Draft Supplemental Remedial Investigation & Feasibility Study

Volume 2: FS Report

Whatcom Waterway Site
Bellingham, Washington

Prepared by:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162

RETEC Project Number: PORTB-18876

Prepared for:

The Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98225

Public Review Draft

October 10, 2006

Draft Supplemental Remedial Investigation & Feasibility Study

Volume 2: FS Report

Whatcom Waterway Site
Bellingham, Washington

Prepared by:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, WA 98134-1162

RETEC Project Number: PORTB-18876

Prepared for:

The Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98225

Prepared by:

Jamie C. Stevens for:

Grant Hainsworth , P.E.

Jamie C. Stevens

Jamie Stevens, Environmental Engineer

Reviewed by:

Mark Larsen , Senior Project Manager

October 10, 2006

Table of Contents

Table of Contents

Table of Contents

Table of Contents

List of Tables

List of Figures

List of Appendices

1 Feasibility Study Introduction

This document is Volume 2 of the *Draft Supplemental Remedial Investigation and Feasibility Study* (RI/FS) for the Whatcom Waterway Site. Together with the companion *Draft Supplemental Environmental Impact Statement* (EIS), the RI/FS document describes the investigation of the Whatcom Waterway site, describes and evaluates a range of potential remedial alternatives, and identifies the preferred approaches for conducting site cleanup.

The preceding *Remedial Investigation Report* (Volume 1) describes the nature and extent of contamination, describes the environmental setting at the site, and concludes with a conceptual model of the site. This document (Volume 2) contains the evaluation of cleanup technologies and alternatives that can be used to conduct cleanup of the site. This document was prepared consistent with the requirements of the Model Toxics Control Act (MTCA) regulations and the Sediment Management Standards (SMS).

This document concludes with the identification of preferred alternatives that best meet regulatory requirements and that provide the best overall cleanup approaches for the Whatcom Waterway site. After considering public comment, the RI/FS will be finalized, and the Department of Ecology (Ecology) will preliminarily select a cleanup alternative for the site. The preliminarily selected cleanup alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

1.1 Site Description and Background

The Whatcom Waterway site is located within Bellingham Bay. The locations and characteristics of the site are shown in Figure 1-1. Property ownership is summarized in Figure 1-2.

The site includes aquatic lands that have been impacted by contaminants historically released from industrial waterfront activities, including mercury discharges from the former Georgia Pacific (GP) chlor-alkali plant. The chlor-alkali plant was constructed by GP in 1965 to produce chlorine and sodium hydroxide for use in bleaching and pulping wood fiber. The chlor-alkali plant discharged mercury-containing wastewater into the Whatcom Waterway during the late 1960s and 1970s. Initial environmental investigations of the site identified mercury in sediment at concentrations that exceed applicable standards, as well other contaminants from industrial releases.

The main state law that governs the cleanup of contaminated sites is the Model Toxics Control Act (MTCA). When contaminated sediments are involved, the cleanup levels and other procedures are also regulated by the Sediment Management Standards (SMS). MTCA regulations specify criteria for the evaluation and conduct of a cleanup action. SMS regulations dictate the standards for cleanup. Under both laws, a cleanup must protect human health and the environment, meet environmental standards in other laws that apply, and provide for monitoring to confirm compliance with site cleanup levels.

The key MTCA decision-making document for site cleanup actions is the remedial investigation and feasibility study (RI/FS). In the RI/FS, different potential alternatives for conducting a site cleanup action are defined. The alternatives are then evaluated against MTCA remedy selection criteria, and one or more preferred alternatives are selected. After reviewing the RI/FS study, and after consideration of public comment, Ecology then selects a cleanup method and documents that selection in a document known as the Cleanup Action Plan. Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

The RI/FS process for the Whatcom Waterway site was initiated under Ecology oversight in 1996 consistent with Agreed Order DE 95TC-N399. The RI/FS study process initially included detailed sampling and analysis in 1996 and 1998. These sampling events formed the basis for development of an RI/FS report in 2000.

In parallel with the 2000 RI/FS activities, the Bellingham Bay Comprehensive Strategy Environmental Impact Statement (EIS) was prepared. The EIS was both a project-specific EIS, evaluating a range of cleanup alternatives for the Whatcom Waterway site, and a programmatic EIS, evaluating the Bellingham Bay Comprehensive Strategy. The Comprehensive Strategy was developed by an interagency consortium known as the Bellingham Bay Demonstration Pilot (Pilot). The Pilot brought together a partnership of agencies, tribes, local government, and businesses known collectively as the Pilot Work Group, to develop a cooperative approach to expedite source control, sediment cleanup and associated habitat restoration in Bellingham Bay. As part of the approach, the Pilot Work Group developed a Comprehensive Strategy that considered contaminated sediments, sources of pollution, habitat restoration and in-water and shoreline land use from a Bay-wide perspective. The strategy integrated this information to identify priority issues requiring action in the near-term and to provide long-term guidance to decision-makers. The Comprehensive Strategy was finalized as a Final Environmental Impact Statement in October 2000 prepared under the State Environmental Policy Act (SEPA). It was a companion document to the 2000 RI/FS for the Whatcom Waterway site.

Since 2000, the Bellingham Waterfront has undergone a series of dramatic land use changes, including the closure of the GP pulp mill and chemical plant, the sale of 137 acres of GP-owned waterfront property to the Port of Bellingham (Port), additional property ownership changes in the Central Waterfront Area, and City of Bellingham/Port land use planning initiatives that shift waterfront uses from industrial to mixed-use development and zoning.

This RI/FS incorporates the results of environmental investigations conducted since completion of the original RI/FS in 2000, updates previously evaluated cleanup alternatives, and describes and evaluates new cleanup alternatives that reflect changes in land use. The EIS companion document to this RI/FS is also currently available for public review. This RI/FS, the companion EIS and public comment on both documents will inform Ecology's preliminary selection of a cleanup alternative for the Whatcom Waterway site. The preliminary selected alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

1.2 Document Organization

This document is intended to be read in conjunction with the site Remedial Investigation report (Volume 1) and in conjunction with the companion Draft Supplemental EIS document (bound separately). This document contains periodic references to those other two documents.

This Feasibility Study was prepared consistent with the process defined under MTCA and SMS for identification of a preferred cleanup alternative. The organization of this document is as follows:

- **Summary of Key RI Findings:** Section 2 summarizes the key findings of the Remedial Investigation, including the Conceptual Site Model developed as part of the RI.

- **Cleanup Requirements:** Section 3 of the document then summarizes cleanup requirements for the site. These requirements include a definition of site cleanup levels and remedial action objectives that are to be met by the cleanup action. Also defined in Section 3 are the regulations and requirements other than those in MTCA and SMS regulations that are addressed by the cleanup and its implementation. Future permits or approvals that may be required for cleanup implementation are identified in that section.

- **Sediment Site Units:** In Section 4, the site is divided geographically into a series of "Site Units" that have different characteristics and that may warrant different types of cleanup based on these characteristics.

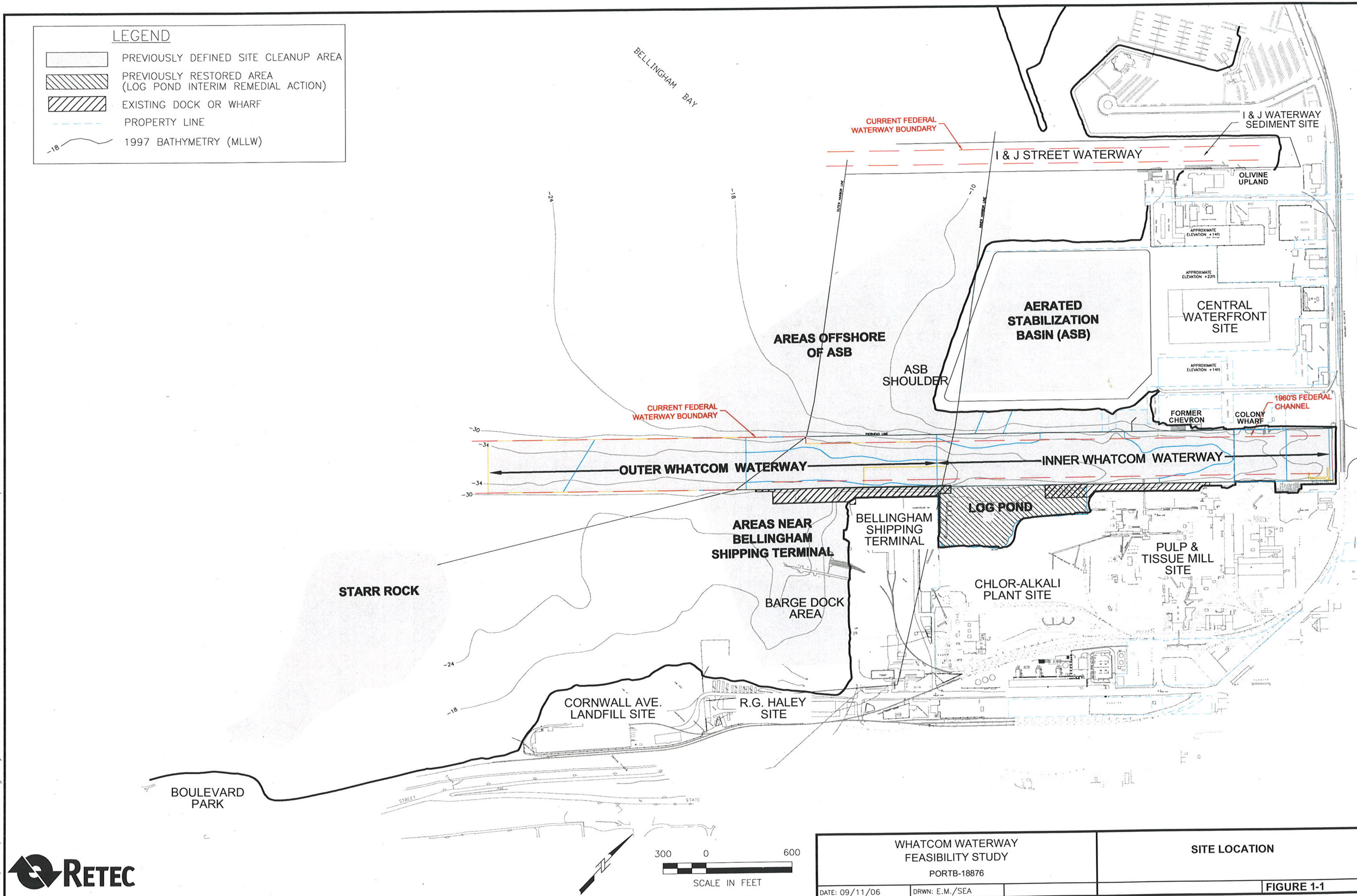
- **Technology Screening:** After definition of site units and cleanup requirements, Section 5 screens available technologies that could potentially be used to conduct site cleanup. The technology screening evaluates which of those technologies are most appropriate to site conditions, consistent with Ecology and EPA guidance for contaminated sediment sites. Technologies that are retained after this screening process are then carried forward for the development of comprehensive cleanup strategies addressing the site. Because multiple potential strategies are analyzed in the Feasibility Study, these cleanup strategies are described in this document as "cleanup alternatives."

- **Description of Cleanup Alternatives:** This Feasibility Study evaluates eight different cleanup alternatives. Each of these alternatives is described in detail in Section 6 of this report. The elements of the cleanup are described, along with a description of how each alternative achieves compliance with the cleanup requirements specified in Section 3. Each alternative uses a different combination of the cleanup technologies from Section 5.

- **MTCA & SMS Evaluation of Alternatives:** Consistent with MTCA and SMS regulations, each remedial alternative is evaluated against a set of defined criteria. The analysis is complex and addresses many factors required under the regulations as described in Section 7. From the MTCA and SMS regulatory analysis, preferred alternatives are identified, representing the alternative(s) that rank best overall among the evaluated alternatives.

