assessment, including effects to higher trophic level organisms (i.e., English sole, pigeon guillemot). If these evaluations show unacceptable risks or exceedances of state sediment cleanup screening levels, the Navy will initiate groundwater control actions or further investigations with input from the community and concurrence by EPA and Ecology. Further investigations may include resampling to confirm chemical results and sediment bioassays tests to confirm risks prior to initiating groundwater controls.

Implementation of groundwater controls will depend on whether Area 8 groundwater is a significant source of the chemicals that cause risk in sediments or tissues. This determination will be made with EPA and Ecology concurrence considering the following factors:

- Whether or not there is a correspondence between chemicals detected in Area 8 groundwater and the chemicals causing risk in sediments or tissues.

- Adequacy of groundwater detection limits for the chemicals causing risk in sediments or tissues.

- Whether or not the chemicals causing risk in sediments or tissues are plating chemicals used at Area 8 (i.e., the inorganics listed in the previous section on sediment and tissue monitoring). If risk is due to these chemicals, groundwater controls would likely be warranted.

- Whether or not the chemicals causing risk in sediments or issues are ubiquitous compounds that could likely be due to other sources in Liberty Bay besides the base. Examples include benzoic acid, phenols, PHCs, or phthalates from sources such as septic tanks, marinas, roadways, or natural plant decay. If risk is due to such chemicals, groundwater controls may not be warranted.

If this determination indicates Area 8 groundwater to be a significant source of the risk in sediment or tissues, groundwater control actions will be initiated. The Navy may elect to initiate groundwater control actions without conducting the confirmatory sampling listed above. Selection of groundwater control actions will be subject to review and concurrence by EPA and Ecology. Examples of groundwater control measures that may be implemented may include the engineered controls described in Alternatives 3 through 8 of the FS report. The listing of these examples does not preclude other feasible actions from being proposed, approved, and implemented. Public notice and a ROD amendment or Explanation or Significant Difference (ESD) would be required should groundwater control measures prove warranted.

10.6.3 Institutional Controls

Institutional controls will be implemented to restrict residential land use at Area 8, prevent construction of potable wells, restrict construction activities, provide for long-term monitoring activities, and control physical access to the property. Once the soil removal action is completed, some of these controls will be discontinued, as discussed below.

The following institutional controls will be implemented and maintained while the Navy owns the property:

- Physical access to the property will be controlled by continued use of existing base security measures, including fencing of the entire base, pass and identification procedures, guardhouses, and security patrols. These controls may be discontinued when the soil removal action is completed.

- Land use restrictions will be imposed to disallow residential land use at Area 8. These controls will include restrictions on cultivation of homegrown produce because of cadmium in soils.

- Land use restrictions will be imposed to prevent construction of wells at Area 8 for drinking water or domestic purposes, control excavation of soils below the water table, and control groundwater discharges from construction projects (e.g., trench dewatering). The groundwater monitoring data will be used to determine when these controls can be discontinued.

- The physical access and land use restrictions will be initiated by issuing a NUWC Division, Keyport Instruction signed by the base Commander. This instrument will constitute orders to base military and civilian personnel to implement and maintain the access controls and restrictions. Implementation of the Instruction will include incorporation of its elements into the facility master plan and the capital improvements plan.

- The Instruction will also include provisions for conducting the long-term monitoring activities called for in this ROD.

- The Instruction will be prepared after this ROD is signed. Its content will be subject to review and approval by EPA and Ecology.

In the event the Navy sells or transfers the property, per 40 C.F.R. §373.1, in accordance with CERCLA section 120(h)(1), the Navy will include a notice that identifies that hazardous substances were stored on the property and were released and disposed of on the property. This notice will identify the type and quantity of such hazardous substance and the time at which such storage, release, and disposal took place. This notification will occur even if the property is transferred to another federal agency.

In addition, per CERCLA section 120(h)(3) the deed will contain specified information regarding the hazardous substances and a covenant warranting that:

1. All remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of such transfer and,

2. Any additional remedial action found to be necessary after the date of such transfer will be conducted by the United States. When the Department of the Navy reports property as excess to the General Services Administration, it is responsible for informing General Services Administration of all inherent hazards and for the expense and supervision of decontamination of the property (41 C.F.R. §1101-47.401-4).

The remedial actions necessary to protect human health and the environment at Area 8 are the following institutional controls, which will be implemented when the Navy transfers the property to a future owner:

- Restrictive covenants on the property will be recorded with the county register of deeds that are binding on the owner's successors and assignees, and that place limiting conditions on property conveyance, restrict land use, and require maintenance of physical access controls.

- The restrictive covenants for land use will disallow residential land use at Area 8, including restrictions on cultivation of homegrown produce because of cadmium in soils.

- The restrictive covenants for land use will control digging, maintenance, and construction activities at Area 8. These covenants will remain in effect until the soil removal action is completed. It will not be necessary to record these covenants if the soil removal action has been completed prior to conveyance of the property.

- The restrictive covenants for land use will prevent construction of wells for drinking water or domestic use, control excavation of soils below the water table, and control groundwater discharges from construction projects (e.g., trench dewatering). The groundwater monitoring data will be used to determine when these controls can be discontinued.

- The restrictive covenants will require the owner to implement and maintain physical access controls equivalent to existing base security measures, which may be satisfied by fencing Area 8 and posting signs. These covenants will remain in effect until the soil removal action is completed. It will not be necessary to record these covenants if the soil removal action has been completed prior to conveyance.

- Conveyance of the property will be subject to the conditions and obligations of this ROD, including long-term monitoring and contingency actions. The property restrictive covenants will require notification to environmental regulatory agencies (EPA, Ecology, or their designees) of any intent to transfer interest in the property, modify its land use, or implement construction activity, and require agency approvals for such actions. The groundwater monitoring data will be used to determine when these controls can be discontinued.

- The location of Area 8 and survey bench marks will be recorded with the county register of deeds. The extent of the property subject to restrictive covenants will also be recorded.

The institutional controls will be applied to the zone of contamination, which includes the area under the plating shop and the land between the plating shop and Liberty Bay to the south and east. Additional wells and sampling will be needed to establish the extent of the groundwater plume north and west of the plating shop. The samples will be analyzed for VOCs and plating chemicals (listed in Section 10.6.2) using standard EPA methods. The analytical methods, number and location of wells, and the details of how data will be evaluated will be documented in the sampling and analysis plan discussed in Section 12.4.2.

10.6.4 Cost

The estimated life cycle cost of the selected remedial actions for Area 8 is shown in Table 10-13, based on a life cycle of 30 years and a net discount factor of 5 percent. Table 10-13 provides a breakdown of the major capital, operating, and maintenance cost items that contribute to the overall life cycle cost.

Table 10-13
Estimated Costs for Selected Remedial Actions, Area 8

A. CAPITAL COSTS	Estimated Cost, $
DIRECT CAPITAL COSTS:	
Monitoring Wells & Borings	66,000
Building Demolition	138,000
Vadose Soil Excavation	196,000
Off-site Soil Treatment & Disposal	3,380,000
Subtotal, Direct Costs:	3,780,000
INDIRECT CAPITAL COSTS:	
Engineering, legal administration (20% of direct costs)	756,000
Contractor overhead and profit (25% of direct costs)	945,000
SUBTOTAL, INDIRECT COSTS:	1,701,000
TOTAL PROJECT CAPITAL COST:	
Total direct and indirect capital costs	5,481,000
Contingency (30%)	1,644,000
SUBTOTAL, PROJECT CAPITAL COST	7,125,000
B. OPERATING & MAINTENANCE COSTS	Annual Cost, $/yr
Monitoring, Years 1-3	91,000
Monitoring, After 3 yrs	54,000
Well Maintenance	3,700
C. LIFE CYCLE COST (30 years at 5% net discount rate)	Present Value, $
Present Value of Project Capital Cost	7,125,000
Present Value of O&M Cost	1,052,000
TOTAL PRESENT WORTH	8,177,000

Note: The costs shown above were based on FS assumptions.

11.O SUMMARY OF INVESTIGATION FOR AREA 9

This section presents a summary of the RI/FS for Area 9.

11.1 SUMMARY OF SITE CHARACTERISTICS

This section presents a summary of site characteristics, including a discussion of the physical characteristics and the nature and extent of contaminants.

11.1.1 Site Description

Area 9 includes approximately 5,000 feet of shoreline around NUWC Division, Keyport, including nearshore areas around the two large, industrial piers. Since inception of Naval activities at Keyport in 1915 until about 1980, a variety of wastes was reportedly discharged to Liberty Bay through sewers or other means. Principal contributors causing discharges may have included the former sewage treatment plant (near Area 5), the plating shop (Building 72 at Area 8), various stone sewers (especially one in the industrial area at the east end of First Street north of Area 8), and from the pier areas (SCS Engineers 1984).

Historical discharges to Liberty Bay reportedly included chromium, cadmium, copper, nickel, lead, zinc, magnesium chips, methyl ethyl ketone, trichloroethane, trichloroethene, carbon tetrachloride, strippers, cyanide, styrene, methylene chloride, coal pile leachate, hydrochloric acid, oil, paint thinners, carbon-zinc and lead batteries, and sandblasting residue. Total discharge quantities were estimated to be 30 tons of metal and cyanide wastes, 80,000 gallons of strippers, thinners, and solvents, 150,000 gallons of waste paint, 150,000 to 450,000 pounds of paint residues, and an unknown quantity of waste Otto fuel (SCS Engineers 1984).