- **Summary of EIS Evaluation:** Section 8 summarizes the findings of the companion EIS analysis.

- **Summary and Conclusions:** A summary and the conclusions of the Feasibility Study are provided in Section 9. References are included in Section 10 and appropriate backup information is attached as appendices.



File: H:\18876\18876S133.dwg Layout: FIGURE 1-1 User: seacad Plotted: Oct 08, 2006 - 6:21pm Xref's:

RETEC

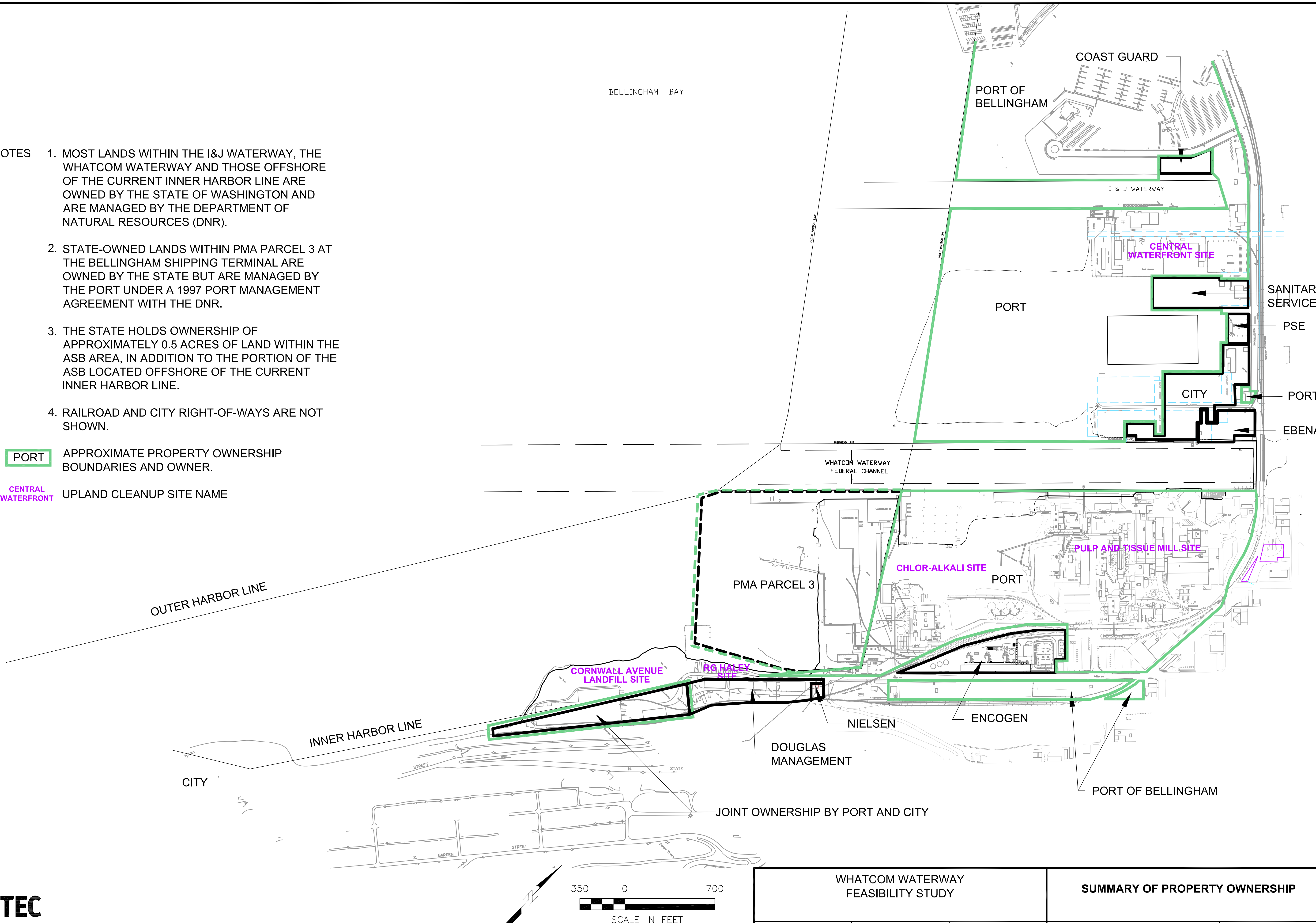
WHATCOM WATERWAY FEASIBILITY STUDY	SITE LOCATION
PORTB-18876	
DATE: 09/11/06 DRWN: E.M./SEA	FIGURE 1-1

NOTES

1. MOST LANDS WITHIN THE I&J WATERWAY, THE WHATCOM WATERWAY AND THOSE OFFSHORE OF THE CURRENT INNER HARBOR LINE ARE OWNED BY THE STATE OF WASHINGTON AND ARE MANAGED BY THE DEPARTMENT OF NATURAL RESOURCES (DNR).
2. STATE-OWNED LANDS WITHIN PMA PARCEL 3 AT THE BELLINGHAM SHIPPING TERMINAL ARE OWNED BY THE STATE BUT ARE MANAGED BY THE PORT UNDER A 1997 PORT MANAGEMENT AGREEMENT WITH THE DNR.
3. THE STATE HOLDS OWNERSHIP OF APPROXIMATELY 0.5 ACRES OF LAND WITHIN THE ASB AREA, IN ADDITION TO THE PORTION OF THE ASB LOCATED OFFSHORE OF THE CURRENT INNER HARBOR LINE.
4. RAILROAD AND CITY RIGHT-OF-WAYS ARE NOT SHOWN.

PORT — APPROXIMATE PROPERTY OWNERSHIP BOUNDARIES AND OWNER.

CENTRAL WATERFRONT — UPLAND CLEANUP SITE NAME



RETEC

WHATCOM WATERWAY FEASIBILITY STUDY

SUMMARY OF PROPERTY OWNERSHIP

DATE: 08/21/06 | DRWN: E.M./SEA

FIGURE 1-2

File: H:\18876\18876S120.dwg Layout: FIGURE 1-2 User: emarshall Plotted: Sep 27, 2006 - 10:30am Xref's:

2 Summary of Key RI Findings

This section provides a brief summary of the key findings of the Remedial Investigation (Volume 1 of this RI/FS), including the Conceptual Site Model (CSM) developed for the Whatcom Waterway site. The CSM provides a concise summary of the findings of the remedial investigation and is presented in Section 8 of the RI Report.

All information contained in this section is described in greater detail in Volume 1 of this RI/FS report. The reader should refer to that document for the detailed information on which the CSM is based.

2.1 Contaminants and Sources

As measured by relative concentration and frequency of detection, the principal contaminants in the site sediments are mercury, 4-methylphenol and phenol. Table 2-1 summarizes the principal contaminants and sources for the Whatcom Waterway site. The table includes a summary of the status of source control activities.

- **Mercury Contamination is Predominantly from Historical Sources:** The primary source of mercury within the Whatcom Waterway site sediments was the discharge of mercury-containing wastewaters from the chlor-alkali plant between 1965 and the 1970s. This historic source of mercury contamination has been controlled. Following initial pollution control upgrades by GP in the early 1970s, direct discharge of chlor-alkali plant wastewaters to the Whatcom Waterway was terminated. Then in 1999 the chlor-alkali plant was closed by GP, eliminating the generation of mercury-containing wastewater. The restoration of the Log Pond area in 2000 and 2001 controlled the secondary source of mercury, by capping impacted sediments in this area. Some regional and natural sources of mercury continue to exist, but these natural and regional sources are not expected to result in exceedances of Site screening levels.

- **Phenolic Compounds are Predominantly from Historical Sources:** The primary sources of phenolic compounds within the Whatcom Waterway Site sediments include historical wood products handling and log rafting, historical pulp mill discharges prior to implementation of primary and secondary wastewater treatment, and potential lesser contributions from historical stormwater and wastewater discharges. These sources have been controlled. Wood products handling activities are less common than there were historically, and additional regulatory and permitting requirements minimize the potential for discharges of wood wastes to sediments. Pulp mill wastewater discharges were better controlled after the

1960s and 1970s, and discharge of process wastewaters to the Whatcom Waterway was terminated in 1979. The pulp mill was closed by GP in 2000, terminating the discharge of pulp and chemical plant wastewaters to the aerated stabilization basin (ASB).

Because primary contamination sources have been controlled, the main focus of the remaining site cleanup actions will be to address secondary contamination sources, the residual contamination in sediments at the site.

A number of other contaminated sites are located in the vicinity of the Whatcom Waterway site and are being address by Ecology. These sites do not represent a current source control concern for Whatcom Waterway site sediments or surface water quality.

2.2 Nature and Extent of Contamination

The nature and extent of contamination impacts within the Whatcom Waterway site have been conclusively determined through over a decade of intensive investigations as part of the RI/FS and Bellingham Bay Pilot activities. These investigations in turn build on previous studies performed by academic researchers, regulatory agencies and local industry and government. The result is a wealth of knowledge about site conditions, and the factors that influence the selection of a final site cleanup.

The findings of the site investigations are the focus of the RI report. Table 2-2 provides a quick summary of the principal RI activities and their findings. These findings are graphically displayed in the Conceptual Site Model in Figures 2-1 and 2-2. Site screening levels discussed in this section are defined in Section 4 of the RI Report.

- **Waterway Sediments:** The Whatcom Waterway sediments generally consist of a layer of soft, silty, impacted sediments. The elevation and thickness of the impacted layer varies with location, but is generally between 2 and 10 feet in thickness. The sediments are thickest in historically dredged and filled areas along the Inner Waterway. The impacted Waterway sediments are subject to natural recovery by ongoing deposition of clean sediments. Except in some high-energy, nearshore areas offshore of the ASB, the impacted sediments are covered by a layer of clean sediments. These clean sediments have been naturally deposited, and the surface sediments of the bioactive zone comply with sediment screening levels protective of environmental receptors. This process of natural recovery is expected to continue into the foreseeable future. Mercury concentrations within the site subsurface sediments are typically in the low part-per-million range, and average subsurface mercury concentrations decrease with distance from the Log Pond source area. Phenolic compounds are also present in the Waterway in the low part-per-million range. The highest phenolic concentrations were detected in subsurface sediments within the Inner Waterway, near the historic pulp mill effluent discharge locations from the 1950s and 1960s. The impacted sediments are underlain by clean, native sandy sediments of varying thicknesses.

- **Log Pond Sediments:** The Log Pond area was the site of the historic mercury-containing wastewater discharge from the chlor-alkali plant during the 1960s and 1970s. Subsurface sediments in this area contain the highest mercury levels present at the site. Ecology determined that removal of these sediments was not technically practicable. This area was remediated by capping as part of an Interim Action that was implemented in 2000 and 2001. Sediment monitoring since that time has demonstrated that the cap is performing well, and is successfully preventing underlying contaminants from migrating upward through the cap. Monitoring of groundwater discharges in the cap area has demonstrated no ongoing impacts to surface water quality or cap conditions from the adjacent chlor-alkali plant upland areas. Biological monitoring has demonstrated that the capped area has recovered biological functions for benthic and epibenthic organisms, for juvenile salmonids and shellfish. Tissue monitoring has demonstrated that bioaccumulation risks have been successfully controlled, and crab tissue sampled from the area is not significantly different from crab tissue collected from clean reference sites. Some wave-induced erosion has been noted at the shoreline edges of the cap, and enhancements to these areas will be required to prevent cap recontamination and to maintain the long-term protectiveness of the remedy. The Feasibility Study includes proposed cap enhancements as part of the final remedial alternatives for the Whatcom Waterway site.

- **ASB Areas:** Figure 2-2 provides a graphical summary of the conditions in the ASB area. The ASB was originally constructed as a stone, sand and clay berm, enclosing a basin dredged in 1978. Some impacted sediments exist underneath portions of the berm. However, the berm consists primarily of clean materials imported at the time of construction. Testing and engineering evaluations have shown that the berm materials are of sufficient quality for reuse. A thick layer of wastewater treatment sludges has accumulated within the ASB. These sludges are soft, flocculant, high-organic materials containing elevated levels of mercury, phenolic compounds and other contaminants. However, the sludges have not significantly impacted the clean native sands underlying the basin. The evaluation of potential remedial alternatives for the ASB area will take into account the special physical and chemical properties of the ASB materials, and the potential future uses of the ASB area.

- **Starr Rock Area:** Site investigations have documented the nature and extent of contamination present at the former Starr Rock dredge disposal site. This area is located in a deep-water, low energy portion of the Whatcom Waterway site. Natural recovery has occurred in this area, with impacted mercury and phenol-impacted sediments being covered by clean sediments. There are no current exceedances of site screening levels in this area.

2.3 Fate and Transport Processes

Sediments within the Whatcom Waterway site are acted upon by natural and anthropogenic forces that affect the fate and transport of sediment contaminants. Significant fate and transport processes evaluated as part of the RI include the following:

- **Sediment Natural Recovery:** Processes of natural recovery have been extensively documented within the Whatcom Waterway site. Sediments in most areas of the site are stable and depositional, and clean sediments continually deposit on top of the sediment surface. RI investigations have documented depositional rates and have verified that patterns of deposition and natural recovery are consistent throughout most site areas. The exception to this general observation is in nearshore, high-energy areas where recovery rates are reduced by the resuspension of fine-grained sediments. In all other areas of the site, cleaner sediments are consistently observed on top of impacted sediments. As part of the 2000 RI/FS, site data and recovery models were used to produce quantitative estimates estimate natural recovery rates. These estimates were then empirically verified by resampling surface sediments and comparing observed recovery rates with model predictions.

- **Erosional Processes:** The effects of wind/wave erosional forces represent the principal natural process affecting sediment stability. RI investigations and FS engineering evaluations have identified high-energy, nearshore areas where the natural deposition of fine-grained sediments does not occur, or occurs at slower rates. In these areas, fine-grained sediments can be resuspended, mixed and/or transported by wave energy. The erosional forces vary with location, water depth, sediment particle size and shoreline geometry. These forces are minimal in deep-water areas which represent the majority of the Whatcom Waterway site. The FS incorporates analyses of erosional forces in consideration of site remediation areas and applicable technologies.

- **Navigation Dredging and Shoreline Infrastructure:** Navigation dredging and the construction of associated shoreline infrastructure have been prominent features of the Whatcom Waterway site, and have shaped the current site lithology. The RI/FS includes extensive discussion of historic and future navigation and infrastructure issues that could affect the fate of site sediments. The FS incorporates potential future dredging activities as part of the evaluation of the long-term effectiveness of the remedial alternatives. The companion EIS document assesses the inter-relationships between site cleanup decisions and community land use and habitat enhancement objectives, consistent with the requirements of SEPA regulations and the goals of the Pilot.

- **Other Processes:** As part of the evaluation of sediment stability, the RI included a discussion of bioturbation, prop wash and anchor drag. These processes can result in periodic disturbances of the sediment column, and can enhance mixing of surface sediments with underlying sediments. These processes are all ongoing and are incorporated in the empirically measured rates and performance of natural recovery. However, they are relevant in the evaluation of the long-term stability of subsurface sediments. Prop-wash in particular will affect sediment stability in near-shore navigation areas. These factors are incorporated into the FS analysis of remedial alternatives.

2.4 Exposure Pathways and Receptors

Section 4 of the RI report discusses the principal environmental receptors and exposure pathways applicable to the Whatcom Waterway site. That section also discusses the site screening levels that are used to evaluate protection of these receptors. Exposure pathways and receptors are illustrated in Figures 2-1 and 2-2, and are summarized in Table 2-4.

- **Protection of Benthic Organisms:** The primary environmental receptors applicable to the Whatcom Waterway site consist of sediment-dwelling organisms. These benthic and epibenthic invertebrates are located near the base of the food chain and are important indicators of overall environmental health. Both chemical and biological monitoring are used to test for potential toxic effects. Chemical and biological standards specified under SMS are used to screen for such effects. The use of SMS whole-sediment bioassays provides an ability to test for potential synergistic effects between multiple chemicals, and to test for potential impacts associated with parameters that may not have been measured as part of chemical testing.

- **Protection of Human Health:** Mercury is one of the primary contaminants present at the Whatcom Waterway site. Mercury can be converted to methylmercury, which in turn can bioaccumulate through the food chain. As part of the 2000 RI/FS a bioaccumulation screening level (BSL) was developed that would be protective of both recreational and tribal fishing and seafood consumption practices as described in Section 4 of the RI Report. The BSL was developed using conservative exposure assumptions, to ensure that the value would be protective. An additional degree of protectiveness has been obtained in the way that the BSL is applied to the site decision-making. Specifically, the BSL has been applied as a "ceiling" value for all surface sediments at the site, including individual data points or clusters. This application provides a substantial additional degree of protectiveness, because it is the area-weighted average sediment mercury concentration that drives biological risks. Area-weighted average concentrations within the Whatcom Waterway site are currently between two and three times lower than the BSL itself. The FS considers remediation of all areas exceeding the BSL on a point-by-point basis, even though the area-weighted average is already below the BSL. This application of the BSL further reduces the potential risks associated with the site. The result is to maintain a robust level of protectiveness, in excess of that required to protect human health under reasonable assumptions.

- **Protection of Ecological Health:** As with human health, ecological receptors can be impacted by mercury bioaccumulation. However, the application of the BSL to cleanup at the site ensures protectiveness to ecological receptors. The protectiveness of the BSL to ecological receptors was evaluated in several ways as part of the RI process. First, the protectiveness of the BSL was evaluated against potential marine mammal exposures. The Second, bioaccumulation testing has been performed on sediments from the Whatcom Waterway site at concentrations exceeding the BSL, demonstrating no significant bioaccumulation at these sediment concentrations. Third, tissue monitoring has been performed a the site as part of the Log Pond Interim Action. That monitoring has shown that compliance with the BSL prevents the accumulation of mercury in crab tissue in comparison to clean reference areas. Based on these three lines of evidence, the compliance with the mercury BSL and with SMS criteria for benthic organisms results in protection of ecological receptors.

- **Other Considerations:** The FS includes evaluations of remedial technologies that may trigger new exposure pathway and receptor risks. For example, dredging of impacted sediments triggers short-term risks at the point of dredging and in material handling areas, and during transport of these materials to the disposal site. Additional exposure pathways and receptors are potentially affected at the location of dredge material disposal. The RI included engineering testing that was focused on providing empirical data necessary to evaluate these additional exposure pathways and receptor risks. These data are then used as part of the FS, in conjunction with applicable regulatory guidelines and requirements, to evaluate the feasibility, protectiveness and costs of different remedial strategies.

Table 2-1. Summary of Principal Contaminants and Sources

Principal Site Contaminants	Principal Source(s)	Source Control Status
Mercury	**Wastewater Discharges to Log Pond**	**Controlled** - Discharges terminated in the 1970s
	Groundwater Discharges to Log Pond	**Controlled** - Monitoring indicates no continuing discharges affecting Log Pond sediments or water quality - Additional actions to be evaluated as part of the chlor-alkali site RI/FS and site cleanup
	Log Pond Sediments	**Partially Controlled** - Area capped as part of successful interim action - Cap enhancements to be included in final site cleanup to ensure long-term stability of cap edges
	Historic Dredge Disposal	**Controlled** - Rigorous dredge material characterization and management protocols now required by regulation and permit for all dredging projects
	Chlor-Alkali Plant Discharges to ASB	**Controlled** - Chlor-alkali plant was closed and demolished by GP, with termination of wastewater discharges to the ASB.
Phenolic Compounds	**Historic Pulp Mill Discharges to Waterway**	**Controlled** - NPDES Wastewater improvements implemented in the 1970s, including primary & secondary treatment, and termination of waterway discharges. - Early remedial efforts completed in the Whatcom Waterway included sediment removal actions in 1974
	Pulp Mill Discharges to ASB	**Controlled** - Pulp mill and associated chemical plant were closed by by GP, with termination of associated wastewater discharges to the ASB.
	Wood Waste from Log Rafting	**Controlled** - Cargo shipments of logs and wood products have been reduced, and additional regulatory and permit-required pollution controls apply to log/wood handling activities.
	Historic Sewer Outfalls	**Controlled** - Sewage treatment and discharge improvements implemented in the 1960s and 1970s.
	Stormwater Discharges	**Controlled** - Ongoing stormwater system upgrades to reduce/eliminate CSO events. - No evidence of ongoing sediment impact in intermittent CSO area - Enhanced stormwater management practices, permitting and monitoring.
Other Compounds	**Boatyard Wastes** (Copper, Zinc, TBT)	**Controlled** - Closure of early over-water boat lift formerly located adjacent to Colony Wharf site. - Enhanced stormwater controls and permitting at Colony Wharf site.
	Creosoted Pilings (PAH Compounds)	**Controlled** - Changes in materials use for new construction - Ongoing pile removal programs being implemented by Port, DNR and Ecology.
	Cargo Spillage (PAH Compounds, Wood Waste)	**Controlled** - Reductions in Log/Wood/Chip handling - Changes in cargo handling practices - Proactive materials management planning for new cargos
	Phthalate & Nickel Sources (I&J Waterway Site Area)	**Controlled** - Elimination of historic sources of these compounds (i.e., Olivine ore, historic plant fire) - Investigation & Cleanup of the I&J Waterway site under an Agreed Order and Ecology oversight
Contaminants at Adjacent Sites		**Ongoing Investigation & Cleanup** - Actions at other waterfront sites coordinated under the Bellingham Bay Demonstration Pilot

Notes:

This table summarizes primary sources of sediment contamination. Secondary sources of sediment contamination (i.e., volumes of impacted sediment present at the site) are to be addressed as part of the final remedial action evaluated in the RI/FS.

Section 2 of the RI contains an overall history of the Whatcom Waterway site.

Section 6.1 of the RI includes a detailed discussion of site source control activities.