11.1.2 Physical Characteristics

The bottom slope of Liberty Bay near NUWC Division, Keyport, from the shore to a 30-foot depth, ranges from moderate (10.5 percent) off the northern shore, to gentle (1.5 percent) off the shore near the shallow lagoon. The deepest part of Liberty Bay offshore of NUWC Division, Keyport is 72 feet in the axis of the bay off the southern shore. The depth of the axis becomes shallower to the northwest, reaching about 40 feet between Keyport and Lemolo.

Currents in the Keyport area are tidally driven, but some wind-driven flow also occurs, depending upon wind speed and direction. Peak current speeds up to 1.3 knots occur in various parts of Liberty Bay, including the "S-shaped" channel around Keyport (Roats Engineering 1970). Scouring by currents, particularly in this channel, apparently maintains the broad areas of coarse-grained sediments. Lower current speeds at both ends of the channel and along the central axis to the north result in fine-grained depositional environments.

Gravel and sand constitute greater than approximately 80 percent (by weight) of sediment samples collected in Liberty Bay. A relatively high-energy (coarse-grained) zone parallels the shoreline 1,000 feet north of Pier 1 to at least 2,000 feet south of the pier. Much of this zone is intertidal and consists of cobble overlying fine sand or silt/clay. A second high energy zone was observed in the narrow, central channel of Liberty Bay north of the Keyport peninsula. This zone consists largely of cobble, sand, and/or shell debris. Two small, relatively low-energy (depositional) zones occur immediately adjacent to and south of Piers 1 and 2. These zones contain chemically reduced, low-shear-strength mud and likely represent areas of long-term, fine grained deposition. Sediment from just south of Pier 1 is particularly unconsolidated and fine grained.

11.1.3 Nature and Extent of Contaminants

Media sampled at Area 9 during the RI include marine surface water, marine sediment, and marine shellfish tissue. The nature and extent discussion considers only those chemicals that are major contributors to human health or ecological risks, or that exceed one or more ARARs. These chemicals are considered to be chemicals of concern and are listed in Table 11-1 with a summary of results.

- Marine Surface Water.

No chemicals were identified in surface water having ARAR exceedences or constituting major contributors to human health or ecological risk.

- Marine Sediment

Cyanide was detected in 1 of 21 sediment samples at an estimated concentration from the intertidal zone near Area 8.

Four semivolatile organic compounds (benzoic acid, phenol, bis(2-ethylhexyl)phthalate, di-n-octylphthalate) were detected in Liberty Bay sediment at concentrations above Washington Sediment Management Standards quality criteria. These semivolatile organic compounds are readily biodegraded, and are widespread in the marine environment of Puget Sound (PSEP 1991, URS 1993a).

Sediment toxicity tests conducted at one station in Liberty Bay exceeded Washington Sediment Management Standards cleanup criteria.

- Marine Shellfish Tissue

Zinc was found in two tissue samples at just above the background value as an ecological risk contributor, and with no apparent distribution trend. Pentachlorophenol was detected in one tissue sample, at a station northwest of Pier 2, and was not detected in associated sediments. Pentachlorophenol is a common wood preservative; its source could be pilings for the piers or other wooden structures near the shore.

Table 11-1
Area 9 - Major Risk Contributors and ARAR-Exceeding Chemicals

Chemical	Number of Samples	Number of Detections Above Background	Background Concentration	Range of Detects Above Background: Minimum	Range of Detects Above Background: Maximum	Major Risk Contributor: Human Health	Major Risk Contributor: Ecological	Exceeds ARAR
MARINE SEDIMENT-LIBERTY BAY (<10 cm)								
Inorganic Chemical (mg/kg)								
Cyanide	21	1	NV	2.0	2.0		*	
Semivolatile Organic Compounds (mg/kg)								
Benzoic Acid	66	12	NV	0.10	0.81		*	*
bis(2-Ethylhexyl)phthalate	66	13	NV	0.09	19		*	*
Phenol	66	7	NV	0.13	0.76			*
MARINE SEDIMENT - LIBERTY BAY (≥10 cm)								
Semivolatile Organic Compound (mg/kg)								
Di-n-octylphthalate	18	1	NV	1.3	1.3		*	*
bis(2-Ethylhexyl)phthalate	18	5	NV	0.12	3.7		*	*
MARINE TISSUE - LIBERTY BAY (P. stamtrea [Deperated])								
Inorganic Chemicals (mg/kg)								
Zinc	17	2	13.43	15	16		*	
Semivolatile Organic Compounds (mg/kg)								
Pentachlorophenol	17	1	NV	4.3	4.3		*	

NV = No Value
ARAR = applicable or relevant and appropriate requirement
NOTE: Major risk contributors identified as follows:
Human Health: Chemical contributes at least 1 x 10-5 excess cancer risk or 0.1 hazard quotient to combined RME risk for scenarios with unacceptable risk, as evaluated in Human Health Risk Assessment.
Ecological: Identified in Ecological Risk Assessment as a risk driver.

11.2 SUMMARY OF SITE RISKS

The following sections summarize human health and ecological risks.

11.2.1 Human Health Risks

This section presents a summary of contaminant identification, exposure assessment, toxicity assessment, and risk characterization for Area 9.

- Initial Contaminant Identification

As a result of the preliminary risk-based screening conducted for Area 9 samples, the following are judged to be human health COPCs at Area 9:

  - Marine Water: chromium, copper, lead, PGDN
  - Marine Sediment: lead, mercury, phenanthrene
  - Marine Tissue: arsenic, cobalt, copper, lead, manganese, mercury, bis(2-ethylhexyl)phthalate, pentachlorophenol

- Exposure Assessment

Surface runoff from industrial areas at NUWC Division, Keyport, as well as point-source discharges (e.g., from outfall pipes) and inflow of contaminated surface and groundwater from other areas on the station (e.g., Area 5, Area 8) may have contributed chemicals to Liberty Bay surface waters. Current and future visitors and future residents in areas adjacent to Liberty Bay may be exposed to these COPCs while swimming in Liberty Bay (through ingestion or dermal contact). Although hazardous constituents were probably introduced to receiving waters in a dissolved form, many organic compounds and trace metals have a strong tendency to sorb to particulate surfaces in an aqueous medium (particularly as the salinity of that medium increases). Therefore, constituents of concern would likely be found in marine sediment near the sources. Current and future visitors and future residents near Liberty Bay could be exposed to contaminants via incidental ingestion of marine sediment and/or dermal contact.

Filter-feeding organisms (e.g., clams) may directly ingest contaminated particulate materials and sediment. Current and future visitors to Liberty Bay and future residents in the area could be exposed to COPCs by ingestion of shellfish. In addition, subsistence fishing occurs in Liberty Bay.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.1.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Tables 11-2 and 11-3 summarize the risk characterization results for Area 9. More detailed risk characterization information is provided in Appendix F of the human health risk assessment (URS 1993c).

Current Land Use. The RME excess cancer risk for current visitors to Area 9 is 2 x 10-5. The major pathway contributing to this risk is ingestion of chemicals in fish/shellfish (pentachlorophenol - 1 x 10-5, arsenic - 3 x 10-6, and bis[2-ethylhexyl]phthalate - 2 x 10-6). The RME excess cancer risk for current and future subsistence fishermen is 4 x 10-5, due to the presence of the same three chemicals in shellfish (pentachlorophenol - 3 x 10-5, arsenic - 7 x 10-6, bis[2-ethylhexyl]phthalate - 5 x 10-6). No occupational exposure pathways have been postulated for this area.

Noncancer risk for current land use is low.

Future Land Use. The RME excess cancer risk for future residents and visitors near Area 9 is 2 x 10-5. The major contributor to this risk is the shellfish ingestion pathway (pentachlorophenol - 1 x 10-5, arsenic - 3 x 10-6, and bis[2-ethylhexyl]phthalate - 2 x 10-6).

Noncancer risk for future land use is low.

Table 11-2
Summary of Risk Results
Area 9 - Current Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Current Visitors				
Ingestion of chemicals in surface water while swimming	-	-	4E-6	2E-6
Ingestion of chemicals in marine sediment	-	-	-	-
Ingestion of chemicals in fish/shellfish	2E-5	6E-7	0.05	0.006
TOTAL	2E-5	6E-7	0.05	0.006

Table 11-3
Summary of Risk Results
Area 9 - Future Land Use

Pathway	Cancer Risk RME	Cancer Risk Average	Hazard Index RME	Hazard Index Average
Future Residents				
Ingestion of chemicals in surface water while swimming	-	-	4E-6	2E-6
Ingestion of chemicals in marine sediment	-	-	-	-
Ingestion of chemicals in fish/shellfish	2E-5	6E-7	0.05	0.006
TOTAL	2E-5	6E-7	0.05	0.006
Future Visitors				
Ingestion of chemicals in surface water while swimming	-	-	4E-6	2E-6
Ingestion of chemicals in marine sediment	-	-	-	-
Ingestion of chemicals in fish/shellfish	2E-5	6E-7	0.05	0.006
TOTAL	2E-5	6E-7	0.05	0.006
Subsistence Users				
Ingestion of chemicals in fish/shellfish	4E-5	3E-6	0.1	0.03

Note on scientific notation: Throughout this and similar tables, scientific notation is used to express very small numbers. An example of scientific notation is "2E-5." This is a shorthand way of writing "2 x 10-5" which is itself a shorthand way of expressing the fraction 2/100,000 or "0.00002."