Table 2-2. Nature & Extent of Impacts

Site Study Area	Study Topics	Principal RI Activities & Findings	Quick Reference to Relevant RI Report Sections
Waterway Sediments	Assess current site lithology, including the impacts of historic dredging and shoreline development activities	Site lithology characterized through review of historic records, review of historic sediment borigns, and completion of extensive subsurface physical and chemical testing	Section 3.1 includes a discussion of site lithology, with accompanying geologic cross-sections developed from subsurface explorations.
	Document the nature & extent of current impacts in the bioactive zone (surface sediments)	Surface sediment testing performed using chemical testing and whole-sediment bioassays	Section 5.2 figures, tables and text summarize the results of chemical and bioassay testing.
	Documentation the extent of natural recovery processes occurring at the site	Natural recovery processes studied with cores and sediment traps, modeled quantitatively and then verified through direct observation of decreasing sediment concentrations	Section 6.2 documents natural recovery processes evaluated at the site. Changes in surface sediment conditiosn over time are documented in Section 5.2.
	Quantify the nature & extent of subsurface sediment impacts	Core sampling used to directly assess the nature and extent of subsurface sediment impacts	Subsurface sediment quality summarized in Section 5.3. Refer also to the cross-sections and the lithology discussion in Section 3.1.
	Assess potential dredge disposal properties of waterway sediments	Dredge disposal suitability testing performed in support of the Feasibility Study	Previous dredge material evaluations summarized in Section 7, and in Appendix H.
Log Pond Sediments	Delineate surface & subsurface impacted sediments	RI activities included surface and subsurface testing prior to implementation of Log Pond Interim Action	Surface and subsurface sediment quality data are summarized in Section 5.2 and 5.3.
	Monitor effectiveness of Interim Action and assess any potentially appropraite cap enhancements	Effectiveness of Interim Action has been assesed through implementation of Year-1, Year-2 and Year-5 monitoring events	The Year-5 Log Pond Monitoring report is attached as Appendix I. Proposed enhancements to the Log Pond cap are discussed in the site Feasibility Study.
	Assess the potential performance of in situ treatment technologies for application at the site	In situ treatment pilot test performed in support of the Feasibility Study	Results of ECRT pilot testing are summarized in Section 7.
ASB Areas	Assess current site lithology, including the impacts of historic dredging and shoreline development activities	Site lithology characterized through review of historic records, review of historic sediment borings, and completion of extensive subsurface physical and chemical testing	Section 3.1 includes a discussion of site lithology, with accompanying geologic cross-sections developed from subsurface explorations.
	Assess the volume and thickness of the ASB sludges	Bathymetric and invasive physical testing used to quantify the volume of the ASB sludges	Bathymetric data are summarized in Section 3.1 and accompanying figures. Physical testing data are summarized in Appendix C and Appendix D to the RI.
	Assess the chemical Properties of ASB Sludges	Core sampling used to document concentrations of mercury, phenoloic compounds and other contaminants in ASB sludges.	Chemical properties of the ASB sludges are summarzied in Section 5.3 and the accompanying figures and tables, and in Appendix C.
	Evaluate the characteristics of the ASB berm materials	Berm sand quality assessed through direct chemical and physical testing, to assess potential for reuse of these materials.	Chemical properties of the berm sands are summarzied in Section 5.3 and the accompanying figures and tables, and in Appendix D.
	Quantify the characteristics of the sands underlying the ASB	Chemical and physical testing performed for the sands underlying the ASB sludges	Chemical properties of the berm sands are summarzied in Section 5.3 and the accompanying figures and tables, and in Appendix C.
	Assess the physical properties of the sludges relevant to site remedial decisions	Physical properties of the sludges assessed through physical and geotechnical testing, and during dewatering tests performed in support of the Feasibility Study.	Geotechnical properties of ASB materials are included in Appendix C. Dewatering test results are summarized in Section 7, and in Appendix D.
Starr Rock Area	Nature & extent of historic dredge disposal area	Area of dredge disposal documented through review of historic records, site bathymetric monitoring and delineation of sediment areas containing elevated mercury levels	Disposal site location identified in Figure 3-1. Sediment quality data are summarized in Section 5.2 and in associated figures and tables.
	Effectiveness of natural recovery	Site monitoring has verified compliance with sediment standards (biological SQS and site-specific BSL)	Current site data are summarized in Section 5.2 and in Figure 5-2.

Table 2-3. Fate & Transport Processes

Fate & Transport Process	Principal Issues & Observations	Summary of RI Findings
Natural Recovery	Deposition of clean surface sediments	Gross & net deposition rates quantified with sediment traps and natural recovery cores
		Reductions in contaminant concentrations documented and correlated to specific time signatures in sediment cores
		Consistent recovery pattern verified with core and grab sampling throughout site
	Measurement of natural recovery rates	Previous natural recovery studies by others
		Predictive recovery modeling as part of 2000 RI/FS
	Verification of recovery model outputs	Measured reduction of surface sediment contaminant levels between 1996/1998 and 2002 sampling events
		Observed contaminant reductions consistent with 2000 model outputs.
	Limitations of natural recovery	Areas of reduced natural recovery identified through physical and chemical mapping, and analysis of erosional properties.
Erosional Processes	Reduced natural recovery in high energy, shallow-water areas	Shallow-water, high energy areas with low natural recovery rates identified offshore of ASB
	Redistribution of fine-grained sediments in nearshore areas	Wind and wave energy analysis conducted as part of RI/FS activities to identify areas of potential significance
		Shoreline stability incoroporated into Feasibility Study and remedial design evaluations
	Shoreline infrastructure needs assessed in relation to navigation uses and shoreline/waterway geometry	Analysis of shoreline stability and potential future shoreline infrastructure needs incorporated into Feasibility Study
Navigation Dredging	Impacts to waterway and ASB bathymetry	Historic dredge contacts documented as part of site lithology
	Periodic re-exposure of subsurface sediments if remaining within proposed dredge units	Potential future navigation dredging needs incorporated into Feasibility Study and remedial design evaluations
	Historic dredge disposal areas	Extent of dredge disposal impacts quantified in Starr Rock area
	Potential disposal options for future navigation dredging	Dredge material characterizations incorporated into RI activities in support of Feasibility Study
Bioturbation	Formation of mixed bioactive zone	Bioactive zone thickness measured to be 12 cm
	Periodic deep sediment mixing	Analaysis of potential deep mixing events conducted
Propellor Wash	Potential sediment erosion in navigation areas	Propellor wash issues identified for evaluation as part of Feasibility Study and remedial design efforts
Anchor Drag	Periodic mixing of surface & subsurface sediments in anchorage areas	Limited impact due to limited use of anchors within principal site areas (i.e., availability of dock moorage, alternative anchorage sites)
		Potential for periodic deep mixing evaluated for consideration during RI/FS and remedial design

Notes:

Natural recovery and fate and transport processes are described in Section 6.2 and 6.3 of the RI report.
Land use and navigation issues are discussed in Section 3.3 of the RI report.

Table 2-4. Exposure Pathways and Receptors

Receptor	Exposure Pathway	Basis for Evaluating Protectiveness
Benthic Organisms	Direct toxicity to benthic/epibenthic invertebrates	Screening for areas of potential impact using SMS numeric standards
		Verification using whole-sediment bioassays and SMS interpretive criteria
Human Health	Contaminant exposure through consumption of seafood containing bioaccumulated mercury and/or methylmercury	Development of a site-specific BSL as part of 2000 RI/FS activities to identify sediment concentrations that will prevent significant bioaccumulation impacts
		Conservative application of BSL in site decision-making to ensure a substantial additional degree of protectiveness
Ecological Health	Exposure of higher trophic level wildlife (e.g., whales) through consumption of benthic organisms	BSL assessed to verify its protectiveness of potential wildlife exposures
		Verification of BSL protectiveness through sediment bioaccumulation tests and seafood tissue monitoring
Other Considerations	Cross-media transfers (e.g., contaminant leaching) and subsequent exposure to human health or environmental receptors	Contaminant mobility studies conducted in support of Feasibility Study and Remedial Design efforts
	Direct contact of human health and ecologyical receptors at dredge disposal locations	Applicable regulatory standards for dredge disposal scenarios evaluated as part of Feasibility Study

Notes:

Section 4 of the RI Report contains a summary of exposure pathways and receptors, and a discussion of the screening levels used to evaluate the protectiveness of site conditions under these exposure conditions.

Figure 2-1
Conceptual Site Model – Part 1 of 2
(Log Pond and Waterway Areas)