In terms of cancer risk, "2E-5" means "two additional chances in one hundred thousand." Similarly, the scientific expression "3E-4" means "three additional chances in ten thousand."

11.2.2 Ecological Risks

- Initial Contaminant Identification

As a result of the evaluation conducted for Area 9 samples, the following are judged to be ecological risk COPCs:

  - Surface water: PGDN

  - Sediment: cyanide, benzoic acid, di-n-octylphthalate, bis(2-ethylbexyl)phthalate, and phenol

  - Shellfish Tissue: copper, lead, selenium, zinc, benzoic acid, and pentachlorophenol

- Exposure Assessment

Area 9 includes approximately 5,000 feet of shoreline around the NUWC Division, Keyport peninsula, plus nearshore areas around Piers 1 and 2. The diverse biological resources of Liberty Bay are influenced by the variety of substrate types and tidally influenced habitats. Macroalgae assemblages appear to be dominated by brown and green algal species, particularly Ulva spp., in many of the intertidal mud/cobble areas along the northern and eastern margins of the site. Seagrass (the eel grass Zostera marina) occurs in relatively sparse beds across the channel from the facility but was not observed along the border of the facility. Unidentified flatfish and Cancer crabs were observed within the beds.

The intertidal and subtidal shoreline of Liberty Bay at NUWC Division, Keyport provides a mixture of substrates including areas of mud and sand, more cobbly areas, and mixtures of finer and coarser material. Additional hard substrate is provided by rocks scattered over the bottom and pier pilings. Common benthic invertebrates in the area include clams such as the native littleneck, Japanese littleneck (Tapes japonica), butter clam, mud clam, and cockle, glycerid and nereid polychaetes; gammarid amphipods; ghost shrimp (Callianassa sp.); mud shrimp; sea cucumbers (Parastichopus sp.); and sea pens (Ptilosarcus gurneyi) (Michael A. Wert and Associates 1985; Washington Department of Fisheries unpublished data).

Common hard-substrate invertebrates are sea anemones (Metridium sp. and Anthopleura sp.); starfish such as the sun star (Pycnopodia helianthoides), Pisaster brevispinus, and P. ochraceus; mussels (Mytilus edulis); oysters (Crassostrea gigas); tunicates (Corella sp.); barnacles (Balanus spp.); and crabs such as the red rock crab (Cancer productus), C. gracilis, and (intertidally) the purple shore crab (Hemigrapsus nudus). A boring bivalve, the rough piddock (Zirfaea pilsbryi), occurs in hard-packed silts and clays in the area.

Common bottom fish in this habitat are English sole, rock sole, starry flounder, speckled sanddab, Pacific staghorn sculpin, plainfin midshipman (Porichthys notatus), spiny dogfish, whitespotted greenling (Hexagrammos stelleri), and copper rockfish (Sebastes caurinus) (Miller 1988; Washington Department of Fisheries unpublished data). Three species of surfperch (shiner perch, striped surfperch, and pile perch) are common in the area and feed primarily on invertebrates attached to pilings, rocks, and other hard substrate. The NUWC Division, Keyport shoreline supports little eel grass and is therefore probably not an important spawning area for Pacific herring, although herring spawning habitat occurs elsewhere in Liberty Bay. The presence of large gravel and cobble over much of the beach in this area generally precludes use by surfsmelt for spawning (Michael A. Wert and Associates 1985). Natural runs of chum salmon and enhanced runs of chinook and coho salmon in the area have supported a commercial fishery since 1988. Outmigrating juvenile salmon feed on invertebrates in the area.

Common birds of the area include mallards, Canada geese, scoters, gulls, pigeon guillemots, great blue herons, willets, godwits, and sandpipers. Ospreys, bald eagles, peregrine falcons, and marbeled murrelets have also been observed in the area.

No breeding populations of marine mammals are reported for the Liberty Bay area (Michael A. Wert and Associates 1985). Harbor seals (Phoca vitulina), California sea lions (Zalophus californiensis), harbor porpoise (Phocaecna phocaena), and river otters (Lutra canadensis) have been observed in the area.

The distribution and characterization of sediments is strongly influenced by current mixing and transport. Four benthic zones have been delineated for Area 9: two low-energy depositional zones and two high-energy depositional zones. The small relatively low-energy zones occur immediately adjacent to and south of Piers 1 and 2. These zones contain reduced, low-shear strength mud, and likely represent areas of long-term fine-grained deposition. Some samples near Pier 2 included thick algal mats and debris (rags, glass bottles, and metal cans), and exhibited sulfide and petroleum odors. Sediments from just south of Pier 1 were particularly unconsolidated and fine-grained.

One of the relatively high-energy zones parallels the shoreline from 1,000 feet north of Pier 1 southward at least 2,000 feet. Much of this zone is intertidal and consists of cobbles overlying fine sand and silt-clay.

Common green algae (primarily Ulva spp.) and brown algae were observed. Sand ripples were noted, indicating strong currents. A second high energy zone was observed in the narrow, central channel of Liberty Bay north of the Keyport peninsula. This zone consists largely of cobbles, sand, and shell debris.

- Risk Characterization

The toxic effects of the COPCs on the representative receptor population (as discussed in Section 6.2.3) were combined with the results of the exposure assessment to arrive at the risk characterization. Based on chemical concentrations, sediments to be tested for toxicity were collected from one station (LB51) located offshore from the northeast corner of the NUWC Division, Keyport facility (Figure 11-1), and the results from these tests were intended to represent the entirety of Area 9. Station LB51 was chosen because it was judged to represent a "worst case" based on results of chemical analyses. Although the principal COPCs present at this station, benzoic acid and bis(2-ethylhexyl)phthalate, are ubiquitous and ephemeral in nature, the failure of the acute toxicity tests may indicate the possible accumulative effects of these or other contaminants that may put organisms in the area of station LB51 at risk.

Based on the weight-of-evidence, there is potential risk to the ecosystem in Area 9. However, based on current data, it is not believed that these risks are related to present Area
8 sources.

11.3 NEED FOR REMEDIAL ACTION

No significant human health risks were identified for Area 9. The ecological risk assessment identified a potential for adverse environmental effects based primarily on the toxicity observed for one of three bioassay test organisms for sediment station LB51 (see Figure 11-1). There is some uncertainty associated with these results, because it is thought that the adverse effects in the bioassay might be attributable to natural causes rather than toxic contaminants. Nonetheless, the existing data indicate that the apparent ecological risk is low and of limited extent, so active cleanup actions do not appear to be warranted for Area 9 and no remedial alternatives have been considered. However, because the bioassay data are limited and there is uncertainty regarding one of the organisms employed in the tests, additional sediment sampling is warranted to better quantify the nature and extent of the apparent risk at LB51.

Based on consideration of CERCLA requirements, the baseline risk assessment, and public comments, the Navy, EPA, and Ecology have determined that the most appropriate remedy for Area 9 is no action. The evaluation of risks associated with Area 9 indicated that no remedial actions appear to be necessary for this portion of OU 2 to ensure adequate protection of human health and the environment. Because of the uncertainties at station LB51, confirmatory sampling will be conducted to verify that possible ecological risk in Area 9 sediments is of limited extent and that a no-action conclusion is appropriate. If the results indicate a problem, Area 9 will be reevaluated.

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Community acceptance was assessed in the context of the preferred alternative presented to the public in the proposed plan and the public meeting. Based on comments received on the proposed plan during the public comment period, as summarized in Appendix A, the preferred alternative (limited sediment sampling to confirm no action) appears to be acceptable to the community.

The following paragraphs describe the major elements of the confirmatory sampling and how these new data will be interpreted. After this ROD is signed, further details of the confirmatory sampling program will be developed by preparation of a sampling and analysis plan, with input from the community and concurrence by EPA and Ecology.

The confirmatory bioassay analysis will be performed on sediment samples taken in the immediate vicinity of RI sediment station LB51, where bioassay results have indicated the sediment may pose some ecological risk. Samples will be collected from four stations near LB51. One station will be at LB51, and three others will be spaced approximately 200 feet north, south and east of LB51. Samples will be collected from each station for bioassay testing. The bioassays will be performed with the same test species as were used in the RI, except that the amphipod Ampelisca abdita will be used in place of Rhepoxynia abronius. The reason for this change is to reduce uncertainty associated with Phepoxynia abronius, which is known to exhibit high mortality in fine-grained sediments like those at station LB51. Samples will also be collected from each station for possible chemical analysis. The sediment chemistry samples will be collected at the same time as the bioassay samples, and will be archived pending the results of the bioassays.

The sediment data will be compared with the state Sediment Management Standards cleanup screening levels to determine whether a no-action decision is appropriate. For this purpose, the sediment results will be evaluated as follows:

- The four sampling stations will be considered to be contiguous and comprise a station cluster for purposes of applying the Washington State Sediment Management Standards cleanup screening levels.

- The bioassay results for the three stations that have the highest level of biological effects will be compared with the cleanup screening levels defined in WAC 173-204-520(3). If less than three of the stations exceed the cleanup screening levels, the no-action decision for Area 9 will be considered confirmed. If all three stations exceed the cleanup screening level, the archived samples will be analyzed for chemical constituents.

- Analysis of the archived sediment chemistry samples will include the target compounds specified in the state sediment management standards for cleanup screening levels (WAC 173-204-520, Table 3) that are in effect when this ROD is signed. The analytical methods will be specified in the sampling and analysis plan, with review and concurrence by EPA and Ecology.

- For each target compound analyzed pursuant to the cleanup screening levels, the results for the three stations within the cluster that have the highest concentrations will be averaged. In general, the three stations with the highest concentrations may differ depending on the specific target compound under consideration.

- If the three-station average concentration does not exceed the cleanup screening level for any of the target compounds, the no-action decision for Area 9 will be considered confirmed.

- If the three-station average concentration for a particular target compound exceeds the corresponding cleanup screening level, the cluster will be designated as a station cluster of potential concern.

If the cluster is designated as a station cluster of potential concern, the Area 9 sediment data will be compared with the Area 8 groundwater monitoring data (in the manner discussed in Section 12.4.2) to determine whether any of the chemicals that cause the cluster to exceed the sediment cleanup screening levels have also been detected in the Area 8 groundwater. If this assessment shows a correspondence between chemicals detected in groundwater and chemicals of concern in sediments, initial action will be taken in the form of further investigation to demonstrate a positive link between contaminants in groundwater and sediments. This may include:

- Sediment and groundwater resampling to confirm the chemical and bioassay results.

- Additional sediment sampling stations, in concurrence with EPA and Ecology.

- Evaluation of the additional sediment chemical and bioassay data in accordance with the hazard assessment procedures of WAC 173-204-530.

If the assessments described above show no correspondence between chemicals detected in Area 8 groundwater and chemicals of concern in the sediment cluster, no further groundwater control measures would be required for Area 8 as related to LB51 confirmatory sampling.

If a positive link is confirmed, the Navy, EPA, and Ecology will reevaluate Area 9 to determine what further action should be taken with respect to the LB51 sediment cluster; this may include:

- Addition of LB51 stations to the long-term sediment monitoring program discussed in Section 10.6.2.

- Further sampling if necessary to delineate the extent of the contamination associated with the sediment cluster, and obtain appropriate chemical and other data as needed to evaluate restoration alternatives.

- Evaluation of restoration alternatives, including natural recovery as well as active cleanup measures. This evaluation would follow Washington State Sediment Management Standards regulations (WAC 173-204-560) and corresponding guidance.

- Selection and implementation of restoration actions.

In the evaluation procedures described above, confirmation of the no-action decision refers to all actions except for possible additional sampling of Area 9. If these evaluations confirm the no-action decision, the need for additional Area 9 sampling will be assessed by comparing the sediment data for the LB51 cluster with the sediment quality standards (SQS) of the state Sediment Management Standards. This assessment will include:

- The sediment data will be assessed according to the SQS designation procedures of WAC 173-204-310 and WAC 173-204-510.

- If these procedures designate the LB51 cluster as passing the SQS, no additional Area 9 sampling will be required and it will not be necessary to include Area 9 in the 5-year review of OU 2.

- If the LB51 cluster does not pass the SQS and is designated under WAC 173-204-510 as a "station cluster of low concern," additional Area 9 sampling may be conducted with concurrence by Ecology and EPA. This additional sampling will not be dependent upon establishing a correspondence between chemicals of concern in the sediment and chemicals detected in Area 8 groundwater. In deciding whether additional Area 9 sampling is warranted, consideration will be given to whether or not the base is a likely or significant source of the chemicals that exceed the SQS, and whether these chemicals are ubiquitous compounds that could reasonably be derived from other sources in Liberty Bay such as septic tanks, road runoff and marinas, and natural plant decay. lf sediment risk appears to be due to ubiquitous compounds from bay-wide sources, it may be more appropriate to conduct further sampling and investigation of Liberty Bay under a separate program outside the scope of this ROD, such as the state's Urban Bay Action Program.

12.O STATUTORY DETERMINATIONS

This section describes how the selected remedy meets the statutory requirements of CERCLA Section 121, which:

- Requires, as a primary goal, that the selected remedy must achieve adequate protection of human health and the environment.

- Specifies that when complete, the selected remedial action must comply with applicable or relevant and appropriate requirements (ARARs) established under federal and state environmental laws unless a statutory waiver is justified.

- Requires that the selected remedy must be cost-effective.

- Specifies that the selected remedy must utilize permanent solutions and treatment or resource recovery technologies to the maximum extent practicable.

- Includes a preference for selecting remedies that employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element of the remedial actions.

Compliance with each of these statutory requirements is described in the following sections. The discussion is arranged by Area because the selected remedial actions and statutory determinations are Area-specific. In accordance with EPA guidance, no discussion is included for those Areas for which it has been determined that no action is needed to ensure protection of human health and the environment.

12.1 STATUTORY DETERMINATIONS FOR AREA 2

<u>12.1.1 Protection of Human Health and the Environment</u>

The selected remedy for Area 2 will protect human health and the environment by preventing potable use of the groundwater via institutional controls, and monitoring groundwater to ensure that concentrations decrease over tune as expected.

Chemicals detected at Area 2 do not threaten the environment but pose potential harm to human health if the shallow groundwater were used for domestic purposes such as drinking and showering. The health risks to future residents are estimated to be close to EPA's acceptable exposure level (i.e., excess cancer risk of 10-4). Currently used drinking water resources are not threatened. The health risk to future residents is caused by vinyl chloride in groundwater. In addition, groundwater concentrations exceed drinking water standards for vinyl chloride and trichloroethene. The groundwater contamination is relatively low (less than 8 times the drinking water standards) and its extent appears to be limited to a relatively small area (centered at monitoring well 2MW-1).

Confirmatory groundwater sampling will be used to check for possible sources upgradient of 2MW-1, and ensure that the contamination is of limited extent. If a significant source is found, the Navy will reevaluate Area 2 for additional study or action, in concurrence with EPA and Ecology.

Protection of human health will be accomplished through the use of institutional controls to prevent future residential use of the site and construction of potable water wells. Groundwater quality is expected to gradually improve by the action of natural processes such as aquifer flushing, volatilization, and biodegradation. Institutional controls will be maintained until such time that nature restores the site. Groundwater monitoring will be used to verify that conditions improve as expected, and to warn of the need for additional study or actions if risks happen to increase instead of diminishing.

12.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all chemical-, location-, and action-specific ARARs that have been identified for the site. The principal ARARs are briefly described below. No waiver for any ARAR is being sought for any component of the remedy.

- Chemical-Specific ARARs

  - The State of Washington Hazardous Waste Cleanup - Model Toxics Control Act (MTCA; Chapter 70.105D RCW) establishes requirements for the identification, investigation, and cleanup of facilities where hazardous substances have come to be located as codified in Chapter 173-340 WAC. Soil and groundwater cleanup standards established under MTCA are applicable for determining remediation areas and volumes and compliance monitoring requirements, and are relevant and appropriate for determining treatment standards.

  - 40 C.F.R §§141, 142, and 143; and WAC 246-290-310, which establish federal and state drinking water standards applicable to public water supplies, are relevant and appropriate for groundwater that may be a drinking water source.

- Location-Specific ARARs

  - The Wetland Protection Act (Federal Executive Order 11990, 40 C.F.R. Part 6, Appendix A) is applicable to actions that may affect the wetlands near Area 2.

  - The Endangered Species Act (16 U.S.C. 1531 promulgated by 33 C.F.R. §§320-330) is applicable to actions that may affect essential habitat of threatened or endangered species. The ecological risk assessment listed the bald eagle, the marbled murrelet, and the peregrine falcon as threatened or endangered species occasionally observed at the base.

- Action-Specific ARARs

  - RCRA regulations 40 C.F.R. §§264.116 and 117, which specify survey requirements and deed restrictions for facilities where hazardous wastes remain after closure, are relevant and appropriate.

  - MTCA regulation WAC 173-340-440, which specifies survey requirements and deed restrictions for cleanup sites where hazardous substances will remain above cleanup levels following remedial actions, is applicable.

  - MTCA regulations WAC 173-340-360 and -410 are applicable; these require that long-term monitoring and institutional controls be implemented if on-site disposal, isolation, or containment is the selected remedy for a site or a portion of a site and be maintained until residual hazardous substance concentrations no longer exceed cleanup levels.

  - State of Washington water well regulation WAC 173-160, which specifies standards for construction and maintenance of wells, is applicable to the monitoring wells.

  - The State of Washington requirements for Hazardous Waste Operations and Emergency Response, as set forth in WAC 296-62 (Part P) are applicable to employees involved in the cleanup operations for Area 2 (e.g., installation and sampling of the monitoring wells).

12.1.3 Cost Effectiveness

The selected remedy is the lowest cost alternative which is protective of human health and the environment. The extra costs associated with the treatment technologies used in the remaining alternatives are disproportionate compared with the benefits that would be gained using treatment. The lowest cost treatment alternative (Alternative 3) would cost about 10 times more than the selected remedy and is not expected to attain a permanent solution in a reasonably short time. Alternatives 5 and 6 appear best suited to quickly restoring the groundwater, but would be more than 30 times more expensive than the selected remedy.