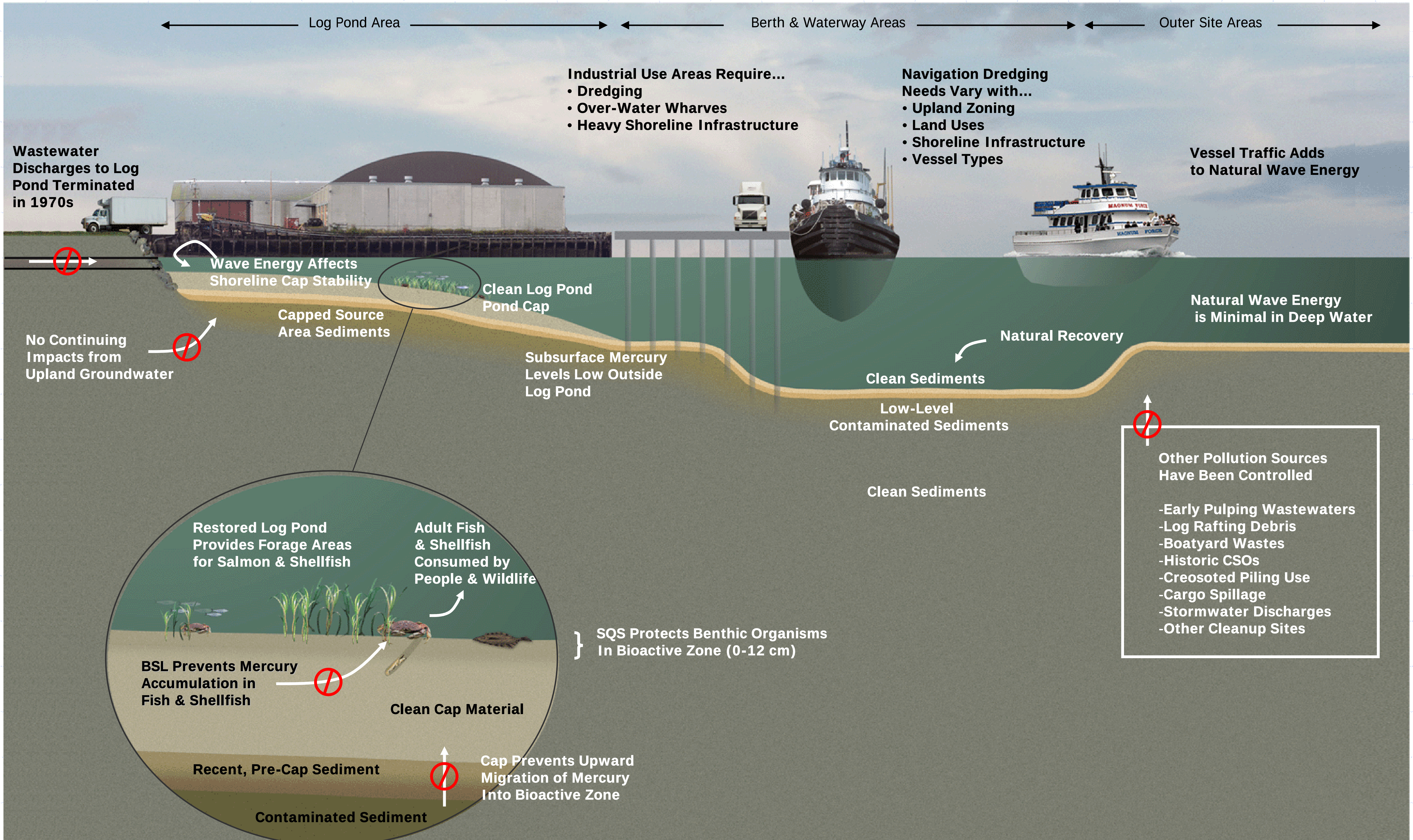
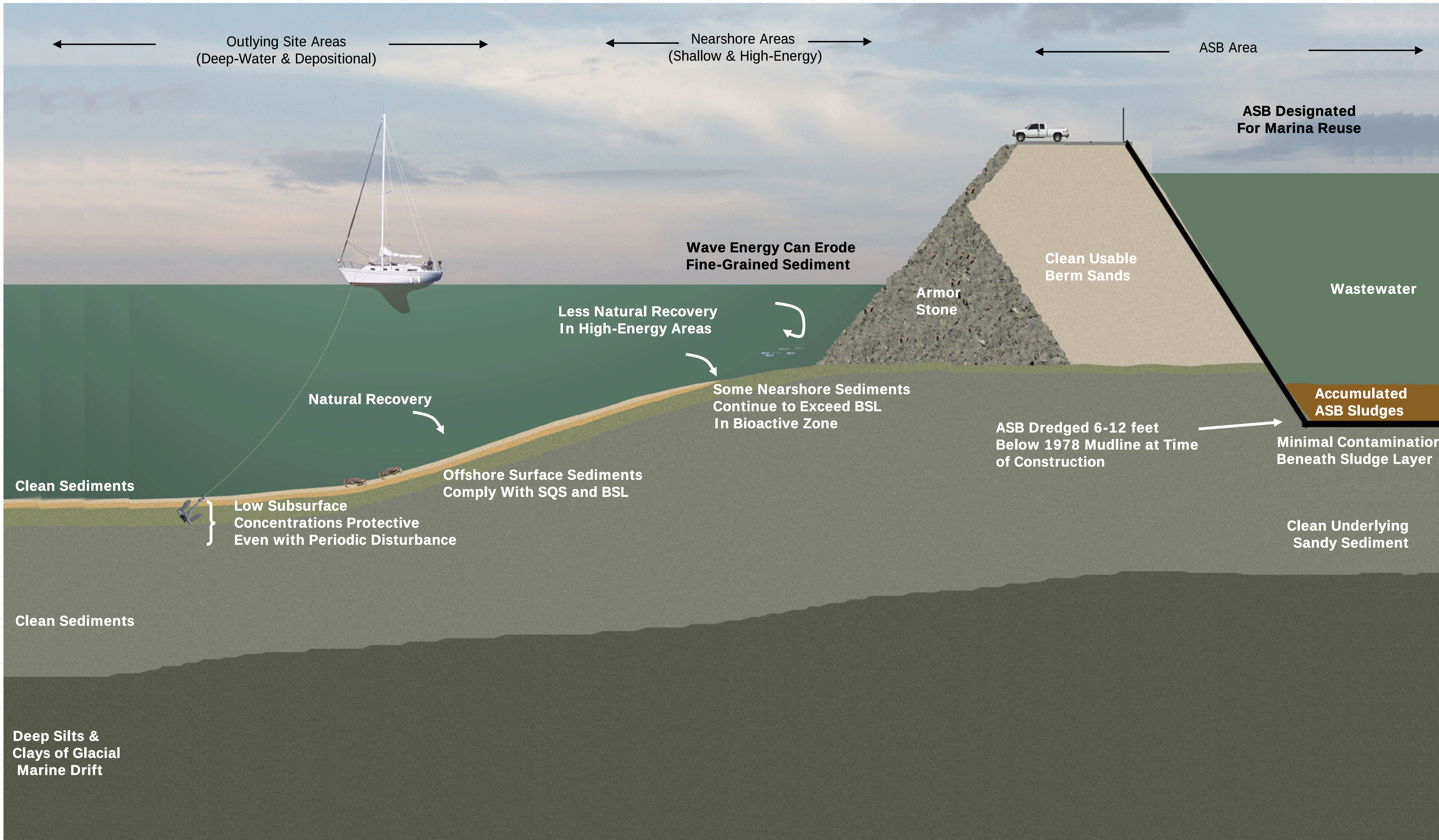
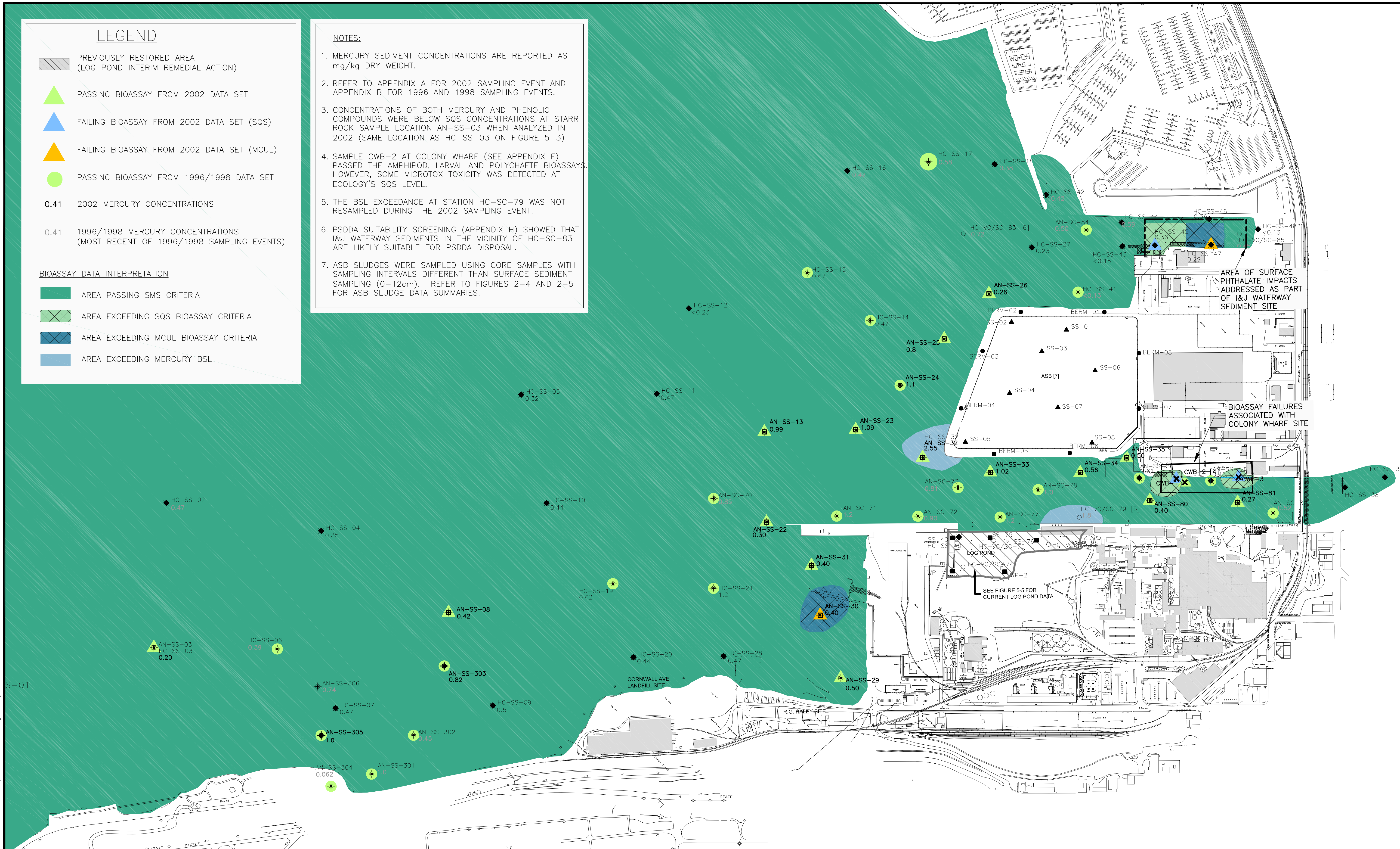


Figure 2-2
Conceptual Site Model – Part 2 of 2
(ASB and Outlying Site Areas)





LEGEND

- PREVIOUSLY RESTORED AREA (LOG POND INTERIM REMEDIAL ACTION)
- PASSING BIOASSAY FROM 2002 DATA SET
- FAILING BIOASSAY FROM 2002 DATA SET (SQS)
- FAILING BIOASSAY FROM 2002 DATA SET (MCUL)
- PASSING BIOASSAY FROM 1996/1998 DATA SET
- 0.41 2002 MERCURY CONCENTRATIONS
- 0.41 1996/1998 MERCURY CONCENTRATIONS (MOST RECENT OF 1996/1998 SAMPLING EVENTS)

BIOASSAY DATA INTERPRETATION

- AREA PASSING SMS CRITERIA
- AREA EXCEEDING SQS BIOASSAY CRITERIA
- AREA EXCEEDING MCUL BIOASSAY CRITERIA
- AREA EXCEEDING MERCURY BSL

NOTES:

1. MERCURY SEDIMENT CONCENTRATIONS ARE REPORTED AS mg/kg DRY WEIGHT.
2. REFER TO APPENDIX A FOR 2002 SAMPLING EVENT AND APPENDIX B FOR 1996 AND 1998 SAMPLING EVENTS.
3. CONCENTRATIONS OF BOTH MERCURY AND PHENOLIC COMPOUNDS WERE BELOW SQS CONCENTRATIONS AT STARR ROCK SAMPLE LOCATION AN-SS-03 WHEN ANALYZED IN 2002 (SAME LOCATION AS HC-SS-03 ON FIGURE 5-3)
4. SAMPLE CWB-2 AT COLONY WHARF (SEE APPENDIX F) PASSED THE AMPHIPOD, LARVAL AND POLYCHAETE BIOASSAYS. HOWEVER, SOME MICROTOX TOXICITY WAS DETECTED AT ECOLOGY'S SQS LEVEL.
5. THE BSL EXCEEDANCE AT STATION HC-SC-79 WAS NOT RESAMPLED DURING THE 2002 SAMPLING EVENT.
6. PSDDA SUITABILITY SCREENING (APPENDIX H) SHOWED THAT I&J WATERWAY SEDIMENTS IN THE VICINITY OF HC-SC-83 ARE LIKELY SUITABLE FOR PSDDA DISPOSAL.
7. ASB SLUDGES WERE SAMPLED USING CORE SAMPLES WITH SAMPLING INTERVALS DIFFERENT THAN SURFACE SEDIMENT SAMPLING (0-12cm). REFER TO FIGURES 2-4 AND 2-5 FOR ASB SLUDGE DATA SUMMARIES.