12.1.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practical

The selected remedy (Alternative 2) represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for Area 2. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume achieved through treatment. Detailed discussion of these tradeoffs is given in Section 7.5 (comparative analysis of alternatives). The major considerations and tradeoffs that provide the basis for this selection are:

- Short-term effectiveness: the selected remedy will have negligible short-term impacts to human health and the environment because the only construction activity will be installing monitoring wells. The remaining alternatives include treatment to reduce contamination, but would pose risks to workers and likely cause short-term environmental impacts to the wetlands at Area 2. The degree of these risks and potential impacts increase as the degree of treatment is increased in the various alternatives (e.g., Alternative 3 provides the least degree of treatment soil vapor extraction of only the vadose zone soils - but would also have the least impacts to the wetlands).

- Long-term effectiveness and permanence: the selected remedy is not expected to restore the groundwater to drinking water quality in a short time frame, and therefore its long-term effectiveness for preventing risks will be reliant on maintaining institutional controls. The remaining alternatives, which all include treatment, should theoretically provide better long-term effectiveness by attaining a permanent solution in a shorter time, but very long treatment times are typically required at other CERCLA sites to achieve drinking water standards for compounds such as trichloroethene. Alternative 5 (dewatering with soil vapor extraction) and Alternative 6 (in-situ steam stripping) have the best chance of meeting drinking water standards in a short time, but their effectiveness at this site is unproven and drinking water goals may be difficult to achieve in the field.

- Cost: the selected remedy is the most cost-effective approach, as discussed in Section 12.1.3.

The selected remedy will address the risks identified at Area 2 by implementing institutional controls to restrict residential and groundwater use. This action can be readily implemented in a short time, will cause no short-term impacts to human health and the environment, and has low cost compared to other options. Alternatives 5 and 6 utilize treatment processes that could theoretically provide a permanent solution in a reasonable time frame, but they are not considered practical since the cost of either would be several orders of magnitude greater than the selected remedy, their actual effectiveness for meeting drinking water goals is not proven, and they would likely cause short-term environmental damage to the adjacent wetlands during remediation. In view of these considerations, the relatively low contaminant concentrations at the site, and the lack of current risks, the selected remedy is determined to be the most appropriate solution for the groundwater contamination at Area 2.

12.1.5 Preference for Treatment as a Principal Element

The selected remedy does not include treatment and thus will not meet the statutory preference for selecting remedial actions that employ treatment technologies as a principal element to permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances posing risks. This preference will not be met because it is not practical or cost-effective to treat the low concentrations of trichloroethene and vinyl chloride in the Area 2 groundwater. A variety of treatment alternatives were evaluated and judged to be impractical for this site, for the reasons discussed in the previous section.

12.2 STATUTORY DETERMINATIONS FOR AREA 8

12.2.1 Protection of Human Health and the Environment

The selected remedy for Area 8 will protect human health and the environment by removing soil hot spots from the vadose zone to reduce risks to future residents and to reduce the source of groundwater contamination, using institutional controls to prevent future groundwater use, and monitoring groundwater to determine the effectiveness of hot spot removal and to ensure that contaminants do not migrate downward toward the deep aquifer.

The baseline risk assessment concluded that contamination at Area 8 does not pose significant risks to current workers or ecological receptors. The major health risks at Area 8 are to future residents from ingestion of vegetables grown in the soil, and from potable use of the groundwater. These risks are eliminated to be above EPA's acceptable exposure levels (i.e., excess cancer risk of 10-4 and noncancer HI of 1). Several VOCs and metals in groundwater also exceed drinking water standards. In addition, cadmium and chromium in the soil exceed state cleanup standards based on residential soil ingestion.

Prior to soil removal, institutional controls will be used to prevent the exposures of concern to future residents by excluding residential use of the property. Removal of hot spots from the vadose zone to achieve MTCA Method B soil cleanup levels will eliminate the risk posed by direct contact exposures to soil contaminants. However, institutional controls will still be needed to restrict groundwater use.

The groundwater quality is expected to gradually improve over time due to natural attenuation mechanisms such as aquifer flushing, elemental fixation of metals into the mineral structure of the soil, and biodegradation of VOCs. The soil removal action will facilitate these natural processes by removing chemicals from the vadose zone that may otherwise act as long-term sources of groundwater contamination. Groundwater monitoring will be used to ensure the groundwater quality does not deteriorate, that the plume is not expanding, and to determine when institutional controls can be discontinued. Because many of the VOCs detected in groundwater have pure-phase densities greater than water, there is potential for downward migration (i.e., if dense chlorinated solvents are present as a separate liquid phase). There are upward hydraulic gradients in the water table aquifer and an aquitard below the site which hinder downward migration. Groundwater monitoring will include wells screened below the present plume to check for possible downward migration and to warn if additional measures are needed.

Because Area 8 groundwater discharges into Liberty Bay, there is a potential for migration of chemicals in the groundwater to cause future risks in the offshore marine environment. Contaminants were detected in some of the Area 8 seep samples at concentrations that exceed surface water quality criteria, but no exceedances were identified in Liberty Bay surface water. No current health or ecological risks have been identified in Liberty Bay surface water and sediment in the immediate vicinity of Area 8. Sediments may pose moderate ecological risk at sample station LB51 north of Area 8, based on failure of one of three test species in bioassay testing. However, the risk at LB51 appears to be of limited extent, and available chemistry data indicate this risk is not related to contaminants in Area 8 groundwater. The lack of impacts in Liberty Bay is likely due to high dilution rates from tidal currents in Liberty Bay offshore of Area 8. Since no significant impacts due to Area 8 groundwater are evident, engineered groundwater controls are not necessary at the present time.

Confirmatory sampling in Liberty Bay will be used to ensure that the apparent risk at LB51 is not related to Area 8 groundwater. As discussed above, the groundwater quality is expected to gradually improve due to natural attenuation enhanced by the soil removal action. Groundwater, sediment, and shellfish tissue monitoring will be used to monitor the situation to ensure that additional actions are taken in a timely fashion if warranted.

12.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all chemical-, location-, and action-specific ARARs that have been identified for the site. The principal ARARs are briefly described below. No waiver for any ARAR is being sought for any component of the remedy.

- Chemical Specific ARARs

  - The State of Washington Hazardous Waste Cleanup - Model Toxics Control Act (MTCA; Chapter 70.105 RCW) establishes requirements for the identification, investigation, and cleanup of facilities where hazardous substances have come to be located as codified in Chapter 173-340 WAC. Soil and groundwater cleanup standards established under MTCA are applicable for determining remediation areas and volumes and compliance monitoring requirements, and are relevant and appropriate for determining treatment standards.

  - 40 C.F.R. §§141, 142, and 143; and WAC 246-290-310, which establish federal and state drinking water standards applicable to public water supplies, are relevant and appropriate for groundwater that may be a drinking water source.

  - The State of Washington Water Pollution Control Act (Chapter 90.48 RCW) establishes water quality standards for surface waters of the state of Washington as codified in Chapter 173-210A WAC. This regulation specifies that toxic substances (as defined in the regulation) shall not be introduced above natural background levels in waters of the state which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic toxicity to the most sensitive biota dependent upon those waters, or adversely affect public health. These regulations are applicable to the marine waters off Area 8.

- State of Washington sediment management regulations (WAC 173-204), which establish state sediment quality and cleanup standards, are applicable to sediments downgradient from Area 8.

- Location-Specific ARARs

  - Federal Coastal Zone Management Act (16 U.S.C. 1451) and the state of Washington shoreline management regulations (WAC 173-14, 16, and 22) are applicable; these require that activities that affect the coastal zone and adjacent shorelands must be consistent to the maximum extent practicable with state shoreline management land use designations, policies, and goals.

- Action-Specific ARARs

  - RCRA regulations 40 C.F.R. §§264.116 and 117, which specify survey requirements and deed restrictions for facilities where hazardous wastes remain after closure, are relevant and appropriate.

  - MTCA regulation WAC 173-340-440, which specifies survey requirements and deed restrictions for cleanup sites where hazardous substances will remain above cleanup levels following remedial actions, is applicable.

  - MTCA regulations WAC 173-340-360 and -410 are applicable; these require that long-term monitoring and institutional controls be implemented if on-site disposal, isolation, or containment is the selected remedy for a site or a portion of a site and be maintained until residual hazardous substance concentrations no longer exceed cleanup levels.

  - State of Washington water well regulation WAC 173-160, which specifies standards for construction and maintenance of wells, is applicable to the monitoring wells.

  - RCRA regulations 40 C.F.R. §§261, 262, 263, and 268, which specify waste identification, storage, manifest, transport, treatment, and disposal requirements for solid waste that may contain hazardous substances, are applicable to management of the excavated soil.

  - The State of Washington Hazardous Waste Management Act (Chapter 70.105 RCW) establishes requirements for dangerous waste and extremely hazardous waste as codified in Chapter 173-303 WAC. This regulation designates those solid wastes which are dangerous or extremely hazardous to the public health and environment; provides surveillance and monitoring requirements for such wastes until they are detoxified, reclaimed, neutralized, or disposed of safely; and establishes the siting, design, operation, closure, post-closure, financial, and monitoring requirements for dangerous and extremely hazardous waste transfer, treatment, storage, and disposal facilities. These regulations are applicable to the management of the excavated soil.