WHATCOM WATERWAY FEASIBILITY STUDY

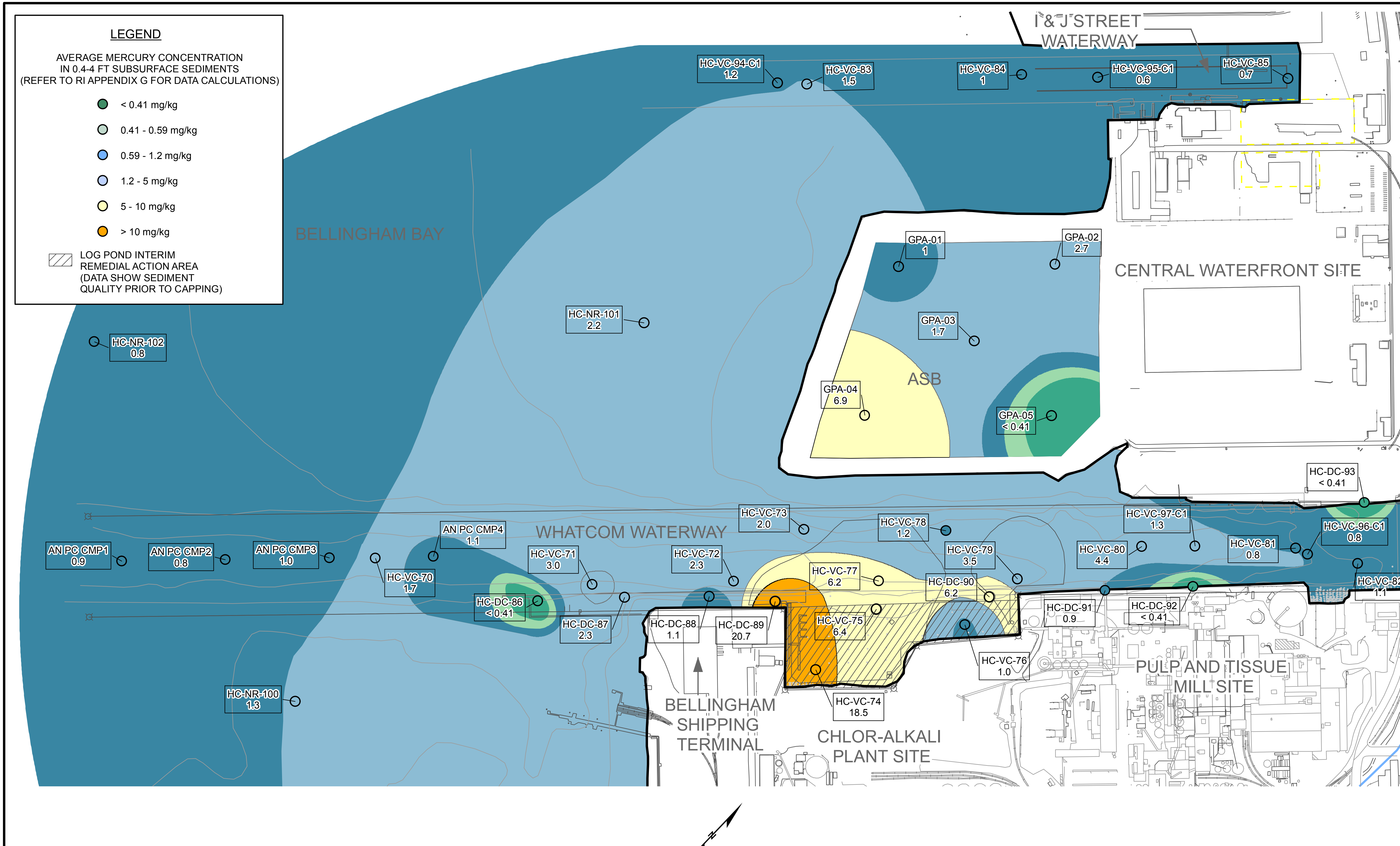
PORTB-18876

DATE: 09/25/06 DRWN: E.M./SEA

MOST RECENT SURFACE SEDIMENT BIOASSAY DATA AND BSL EXCEEDANCE AREAS

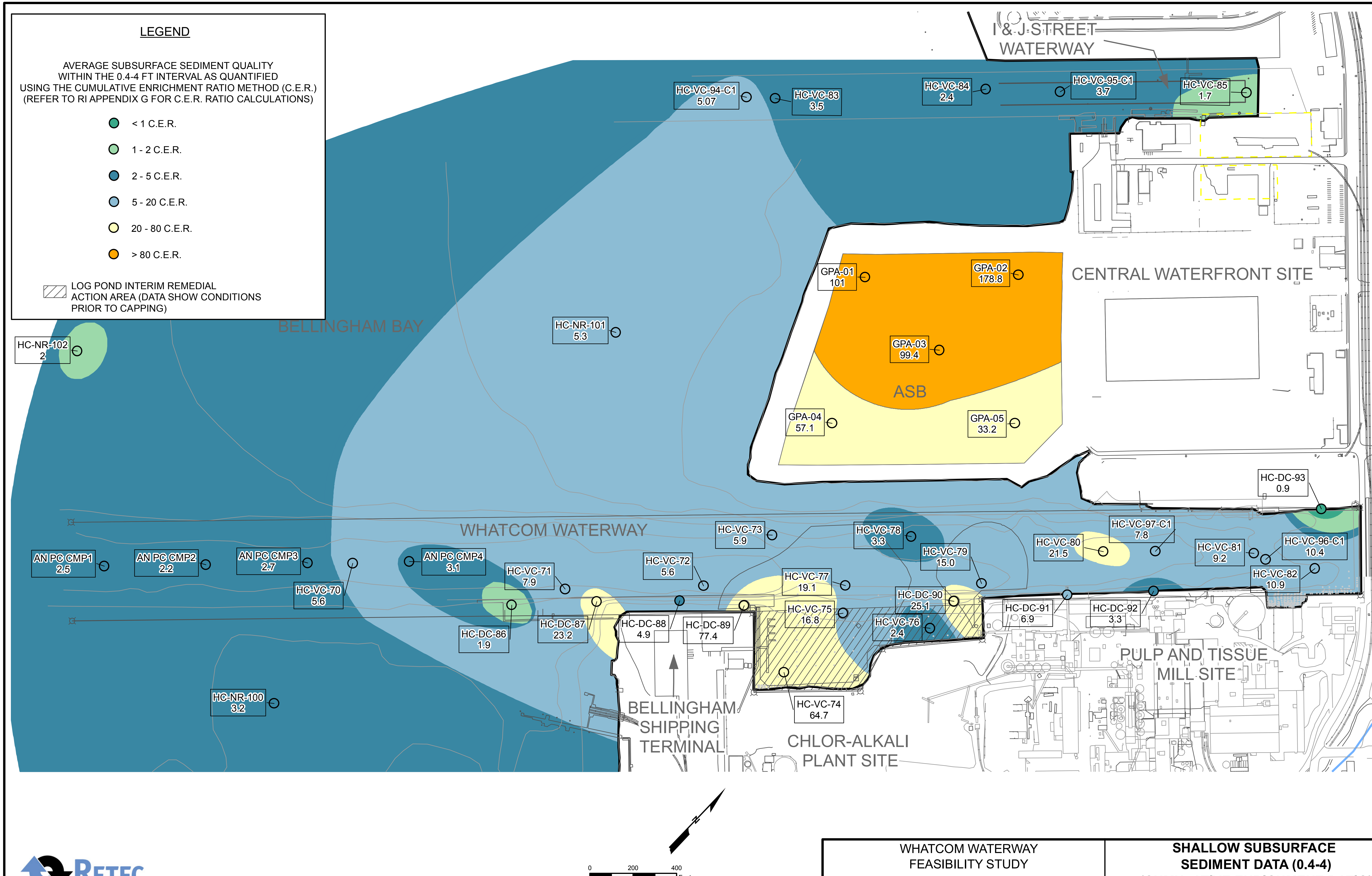
FIGURE 2-3

File: H:\18876\FEASIBILITY STUDY\18876S222.dwg Layout: FIGURE 2-3 User: emarshall Plotted: Oct 04, 2006 - 9:22am Xref's:



RETEC

WHATCOM WATERWAY FEASIBILITY STUDY PORTB-18876-240	SHALLOW SUBSURFACE SEDIMENT DATA (0.4 - 4') (MERCURY)
DATE: 9/19/06 · DWN. BY: KBL/ftc · FILE: T:/POB_WHATCOM/PROJECTS/erhg_HC.MXD	FIGURE: 2-4



RETEC

WHATCOM WATERWAY FEASIBILITY STUDY PORTB-18876-240	SHALLOW SUBSURFACE SEDIMENT DATA (0.4-4) (CUMULATIVE ENRICHMENT RATIO)
DATE: 9/19/06 DWN. BY: KBL/ftc FILE: T:/POB_WHATCOM/PROJECTS/CER_HC.MXD	FIGURE: 2-5

3 Cleanup Requirements

This section describes the cleanup requirements that must be met by the cleanup of the Whatcom Waterway site. Consistent with MTCA and SMS requirements, this section addresses three types of requirements:

- **Cleanup Levels (Section 3.1)**: Cleanup levels represent the numeric and/or narrative standards that must be met by a cleanup action in order for it to be considered successful. These standards are based on MTCA and SMS requirements.

- **Remedial Action Objectives (Section 3.2):** Remedial action objectives are narrative statements about the types of actions that must be performed to ensure compliance with the cleanup levels.

- **Potentially Applicable Laws (Section 3.3):** In addition to the requirements of the SMS and the MTCA, many other laws potentially apply to sediment cleanups.

These requirements are described below, and in the tables of this section. Technologies capable of meeting these requirements are then screened in Section 5, and cleanup alternatives are developed and ranked in Sections 6, 7 and 8.

3.1 Site Cleanup Levels

The Whatcom Waterway site is defined by contaminated sediment. Cleanup levels applicable to sediments are defined by SMS regulations as described in Section 3.1.1 below. Some cleanup alternatives may trigger the applicability of cleanup levels for other media, particularly soil and groundwater. These potentially-relevant cleanup levels are described in Section 3.1.2.

3.1.1 Sediment Cleanup Levels

SMS regulations govern the identification and cleanup of contaminated sediment sites and establish two sets of numerical chemical criteria against which surface sediment concentrations are evaluated. The more conservative Sediment Quality Standards (SQS) provide a regulatory goal by identifying surface sediments that have no adverse effects on human health or biological resources. The minimum cleanup level (MCUL) (equivalent to the Cleanup Screening Level or CSL), represents the regulatory level that defines minor adverse effects.

The SQS is Ecology's preferred cleanup standard, though Ecology may approve an alternate cleanup level within the range of the SQS and the MCUL if justified by a weighing of environmental benefits, technical feasibility, and cost. Chemical concentrations or confirmatory biological testing data may define compliance with the SQS and MCUL criteria.

The primary cleanup levels for the Whatcom Waterway site are defined as the SQS, as measured using bioassay testing procedures. Chemical numeric standards may also be used to evaluate SQS, but bioassays are given preference under SMS regulations because they are considered a more direct and representative measure of potential biological effects. The bioassay test methods that may be used to evaluate compliance with the SQS are defined in current Ecology regulations and guidance and include tests using the amphipod, larval or juvenile polychaete tests.

Based on the series of sediment investigations performed for surface and subsurface sediments in 1996, 1998, and 2002, the key constituents of concern for the sediments in the Whatcom Waterway site areas include mercury and phenolic compounds. The chemical SQS for mercury is 0.41 mg/kg. The chemical MCUL for mercury is 0.59 mg/kg. These levels apply to total mercury, which is the parameter measured directly in the RI chemical testing program. The main phenolic compound detected at elevated concentrations at the site was 4-methylphenol. The SQS and MCUL values for 4-methylphenol are both 0.67 mg/kg. The phenolic compounds phenol and 2,4-dimethylphenol were noted sporadically in surface sediments. The SQS and MCUL values for 2,4-dimethylphenol are both 0.029 mg/kg.

In addition to the evaluation of benthic effects and compliance with the SQS, cleanup levels at the site must protect against other adverse effects to human health and the environment, including food chain effects associated with the potential bioaccumulation of mercury. As described in the R I report, a site-specific BSL of 1.2 mg/kg mercury was developed as part of the RI/FS process. This BSL provides an area-wide average concentration of mercury in sediments that is protective of subsistence-level human consumption of seafood from Bellingham Bay. Bioaccumulation testing performed as part of the RI/FS and related studies has demonstrated that sediment mercury concentrations below this value do not present a risk of food chain effects to ecological receptors. Ecology has conservatively applied the BSL as a cleanup level that must be met for surface sediments within the site, whether or not the area-wide average concentration of mercury exceeds the BSL. This conservative application of the BSL by Ecology provides a substantial additional level of protectiveness to site cleanup decisions.

Consistent with the SMS regulations, sediment cleanup levels apply to the sediment bioactive zone. Previous studies performed as part of the RI/FS documented that this zone consists of the upper 12 centimeters of the sediment column. The cleanup levels do not directly apply to subsurface sediments, but remedial action objectives require that the potential risks of the exposure of deeper sediments be considered and be minimized through the implementation of the cleanup action.

3.1.2 Cleanup Levels for Other Media

Under certain remedial scenarios, the sediments at the site could also be regulated under other programs with regulatory cleanup levels different from SMS criteria, or could potentially impact other media. For example, if the sediments were excavated and were reused as upland soil, then MTCA soil and/or groundwater cleanup levels could be relevant. Additional criteria considered include state and federal water quality criteria, the Puget Sound Dredged Disposal Analysis program (PSDDA), the State of Washington Dangerous Waste Regulations, and the federal Resource Conservation and Recovery Act (RCRA). Table 3-1 summarizes cleanup levels for media other than sediment that may be applicable to various remedial alternatives.

3.2 Remedial Action Objectives

Based on the site conditions and current regulations, remedial goals applicable to the site include the following:

- **Surface Sediments**: Use appropriate technologies including active and/or passive measures to ensure compliance with site cleanup levels as defined in Section 3.1 for the sediment bioactive zone

- **Subsurface Sediments:** Where subsurface sediments have the potential to become exposed, use appropriate technologies including active and/or passive measures to ensure long-term compliance with site cleanup levels in the bioactive zone as defined in Section 3.1

- **Applicable Laws:** Ensure that implementation of the remedial action complies with other applicable laws.

These remedial action objectives are used in subsequent sections of the Feasibility Study to assist in the development, evaluation and ranking of remedial alternatives. The analyses conducted in Sections 7 and 8 of this report ensure that these remedial action objectives are achieved by the preferred remedial alternatives.

3.3 Potentially Applicable Laws

In addition to the requirements of the SMS and the MTCA, many other laws potentially apply to sediment cleanups. These other potential regulatory requirements are listed in Tables 3-1 through 3-3 and are discussed briefly below. Applicable laws will be discussed in further detail for the selected cleanup action at the time the Cleanup Action Plan is completed.