  - The State of Washington Solid Waste Management Act (Chapter 70.95 RCW) establishes minimum functional performance standards for the proper handling of all solid waste materials originating from residences, commercial, agricultural and industrial operations and other sources as codified in Chapter 173-304 WAC. This regulation requires the use of the best available technology for siting, and all known available and reasonable methods for designing, constructing, operating and closing solid waste handling facilities. These regulations are applicable to the management of the excavated soil.

  - The Clean Air Act, Section 101, 42 U.S.C. 7405 and 7601, is applicable to sources of fugitive dust generated during the remediation efforts; such dust must be controlled to avoid nuisance conditions.

  - The State of Washington General Regulations for Air (WAC 173-400, implemented by PSAPCA Regulation I) are applicable to sources of fugitive dust generated during the remediation efforts; such dust must be controlled to avoid nuisance conditions.

  - The National Oil and Hazardous Substances Contingency Plan off-Site Rule (40 C.F.R. §300.440) is applicable to soils removed from Area 8 and transported to an off-site area for disposal.

  - The State of Washington requirements for Hazardous Waste Operations and Emergency Response, as set forth in WAC 296-62 (Part P) are applicable to employees involved in the cleanup operations for Area 8 (e.g., soil removal actions, installation of monitoring wells, and sampling activities).

12.2.3 Cost Effectiveness

The selected remedy for Area 8 is cost-effective because it has been determined to provide overall effectiveness proportional to its cost, with an estimated present worth of $8 million. The selected remedy would be as much as ten times more expensive than the limited action alternative (institutional controls), yet it would provide much greater assurance that the remedy will be effective in the long-term due to the significant contaminant reductions achieved by the removal of vadose soil hot spots. The estimated cost of the selected remedy is about half that of the physical and hydraulic containment alternatives yet the selected remedy will permanently eliminate risks to future residents posed by direct contact exposures to the site soils, whereas these risks would remain under the containment options. The selected remedy will effectively reduce hazards posed by contaminants at the site and will facilitate long-term natural restoration of the groundwater, while costing four to nine times less than more extensive alternatives that would involve excavation of saturated zone soil, on-site soil treatment, or aquifer flushing (pump and treat) technologies. These technologies have implementation or performance limitations (described in Section 12.2.4), in addition to much higher cost, that make them impractical and not cost-effective compared with the selected remedy.

12.2.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practical

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for Area 8. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume achieved through treatment.

The selected remedy will address the threat posed by the soils at Area 8 (i.e., direct contact exposure, by soil ingestion, to future residents), by removing hot spots from the vadose zone and disposing them off site. The excavated soils will be treated off site as necessary for proper disposal as specified by state and federal solid and hazardous waste regulations. It is anticipated that some of the soil may need chemical stabilization of metals or treatment for VOCs prior to disposal, or both. These treatments would reduce the mobility and toxicity of the excavated soils. The removal of hot spots will eliminate the need to restrict access to the site, although institutional controls will still be needed for residential use of the property. In contrast, the limited action, containment, and on-site treatment alternatives require access restrictions because contaminants would remain in the vadose soils, and metals-stabilized soils would still pose risk due to soil ingestion. The remaining alternatives would have the same institutional controls as the selected remedy, except residential restrictions for Alternative 8 could be limited to groundwater controls because all vadose zone soils would be removed in this alternative.

Another threat posed by Area 8 is to future residents if they were to use the shallow groundwater for domestic purposes (e.g., drinking, showering). The selected remedy will help to reduce this threat in the long-term by removing the major sources of groundwater contamination from the vadose zone soils, which will accelerate restoration of the groundwater by natural processes. None of the alternatives evaluated in the FS are expected to be effective in restoring the groundwater to drinking water quality in a short time frame, except perhaps Alternative 8 which would involve complete removal of all vadose zone soils and removal of hot spot soils from the saturated zone. This is because significant contamination exists in the soils below the water table, and these soils must be removed or treated in order to restore the groundwater. Alternative 8 is not considered practical due to very high cost (about nine times higher than the selected remedy) and serious implementability difficulties associated with dewatering the site to allow excavation of soil from below the water table. The dewatering difficulties are due to the relatively coarse soils at the site, the proximity of the site to Liberty Bay, the great depth of excavation that would be required, and the need to pump, treat, and discharge large volumes of groundwater.

The selected remedy will take longer to implement than the limited action, groundwater interception, and containment alternatives, but will provide much better long-term effectiveness and permanence by removing principal risks in soil and enhancing natural restoration of the groundwater. The time to implement the selected remedy would be similar to that for the remaining alternatives, which all depend on demolition of the plating shop to gain access to contaminated soils. The aquifer flushing alternative is not expected to accomplish restoration of the groundwater in a short time-frame, and is therefore not cost-effective compared to the selected actions.

The selected remedy will cost less than all the alternatives except for limited action. It has an intermediate potential compared with other alternatives for causing short-term impacts so health and the environment, because the amount of soil disturbed during remediation would be more than that for the limited action, groundwater interception, and containment actions, but much less than that for the on-site treatment or the saturated zone soil removal options. It will have few implementation difficulties once the plating shop is demolished, and in any case will be easier to implement than the alternatives that feature on-site treatment, containment, and saturated zone soil removal. The long-term effectiveness of containment is questionable, because there is no shallow aquitard for the containment walls to be keyed into, and downward migration may not be adequately controlled. Furthermore, containment would not restore the site for residential use. The long-term effectiveness of on-site treatment is also in doubt, because chemical stabilization may not permanently control the leaching of metals, especially for any soils treated or replaced below the water table. On-site treatment would also have implementation difficulties due to the lack of space at Area 8 (and on the base in general) for staging treatment facilities, and because of the need for treatability studies to verify effectiveness and final design parameters for treatment methods such as soil washing, in-situ stabilization and in-situ steam stripping. The high density of underground utilities at Area 8 would also interfere with in-situ treatment. The cost of treatability studies is not warranted for the relatively small volumes of soil that are anticipated for removal in the selected remedy.

For soils removed from vadose hot spots in the selected remedy, treatment could be done either on-site or off-site. The major tradeoffs that provide the basis for selecting off-site treatment rather than on-site treatment are long-term effectiveness and permanence, implementability, and cost, all of which favor off-site treatment and disposal for the reasons given above. In addition, on-site treatment would have somewhat poorer short-term effectiveness because it would be more complex and take longer to implement than off-site treatment. On-site treatment may have an advantage over off-site treatment if soil washing were effective, because the volume of soil requiring further treatment and disposal would be reduced. However, treatability studies would be needed to confirm this potential advantage, and the potential benefit would not be very great for the relatively small volumes of soil that would be excavated. Reductions in mobility and toxicity of the soil contaminants would be equivalent for on-site or off-site treatment.

In view of all the considerations and tradeoffs described above, the selected remedy is determined to be the most appropriate solution for addressing the contaminated soils and groundwater at Area 8.

12.2.5 Preference for Treatment as a Principal Element

The selected remedy may not meet the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances as a principal element. Although the selected remedy will include off-site treatment of excavated soil if this is necessary to comply with hazardous waste disposal regulations, this treatment may not be necessary and it will not reduce the mobility, toxicity, or volume of hazardous residuals left at the site. Other treatment alternatives were evaluated and judged to be impractical for this site, as discussed in the previous section.

13.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan for the NUWC Division, Keyport site was released for public comment in January 1994. The proposed plan identified the preferred alternatives for the various Areas of the site as follows:

- Area 1: The preferred alternative was identified as a combination of actions selected from the alternatives developed in the FS report, including institutional controls, monitoring, vacating buildings where indoor air risks are identified, and installing a final landfill cover.

- Area 2: The preferred alternative was identified as Alternative 2 of the FS report (limited action), which includes institutional controls and groundwater monitoring.

- Area 3: No action was stated as the preferred alternative.

- Area 5: No action, with confirmatory groundwater sampling, was stated as the preferred alternative.

- Area 8: The preferred alternative was identified as a combination of actions selected from the alternatives developed in the FS report, including excavation and off-site treatment/disposal of vadose soil hot spots, institutional controls, and groundwater monitoring.

- Area 9: No action, with confirmatory sediment sampling, was stated as the preferred alternative.

As a result of public concerns about the preferred alternative for Area 1, the NUWC Division, Keyport site was split into two operable units: Operable Unit 1 (OU 1) consisting of Area 1, and operable Unit 2 (OU 2) consisting of Areas 2, 3, 5, 8, and 9. Splitting the site into two operable units was done to allow more time to consider alternatives for Area 1 while proceeding to a decision for the remaining Areas. Creation of two operable units represents a significant change compared with the proposed plan. The Navy, EPA, and Ecology reviewed all written and verbal comments submitted during the public comment period for the Areas that constitute OU 2. Upon review of these comments, it was determined that no significant changes to the remedy for OU 2, as it was originally identified in the proposed plan, were necessary. At the present time, the Navy, EPA and Ecology have not formulated a revised preferred alternative for Area 1, so it is premature to evaluate the significance of changes that may occur to the remedy for this Area.

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APPENDIX A
RESPONSIVENESS SUMMARY

The responsiveness summary addresses public comments on the proposed plan for remedial action at Naval Undersea Warfare Center (NUWC) Division, Keyport. The public comment period on the proposed plan was held from January 24, 1994 through May 1, 1994. Public meetings were held on February 17, 1994 (Area 1), April 21, 1994 (Areas 2, 3, and 5), and April 28, 1994 (Areas 8 and 9) to explain the proposed plan and solicit public comment. A transcript of the meetings is available in the administrative record. In response to public comment to further evaluate the Area 1 landfill, NUWC Division, Keyport was split into two operable units (OU). OU 1 consists of Area 1 and OU 2 consists of the remaining areas (Areas 2, 3, 5, 8, and 9). This Record of Decision (ROD) and responsiveness summary is concerned with OU 2.

There were 14 public comments to the Proposed Plan relating to OU 2. Nine were written and five were received orally at the February 17, April 21, or April 28, 1994 public meeting. Most of the public comments included more than one comment on the plan; therefore, out of the 14 individual public comments there were 51 comments in all related to OU 2.

Comments received fall into seven broad categories relating to:

- The considerations that must be part of environmental cleanup decisions, such as protection of human health and the environment, both now and in the future
- The means of public and tribal involvement in the remedial process
- The responsibility of the Navy to clean up the contaminated areas and concern about continuation of future remediation and monitoring, especially if the base should close
- The adequacy of analytical data for use in the Remedial Investigation/Feasibility Study (RI/FS)
- The degree of conservatism in the reporting of ecological risk
- The potential threat of dense non-aqueous phase liquids (DNAPLs) to drinking water
- The acceptability or unacceptability of the preferred alternatives in terms of scope, schedule, and impact on base mission and viability

Table A-1 presents each comment received (by Area), indicates the number of times the same comment was made by different people, and presents the response to the comment. Responses were written jointly by the Navy, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology). In addition to answering specific technical questions, the responses strive to indicate how public input has been incorporated into the remedial decision making process.

Public acceptance is an important evaluation criterion used in selecting the remedy for each Area. Public acceptance is discussed in Sections 7.5.9, 8.3, 9.3, 10.5.9, and 11.3 of the body of this Record of Decision.

Table A-1
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
General	What percentage of analytical data fails to meet Sampling and Analysis Plan (SAP) objectives? What steps will the Navy take in future monitoring programs to ensure all SAP objectives are met?	1	SAP objectives specify limits on three parameters: accuracy, precision, and completeness. All accuracy and precision goals were met for the Remedial Investigation (RI). Overall, the completeness goal (measured by the percent of data rejected during validation) of 90% was met for OU 2 (which has an overall completeness of 94%). By Area, the completeness goal was not met by a small margin for Areas 5 (86%) and 8 (88%). The Navy, EPA, and Ecology ensure data quality through development and implementation of project-specific Quality Assurance Project Plans (QAPjP). In part, these plans set forth Data Quality Objectives and specify sampling and analysis methods, detection limit goals, and field and laboratory quality control (QC) requirements and corrective actions. Such plans would be required of monitoring plans described for OU 2.
General	The Navy must take responsibility for cleaning up its contaminated areas.	4	As is reflected in this ROD, the Navy will clean up its contaminated sites. The Navy is committed to compliance with all applicable environmental laws and to cleaning up all contaminated areas that pose risks to human health and the environment through its Installation Restoration Program. The Navy has worked closely with EPA and Ecology to determine the appropriate cleanup actions for the NUWC Keyport site and will continue to work closely with the regulatory agencies, tribes, and local citizens through the completion of all remedial actions.
General	The length of the investigation and cleanup makes continuing community involvement very difficult because it relies on volunteer effort.	1	The Navy has made every effort to involve and inform the public during the investigation, feasibility study, and preparation of the ROD. The Navy will continue this involvement during remediation. The Navy recognizes the length of time investigations and remediations of this magnitude take, and understands that community involvement requires substantial volunteer effort. As one way of lessening the burden of volunteer effort, EPA and Ecology have funded a local citizen's group, the Olympic View Environmental Review Council (OVER-C), with the express purpose of maintaining such involvement through the use of paid managers and consultants. Finally, the Navy, EPA, and Ecology are always looking for additional ways to involve tho public and welcome any and all suggestions from the public.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
General	Public involvement is very important throughout all phases of the process.	2	The Navy has recognized that public involvement is important during the remedial process and has issued fact sheets, held open houses and availability sessions, surveyed the community, and held public meetings to inform the public, identify their concerns, and take comment on the proposed remedial actions. In addition, the Technical Review Committee (TRC) has included the citizens group OVER-C. Furthermore, a Restoration Advisory Board (RAB) is being established at NUWC Keyport. It will have a co-chair from the community and membership from additional interested individuals and representatives from a variety of community organizations and local tribes. Its purpose is to provide a forum for interested parties who are affected by the cleanup to discuss and exchange information and provide input to the decision making process.
General	Include public involvement in the writing of the ROD.	3	Typically, there is no public comment period for the ROD itself; public input for the ROD is obtained through the public comments received on the Proposed Plan on which the ROD is based. However, in response to public requests such as this, the Navy and agencies have given members of the TRC the opportunity to review the drafts of the ROD and comment on them. When the RAB is established, its members will have the opportunity to review future decision documents as well.
General	The Suquamish Tribe requests the opportunity to review and comment on draft monitoring plans for those areas where further monitoring is part of the preferred alternative.	1	The Suquamish Tribe and other members of the TRC/RAB will have the opportunity to review and comment on draft monitoring plans.
General	The Suquamish Tribe request the opportunity to review the draft ROD.	1	The Suquamish Tribe was invited to review the draft version of this ROD through its participation in the TRC.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
General	Environmental decisions made today must be based on their effects to our descendants.	1	The Navy, EPA, and Ecology strongly agree with this. Federal and state hazardous cleanup laws require consideration of future, as well as present, risks to human health and the environment.
General	Impacts to human health and natural resources should be taken into account in choosing remediation.	1	The Navy, EPA, and Ecology strongly agree with this. Federal and state hazardous cleanup laws require this.
General	Consider local tribes, especially the Suquamish, during the evaluation and cleanup.	1	The Suquamish Tribe will continue to be involved in all further investigation and cleanup through its participation in the TRC/RAB. Other local tribes are invited to contact the Navy, EPA, or Ecology about how they can participate in these organizations.
General	The selected remedies should not threaten the viability of the base and its mission.	1	As reflected in this ROD, every attempt was made to arrive at effective remediation that does not negatively impact the viability or mission of the base while at the same time protecting human health and the environment through compliance with federal and state environmental laws.
General	The ecological risk assessment contains a very pronounced non-conservative approach to statements of potential ecological risk for several Areas; it is recommended that these be changed. (Comment includes several examples.)	1	The ecological risk assessment was prepared in a manner consistent with current EPA Superfund guidance following state of the practice methods. This includes a large degree of conservatism (i.e., erring on the side of ecological protection). An example of this is the use of a ten-fold "safety factor" in the calculation of ecological risk.
2	The preferred alternative is acceptable.	1	The Navy, EPA, and Ecology agree; this alternative is reflected in this ROD.
2	What is the background level of arsenic?	1	The background (i.e., naturally occurring) levels used in the RI for arsenic were 12 parts per billion (ppb) for groundwater, 6 ppb in soil, and 2.2 ppb in stream sediment.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
2 and 3	Additional marine sampling should be conducted in front of the shallow lagoon in two to three years to check on the flow of any contaminants from Areas 2 and 3.	1	Sampling indicated that no significant ecological risk existed in the shallow lagoon at the time of the RI sampling. Area 3 groundwater contained only very low concentrations of chemicals, which were below levels of concern. However, Area 2 groundwater contained concentrations above drinking water standards. If Area 2 groundwater monitoring, as outlined in the ROD, shows the potential for increased contaminant loading to the shallow lagoon, additional sampling of the lagoon and the areas outside the lagoon might be warranted. This course of action would come about through the periodic meetings between the Navy, EPA, and Ecology that will occur between the signing the ROD and the mandatory five-year review to review the ongoing Area 2 monitoring data.
3	How has rejected data at Area 3 impacted the analysis? (Appendix F states 47.5% of Otto-GC and 0% of ORD-HPLC analyses resulted in useable data.)	1	The comment may have resulted from a misinterpretation of Appendix F concerning these two types of chemical analysis. Appendix F of the RI report (page F-26 states that 95% (not 47.5% of Otto-GC and 0% of ORD-HPLC analyses resulted in useable data. The fact that the major constituent of Otto (torpedo) fuel, propylene glycol dinitrate (PGDN), is common to both analyses means that 95% of PGDN data are useable. Since only very low concentrations of PGDN were detected (low parts per billion concentrations, which were below levels of concern), the Navy, EPA, and Ecology concluded that Otto fuel data is adequate.
3	Some institutional controls should be placed on groundwater if and when the base is closed.	1	Institutional controls (for example, deed restrictions on the drilling of wells) are not warranted based on the groundwater chemistry of Area 3. However, no wells would every be placed in this Area because state regulations prohibit installation of a drinking water well within 1,000 feet of a landfill (such as Area 1).
5	Was testing done around the former sludge drying beds? Even though they were concrete, rain could have washed heavy metals onto the surrounding soil.	1	Sampling was not done in the vicinity of the former sludge drying beds during the RI. This area was not recommended for additional study as reported in the Initial Assessment Study or the Current Situation Report. The drying beds were designed and constructed with corrugated aluminum roofing to prevent rain from washing sludge onto the surrounding area.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
8	Is chromium contamination a source of DNAPL?	1	Strictly speaking, chromium is not a DNAPL (dense non-aqueous phase liquid) because chromium solutions (such as plating baths) are aqueous (i.e., dissolved in water) liquids. However, concentrated plating baths have, at some sites, been observed to behave like DNAPLs by sinking as dense masses through groundwater before becoming completely mixed with the groundwater. We have not seen evidence that this happened at Area 8, probably because the plating solutions leaked slowly enough that the mixing processes in the groundwater (perhaps aided by tidal effects) were fast enough to keep dense masses of contaminated groundwater from forming.
8	Given the likely presence of DNAPL and the absence of the aquitard, how soon will DNAPL migrate downward and contaminate drinking water aquifers?	1	Current drinking water sources are from the deep aquifer below the Clover Park aquitard at depths from 700 to 1,000 feet below ground. There are no shallow-aquifer drinking water wells at or downgradient of Area 8. Continued sampling of deep monitoring wells above the aquitard is part of the action at this Area. If monitoring indicates contamination is moving downward, the Navy, EPA, and Ecology will decide on appropriate additional remedial action. Contrary to the comment, the Clover Park aquitard under Area 8 is approximately 16 feet thick at its thinnest measured location. DNAPLs are usually chlorinated solvents that, in pure form, can exist as liquids that do not mix with and denser than water. Pure DNAPLs were not observed at Area 8; however, because low concentrations of DNAPL-forming chemicals were detected in shallow wells at Area 8, the presence or absence of DNAPLs cannot be determined. Based upon available data, it is unknown how soon or if contaminants will migrate through the aquitard to lower aquifers. However, the lack of detection of DNAPL-forming chemicals in the deepest monitoring well above the aquitard at Area 8 indicated that such contamination has not migrated downward to the vicinity of the aquitard and, therefore, does not currently threaten deep-aquifer drinking water sources.