3.3.1 Project Permitting and Implementation

Table 3-2 summarizes regulatory requirements that may impact project permitting and implementation. For actions conducted under a MTCA Order or a Consent Decree, the project would be exempt from state and local permits and procedural requirements. However, MTCA requires compliance with the substantive provisions of these regulatory programs. MTCA does not contain a procedural exemption from federal permitting.

Construction projects are subject to environmental impact review under SEPA and/or NEPA regulations. The SEPA review for the cleanup of the Whatcom Waterway site is being completed by Ecology through the Draft Supplemental Bellingham Bay Comprehensive Strategy EIS; companion document to the RI/FS. NEPA review will be completed in the future at the time of project permitting by the Corps of Engineers.

The City is currently updating their State-mandated Shoreline Master Plan (SMP) which regulates and manages uses and activities within 200 feet of the shorelines of the City. Shoreline regulations defer to Ecology for site-specific review of cleanup actions conducted under MTCA, provided that those actions are consistent with the substantive requirements of the Shoreline Master Program. The City and Port are working with the Bellingham community to ensure that the land use vision articulated in the Waterfront Vision and Framework Plan is reflected in the SMP update. The SMP update is expected to be completed in early 2007.

As part of the Cleanup Action Plan development, a request will be made to the City of Bellingham and the Department of Fish and Wildlife for a written description of their substantive permit requirements for the preliminary selected remedy. This additional information will be included in the Cleanup Action Plan.

Federal permitting for in-water construction can be implemented under either a Federal 404 Individual permit, or under a Nationwide 38 permit. The federal permitting process includes review of issues relating to wetlands, tribal treaty rights, threatened and endangered species, habitat impacts, and other factors. It is anticipated that the cleanup of the Whatcom Waterway site will be performed using a Federal 404 Individual permit. Where appropriate, that permit will include related actions (e.g., updates to shoreline infrastructure, habitat enhancement projects).

3.3.2 Treatment and Disposal

Table 3-3 summarizes regulatory requirements potentially applicable to sediment treatment or disposal alternatives.

In-water containment, treatment, or disposal options are affected by a series of permits and evaluation criteria including those of the Clean Water Act and the Rivers and Harbors Act, as well as the Washington Hydraulics Code. Dredged material disposal at PSDDA disposal sites or beneficial use of dredged material are regulated by the Dredged Materials Management Program (DMMP) Guidelines.

Alternatives involving sediment disposal on state-owned lands require use authorizations from the Washington Department of Natural Resources (WDNR). These are provided consistent with requirements of state regulations and the state constitution. Where disposal occurs on private lands or as part of a multi-user disposal site, the disposal could be regulated by a series of agreements specific to that disposal facility. Use authorizations or other property-owner agreements can be required for some activities on privately-owned or state-owned aquatic lands.

As shown in Table 3-3, upland off-site disposal options are regulated under the state Solid Waste Regulations (WAC 173-303 and WAC 173-350). For alternatives involving sediment treatment or upland handling, air emissions regulations may apply. These requirements result in limitations on materials accepted by fixed treatment facilities. Requirements such as dust control result from these regulations for upland sediment handling activities.

Water Management

For remediation alternatives involving water generation, the discharge of generated waters may be regulated under state and federal regulations. Discharges from upland areas to surface waters require permits under restrictions of the National Pollutant Discharge Elimination System (NPDES) program. Discharges to the sanitary sewer are subject to pretreatment standards and local discharge standards and permitting.

Puget Sound Dredged Material Management Program

In Puget Sound, the open water disposal of sediments is managed under DMMP. This program is administered jointly by the US Army Corps of Engineers, the US Environmental Protection Agency, the WDNR, and Ecology. The DMMP has developed the PSDDA protocols which include testing requirements to determine whether dredged sediments are appropriate for open-water disposal. The DMMP has also designated disposal sites throughout Puget Sound. While some PSDDA characterization work has been performed at the Whatcom Waterway site, if a remedial alternative is ultimately selected by Ecology that includes PSDDA disposal of sediments, additional characterization work will be required. Use of PSDDA facilities would need to comply with other DMMP requirements including material approval, disposal requirements and payment of disposal site fees.

Solid Waste and Dangerous Waste Criteria

Sediments that are dredged and transferred to upland management may be subject to additional profiling requirements and/or other requirements under federal RCRA regulations and under Washington State Dangerous Waste regulations. However, as described in the RI, state-only toxicity designations and federal TCLP and listing criteria have been evaluated as part of the RI/FS activities and are not anticipated to impact Whatcom Waterway sediment disposition.

The Whatcom County Health Department has primary jurisdictional responsibility for the regulation of solid wastes in the county. They must implement, as minimum standards, the state Solid Waste Handling Standards (WAC 173-350).

The Solid Waste Handling Standards are applicable to and apply specific requirements and permitting for the handling of contaminated soils and "*contaminated dredged material*" (WAC 173-350).

- "*Contaminated dredged material*" means dredged material resulting from the dredging of surface waters of the state where contaminants are present in the dredged material at concentrations not suitable for open water disposal and the deredged material are not dangerous wastes and are not regulated by section 404 of the Federal Clean Water Act (P.L. 95-217).

Sediments managed in other Solid Waste facilities must comply with applicable permit requirements for the receiving facility. Some landfills may require elimination of free liquids from sediments prior to landfill disposal, whereas other facilities are permitted to accept wet sediments for use as daily cover.

Table 3-1 Potentially Applicable Laws —Cleanup Levels

Medium	Standard/Criterion	Citation	Comments and Substantive Requirements
Sediment	Criteria used to identify sediments that have no adverse effects on biological resources and correspond to no significant health risk to humans.	Sediment Management Standards (WAC 173-204)	As described in Section 3.1, cleanup levels apply to the sediment bioactive zone and shall include the SQS as measured using larval, amphipod and juvenile polychaete bioassay tests. The numeric SQS may be used to screen for potential compliance with the SQS if bioassays are not performed. Sediments must also achieve a mercury concentration in surface sediments less than the site-specific mercury BSL (1.2 mg/kg dry weight).
Surface Water	Requirements for establishing numeric or risk-based goals and selecting cleanup actions.	Model Toxics Control Act (WAC 173-340, Sections 720 and 730)	Anticipated to be relevant and appropriate to site remediation alternatives that create new upland (e.g., Alternative 3 creation of ASB fill). • Groundwater created within a fill area must comply with MTCA groundwater cleanup levels at the applicable point of compliance. For a confined nearshore disposal facility, this is assumed to require compliance with MTCA cleanup levels for surface water at the point that groundwater discharges to adjacent surface waters.
	Ambient water quality criteria for the protection of aquatic organisms and human health.	Federal Water Pollution Control Act/ Clean Water Act (CWA) (33 USC 1251–1376; 40 CFR 100–149) 40 CFR 131	MTCA requires the attainment of water quality criteria where relevant to the circumstances of the release. Groundwater within any potential confined nearshore disposal facilities would need to comply with AWQC values at the point of discharge into surface water. • Permitting for sediment cleanup action will define measures to be taken to comply with surface water standards during cleanup implementation.
	State water quality standards; conventional water quality parameters and toxic criteria.	Washington Water Pollution Control Act - State Water Quality Standards for Surface Water (RCW 90.48) WAC 173-201A-130	Narrative and quantitative limitations for surface water protection. • Permitting for sediment cleanup action will define measures to be taken to comply with surface water standards during cleanup implementation.
Soil and Groundwater	State cleanup levels for soils	Model Toxics Control Act (WAC 173-340, Section 740 and 745)	Potentially applicable if sediments are placed in upland areas. Proposed cleanup action does not involve upland reuse of soils.
	State cleanup levels for groundwater	Model Toxics Control Act (WAC 173-340, Section 720)	Potentially applicable if sediments are placed in upland areas. Proposed cleanup action does not involve upland reuse of soils.
	Federal criteria for drinking water	Safe Drinking Water Act (40 CFR 141, 143)	Upland placement of dredged sediments must not impact groundwater that is a current or potential source of drinking water. Proposed cleanup action does not involve upland reuse of soils.

Table 3-2 Potentially Applicable Laws —Project Permitting and Implementation

Location/Activity	Requirement/Prerequisite	Citation	Comments and Substantive Requirements
Evaluation of environmental impacts	Evaluation of project environmental impacts and definition of appropriate measures for impact mitigation	State Environmental Policy Act (SEPA; WAC 197-11), National Environmental Policy Act (42 WSC 4321 et seq.)	Project alternatives contemplated in the RI/FS have been analyzed as part of the companion EIS document, prepared consistent with the Bellingham Bay Demonstration Pilot Environmental Impact Statement Comprehensive Strategy. • Additional environmental review including NEPA compliance will be conducted as part of project permitting and implementation.
Construction Activities within 200 Feet of Shoreline	Construction near shorelines of statewide significance, including marine waters and wetlands.	Shoreline Management Act (WAC 173-14), Bellingham Bay Shoreline Master Program Coastal Zone Management Act (16 USC 1451 et seq.)	Two of the project alternatives involve creation of new sediment disposal sites. If these alternatives are selected for implementation, updates to the Shoreline Master Program will be required. The Bellingham Bay SMP is undergoing amendment by the City of Bellingham during 2006.
Construction in State Waters	Requirements for construction and development projects for the protection of fish and shellfish in state waters.	Construction in State Waters, Hydraulic Code Rules (RCW 75.20; WAC 220-1101),	State HPA permit required unless project implemented under MTCA Consent Decree or Order. Under Consent Decree substantive requirements would still be addressed. • Project implementation and permitting includes coordination with Washington Department of Fish And Wildlife staff. This coordination will address all substantive requirements of the HPA permitting process including information submittals and evaluation of potential mitigation requirements and definition of work procedures and timing. • Dredging, capping and other in-water work activities will be performed at appropriate times of the year to comply with fisheries protection requirements.

Table 3-2 Potentially Applicable Laws —Project Permitting and Implementation

Location/Activity	Requirement/Prerequisite	Citation	Comments and Substantive Requirements
		Rivers and Harbors Appropriation Act (33 USC 401, 40 CFR 230, 33 CFR 320, 322, 323, 325)	Army Corps 404 permit (or Nationwide permit)to be used for project implementation. • Project implementation includes Army Corps of Engineers permitting after final approval by Ecology of a Cleanup Action Plan.
Federal Channel	Project permitting for activities in the federal channel requires approval of the local sponsor and of the Corps of Engineers.	Port-DNR Memorandum of Understanding (December 2005) and Port Resolution 1230	Working with the Department of Natural Resources, the Port has requested that the Washington State Congressional Delegation to update the federal channel designations, including de-authorization of the federal channel in the Inner Waterway area, with future management of that area by the Port as a locally-managed, multi-purpose waterway.
Activities within/Adjacent to Wetlands	Actions must be performed so as to minimize the destruction, loss, or degradation of wetlands as defined by Executive Order 11990 Section 7. Requirement for no net loss of remaining wetlands.	Executive Order 11990, Protection of Wetlands (40 CFR 6, Appendix A) EPA Wetland Actions Plan. (January 1989, OWWP)	Project must result in no net loss or degradation of wetlands. Preferred alternatives identified in the RI/FS comply with the no net loss requirement. • Additional evaluations will be performed during project final design and permitting.
Impacts to Tribal Treaty Rights	United States treaties protect certain rights of recognized tribes of native Americans, including property rights, water rights and fish/shellfish gathering rights.	Treaty of Point Elliott (12 Stat. 927) Treaty of Medicine Creek (10 Stat. 1132)	Impacts to treaty rights are typically addressed during project permitting. Project alternatives evaluated in the RI/FS protect environmental quality at the site and result in no significant changes to site features. • Consultation with area tribal nations will be conducted during project permitting to ensure that there are no adverse impacts to tribal treaty rights.