Area	Comment	Comment Frequency (Number Received)	Response
			As stated above, monitoring will be used to check that any downward migration does not go undetected.
8	The assertion in the Proposed Plan that groundwater is not an exposure pathway may be incorrect.		This statement is made in the context of describing the preferred alternative and refers to current drinking water pathways. There are no current uses of Area 8 groundwater. As part of the selected remedy, future groundwater pathways will be eliminated through institutional restrictions on groundwater use. Although the RI discovered no current impacts to the marine environment caused by Area 8 groundwater, the selected remedy will address this exposure pathway by continuing to monitor marine sediment and shellfish offshore of Area 8. This monitoring will lead to additional action if the Area 8 groundwater begins to impact the marine environment in the future.
8	A groundwater extraction and treatment program should be implemented simultaneously with soil remediation to prevent discharge of contaminants to surface water or groundwater drinking water sources.	1	Alternatives that included these features were fully evaluated in the Feasibility Study. However, because there are no current uses of Area 8 groundwater and because the RI discovered no current impacts to the marine environment caused by Area 8 groundwater the Navy, EPA, and Ecology judged that the selected remedy provides the best balance between the various evaluation criteria. As part of the selected remedy, future groundwater pathways will be eliminated through institutional restrictions on groundwater use. In addition, the selected remedy will address the groundwater to marine environment exposure pathway by continuing to monitor marine sediment and shellfish offshore of Area 8. This monitoring will lead to additional action (which may include groundwater extraction and treatment) if the Area 8 groundwater begins to impact the marine environment in the future.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
8	Groundwater contaminant concentrations have increased since the RI sampling. (Commenter cites example of TCE in well MW8-12.)	1	The trichloroethene (TCE) concentration in well MW8-12 has not shown an overall upward trend during more than two years of frequent sampling. It has fluctuated periodically during the course of sampling remaining at levels between about 50 and 800 ppb. The most recent results from June 1994 show TCE at a concentration of 190 ppb in MW8-12. Similarly, for other wells and contaminants at Area 8 there has been no clear trend in contaminant levels over time.
8	What DNAPLs are present and how will drinking water supplies be protected from contamination by these compounds?	1	Current data can not confine or rule out the presence of chlorinated organic solvent DNAPLs. (That is, although DNAPL-forming chemicals such as TCE, have been detected it is not known whether they actually exist as DNAPLs at the site.) Based upon available data, it is unknown how soon or if contaminants will migrate to lower aquifers. However, the lack of detection of DNAPL-forming chemicals in the deepest monitoring well at Area 8 indicates that such contamination has not migrated downward to the vicinity of the aquitard and, therefore, does not currently threaten deep-aquifer drinking water sources. (There are no shallow-aquifer drinking water wells at or downgradient of Area 8.) Continued monitoring of deep wells above the aquitard is part of the action at this Area. If monitoring indicates contamination is moving downward, the Navy, EPA, and Ecology will decide on appropriate additional remedial action.
8	Who will be responsible for the monitoring program and cleanup if the base closes?	1	The federal government will be responsible for monitoring and cleanup if the base closes. The Department of Navy will be responsible for funding these activities.
8	The Navy may not have the funds or commitment to follow through on future monitoring or cleanup; cleanup should be done now while money is available.	1	The Navy is obligated by federal law to perform monitoring or cleanup. Funding is appropriated by Congress to perform cleanup and monitoring. The Department of Defense gives top priority for funding action necessary to comply with environmental regulatory agreements. Thus, the Navy expects funding will be available for future cleanup and monitoring actions.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
8	The Navy had the opportunity to clean up the area under part of the plating shop when it was rebuilt but chose not to.	1	The Navy's investigation of the contaminated soil under the Plating Facility in 1991 indicated that it posed no current unacceptable risk to human health warranting immediate action. This conclusion was consistent with the later RI risk assessment. The earlier investigation recommended that source control actions such as repairing leaking waste transfer sumps would be effective in eliminating current sources of groundwater contamination. This was done. The Navy also performed a removal action in 1992 to remove contamination sources outside the building, but digging up soil under the building would have been disruptive to NUWC Keyport's operations. Based on the RI risk assessment for future land uses, there is a need to remove contaminated soil from beneath the building after it is demolished, as well as from additional hot spots outside the building.
8	The proposed cleanup should be completed sooner than it would be under the preferred alternative.	1	Based on public comment, the last phase of soil removal has been moved up from the year 2002 to 1998. The initial phase of soil removal will start no later than 15 months from the final acceptance of the ROD.
8	Groundwater is contaminated and discharges to Liberty Bay -- it should be remediated more aggressively than it would be under the preferred alternative.	1	Alternatives that included more aggressive groundwater management were fully evaluated in the Feasibility Study. However, because contaminant discharges to Liberty Bay have not resulted in unacceptable ecological risks and because institutional controls on groundwater use will protect human health, the Navy, EPA, and Ecology judged that the preferred alternative provides the best balance between the various evaluation criteria.
8	The beach is contaminated and should be cleaned up.	1	Contamination of beach (i.e., Area 9) sediment, tissue, or marine water was not detected at levels posing unacceptable risks to human health or terrestrial or marine organisms.
8	Cleanup of this site should receive top priority; the Navy should immediately initiate the budget process for a new plating shop.	1	This site does have top priority for cleanup. The Navy has already initiated the process to obtain a new plating facility. It is scheduled for inclusion in the Fiscal Year 1996 Military Construction Program to be acted upon by Congress.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
8	The cleanup progress versus the timeline presented at the public meeting will be closely watched by Over-C.	1	The Navy welcomes and encourages public oversight of all cleanup activities.
8	Continued groundwater monitoring, especially after source removal, is appropriate to determine that contaminant levels are decreasing.	1	The Navy, EPA, and Ecology agree that continued monitoring is necessary and will be implemented; this is reflected in this ROD.
8	The ROD should set a time limit on construction of a new plating facility; if that time expires, remediation should begin regardless.	1	The Navy, EPA, and Ecology agree with this statement; such a time limit is reflected in this ROD (i.e., Phase II cleanup must be begun by 1998).
8	Hot spots should be removed.	1	The Navy, EPA, and Ecology agree with this statement; hot spot removal is reflected in this ROD.
9	Because some samples exceeded Washington Sediment Management Standards (SMS) the Navy should implement a source control program to prevent further contamination of the sediments.	1	Source control, in the form of hot spot removal at Area 8, will be done under this ROD. In 1991, the Navy upgraded the interior sumps in Building 72 to prevent discharges; in 1992 the Navy removed leaking exterior sumps. In addition, the Navy has eliminated all unpermitted discharges.
9	Continued monitoring is appropriate to confirm that risks remain within EPA's acceptable range.	2	Confirmatory monitoring of Liberty Bay sediment and bivalve tissue is part of the selected remedy that will be done under this ROD.

Table A-1 (Continued)
Public Comments Received on NUWC Division, Keyport Proposed Plan and Navy and Agency Responses

Area	Comment	Comment Frequency (Number Received)	Response
9	Continued monitoring is appropriate to confirm the extent of contamination because state sediment management standards are exceeded.	2	Confirmatory monitoring of Liberty Bay sediment (and bivalve tissue) is part of the selected remedy that will be done under this ROD.
9	The Navy, EPA, and Ecology should ensure that the local tribes accept the preferred alternative.	1	The Suquamish Tribe has participated in the TRC and has had the opportunity to review and comment on all documents including the Proposed Plan. In addition, The Tribe has had the opportunity to review and comment on draft versions of the ROD. Other local tribes are invited to contact the Navy, EPA, or Ecology about how they can participate in these decisions.