Table 3-2 Potentially Applicable Laws —Project Permitting and Implementation

Location/Activity	Requirement/Prerequisite	Citation	Comments and Substantive Requirements
Endangered & Threatened Species	Actions must be performed so as to conserve endangered or threatened species, including consultation with the Department of the Interior.	Endangered Species Act of 1973 (16 USC 1531 et seq.) (50 CFR Part 200) (50 CFR Part 402)	Chinook salmon, bull trout and Orca whales have been listed as threatened species. Federal agencies must confer with NOAA Fisheries on any action that may impact listed species. • Project permitting will include compliance with ESA requirements, including consultation with state and federal permitting agencies, completion of a Biological Assessment, and incorporation of appropriate measures as required to avoid adverse impacts to endangered or threatened species.
Habitat Impacts and Mitigation	Policies and procedures have been established by state and federal agencies to evaluate and mitigate habitat impacts	Memorandum of Agreement between EPA and U.S. Army Corps of Engineers (Mitigation under CWA Section 404(b)(1), U.S. Fish & Wildlife Mitigation Policy (46 FR 7644), Fish and Wildlife Coordination Act (16 USC 661 et seq.), Washington Department of Fisheries Habitat Management Policy (POL-410), Compensatory Mitigation Policy for Aquatic Resources (Chapters 75.20 and 90.48 RCW) Bellingham Bay Demonstration Pilot Habitat Mitigation Framework	Mitigation requirements for projects are defined in project permitting and vary with the type of work conducted. The preferred alternatives identified in the RI/FS have been designed to achieve a net gain of sensitive or critical habitats. The need for significant mitigation over-and-above that already included in the RI/FS alternatives is considered unlikely. • Project final design and permitting (e.g., as part of the Biological Assessment performed during project permitting) will include evaluation of project impacts and definition of any mitigation required or appropriate to the work being performed.

Table 3-2 Potentially Applicable Laws —Project Permitting and Implementation

Location/Activity	Requirement/Prerequisite	Citation	Comments and Substantive Requirements
Health and Safety	Development of a health and safety plan with appropriate controls, worker certifications and monitoring	WISHA (WAC 296-62) OSHA (29 CFR 1910.120)	Relevant requirement for environmental remediation operations. • All work activities performed at the site will comply with OSHA/WISHA requirements. • Project final design will include definition of contractor safety requirements, including preparation and compliance with a project Health and Safety Plan, worker training and record-keeping requirements, and other applicable measures.

Table 3-3 Potentially Applicable Laws —Treatment and Disposal

Activity	Requirement	Citation	Comments and Substantive Requirements
In-Water Sediment Disposal or Capping	Army Corps of Engineers Permitting requirements	Sections 401 and 404 of the Clean Water Act (40 CFR 230; & 33 CFR 320, 323, 325 and 328) Section 10 of the Rivers & Harbors Act (33 CFR 320 & 322)	Permitting requirements for discharges into waters of the United States Permitting requirements for dredging or disposal in navigable waters of the United States. • Project implementation includes Army Corps of Engineers permitting to be initiated after development of a final Cleanup Action Plan.
	State HPA permitting	Washington Hydraulics Code (WAC 220-110)	Permitting for work that would use, divert, obstruct or change the natural flow or bed of any salt or fresh waters. • Project implementation and permitting includes coordination with Washington Department of Fish And Wildlife staff. This coordination will address all substantive requirements of the HPA permitting process including evaluation of potential mitigation requirements and definition of work procedures and timing. • Dredging, capping and other in-water work activities will be performed at appropriate times of the year to comply with fisheries protection requirements.
	PSDDA Characterization and Permitting Procedures	Dredged Material Management Program Guidelines (RCW 79.90; WAC 332-30)	Characterization and permitting process for sediments destined for unconfined open-water disposal. • Selected sediments from the site may be characterized and authorized for PSDDA disposal and/or beneficial reuse. • Project implementation will follow PSDDA procedures including obtaining DNR use authorization for sediment disposal at the PSDDA site.
	Multi-User Disposal Site Operating Agreements	Typically the use of multi-user disposal sites is governed by site-specific permits and/or agreements.	The RI/FS does not contemplate use of a multi-user disposal site for sediment disposal.

Table 3-3 Potentially Applicable Laws —Treatment and Disposal

Activity	Requirement	Citation	Comments and Substantive Requirements
	Rules for management of state-owned aquatic lands	State Aquatic Lands Mangement Laws (RCW 79.90 through 79.96; WAC 332-30) State Constitution (Articles XV, XVII, XXVII) Public Trust Doctrine	Sediment disposal, if performed on state-owned aquatic lands, must not be in conflict with state regulations. • Project implementation for PSDDA sediment disposal will follow PSDDA procedures including obtaining DNR use authorization for sediment disposal at the PSDDA site. • If beneficial reuse of sediment is performed on state-owned lands, a sediment use authorization will be obtained. • Sediment capping on state-owned lands, if performed as part of the remedy, will comply with rules for management of state-owned aquatic lands.
Upland Disposal of Dredged Sediments	State criteria for dangerous waste (which are broader than federal hazardous waste criteria)	Washington Dangerous Waste Regulations (WAC 173-303) Designation procedures (Section -070)	State and federal laws prohibit land disposal of certain hazardous or dangerous wastes. • Sediments managed by upland disposal will comply with disposal site criteria. Based on existing characterization data, none of the materials to be managed by upland disposal appear to be Dangerous Wastes. • The need for additional waste profiling will be addressed as part of the engineering design for the project.
	Requirements for solid waste management.	Solid Waste Disposal Act (42 USC Sec. 325103259, 6901-6991), as administered under 40 CFR 257, 258; WAC 173-304, Minimum Functional Standards for Solid Waste Handling. WAC 173-350. Solid Waste Handling Standards.	Applicable to non-hazardous waste generated during remedial activities and disposed of off site unless wastes meet recycling exemptions. • Sediments managed by upland disposal will comply with disposal site criteria. RI/FS alternatives are based on existing permitted facilities that are compliant with these regulations and are permitted to accept impacted dredged materials. • Upland beneficial reuse of sediments which would be regulated under WAC 173-350 is not contemplated under any of the alternatives evaluated in the RI/FS.
Air Emissions	State implementation of ambient air quality standards. NWAPA ambient and emission standards.	Washington State Clean Air Act (70.94 RCW) General Requirements for Air Pollution Sources (WAC 173-400)	Potentially applicable to alternatives involving sediment treatment or upland handling. • On-site treatment of dredged materials using methods that may require an air pollution control permit is not contemplated in the RI/FS alternatives. • Off-site sediment handling and/or treatment/disposal facilities contemplated for use under the RI/FS alternatives comply with applicable air regulations and maintain appropriate permits. • Permitting requirements and compliance of facilities used for dredged material management will be reviewed as part of project final design.

Table 3-3 Potentially Applicable Laws —Treatment and Disposal

Activity	Requirement	Citation	Comments and Substantive Requirements
Wastewater	Permitting & treatment requirements for direct discharges into surface water.	National Pollutant Discharge Elimination System (NPDES) (40 CFR 122, 125) State Discharge Permit Program; NPDES Program (WAC 173-216, -220)	Anticipated to be relevant only if collected waters are discharged to on-site water body. Discharges must comply with substantive requirements of the NPDES permit. Applicable for off-site discharges; a permit would be required. • Construction stormwater requirements will be satisfied for upland handling of sediment, including development of a Storm Water Pollution Prevention Plan and implementation of best management practices. • NPDES program requirements will be reviewed as part of project final design.
	Permitting & pre-treatment requirements for discharges to a POTW	National Pretreatment Standards (40 CFR 403); City of Bellingham Wastewater treatment requirements	Discharges to POTWs are considered off-site activities; pretreatment and permitting requirements would be applicable. • Alternatives include water pretreatment and POTW discharge. Such work would be subject to POTW permitting and pre-treatment standards. Project design and implementation must incorporate waste characterization, pretreatment and permitting. • Permitting requirements will be reviewed as part of project final design.

4 Sediment Site Units

This FS evaluates potential cleanup alternatives for the Whatcom Waterway site. At most cleanup sites, the application of remediation technologies varies across the site, with different technologies being applied to appropriate site areas to accomplish overall site remediation. The division of the site into different areas or "Sediment Site Units" is performed in this section consistent with the requirements of the Sediment Management Standards. In accordance with the SMS, these units are "based on consideration of unique locational, environmental, spatial, or other conditions" (WAC 173-204-200(25)).

This section describes the sediment site units (site units) that are used for the FS, and discusses the characteristics of each of those units. Key characteristics of each site unit that are relevant to the application of remedial technologies and/or the evaluation of remedial alternatives are discussed. These characteristics are described in four groups:

- **Physical Factors** including bathymetry, sediment particle size and texture, wood material distribution, wind and wave energies, and the characteristics of adjacent shorelines

- **Land Use and Navigation** including upland zoning, shoreline infrastructure, navigation uses, natural resources, ongoing waterfront revitalization activities, and potential interrelationships between cleanup considerations and these factors

- **Natural Resources** including the types of existing aquatic habitats within the site unit

- **Contaminant Distribution**, including patterns of surface and subsurface contamination and relative contaminant concentrations.

Figure 4-1 shows the Whatcom Waterway site units used in this FS. These site units are generally consistent with the site units used in previous FS analyses performed in 2000 and 2002. Site units have been numbered 1 through 8 as shown on Figure 4-1. Characteristics of each of the site units are described below.

4.1 Outer Whatcom Waterway (Unit 1)

The Outer Whatcom Waterway includes portions of the Whatcom Waterway located offshore of the Bellingham Shipping Terminal. Unit 1 is divided into three subareas:

- **Units 1A and 1B:** These sub-areas are located offshore of the Bellingham Shipping terminal and connect the outer portions of the Whatcom Waterway to deepwater areas of Bellingham Bay

- **Unit 1C:** This portion of the Waterway is located immediately adjacent to the Bellingham Shipping Terminal. Based on bathymetry, this unit is subdivided into Units 1C1, 1C2 and 1C3.

4.1.1 Physical Factors

The Outer Whatcom Waterway consists of deep-water areas of the Whatcom Waterway navigation channel. Current water depths in this area vary from approximately 30 feet to greater than 36 feet. These depths are largely the result of historical dredging activities in the Waterway.

Sediments in the Outer Waterway are dominated by fine particle size distributions (silts and clays), with a total fines content generally greater than 80 percent. The TOC content of the sediments is generally between 1 and 5 percent, consistent with average TOC distribution for the site.

The bathymetry in most areas of the Outer Waterway is relatively flat, with slopes flatter than 10H:1V. However, slopes become significant along the outer edges of the Waterway, including at the Bellingham Shipping Terminal. The shoreline at the Bellingham Shipping terminal is an engineered slope, including a pile-supported concrete bulkhead and areas of armored slope.

4.1.2 Land Use and Navigation

Navigation uses in Units 1A and 1B of the Outer Waterway are largely transitory, with vessels entering and exiting the Waterway. Vessels are generally not anchored in these areas, and there are no permanent dock structures or mooring dolphins.

In contrast, the areas of Unit 1C include berths for vessels at the Bellingham Shipping Terminal. Propwash effects from vessel traffic are potentially significant at Unit 1C from vessel berthing activities, including both operations of tug boats and potentially the use of bow thrusters on some vessels. Some areas of coarse sediment have been identified along the Unit 1C shoreline near the berth, consistent with fines redistribution common with prop wash effects. Shell accumulations common in berth areas (caused by shells falling from sea life encrusted on dock pilings) may also affect observed particle sizes in this area.

A federal navigation channel is located in the Outer Waterway. As described in the RI Report, federal navigation channels represent a conditional agreement between the Corps of Engineers and a local entity (the "local sponsor," in this case the Port of Bellingham) under which the federal government shares the cost and assists with the implementation of certain defined navigation maintenance activities. The limits of the federal commitment are defined geographically by the dimensions of the "project." For the Outer Waterway, the project depth is defined as 30 feet below mean lower low water (MLLW) and the width varies from 263 feet in Unit 1C to 363 feet in Units 1A and 1B.

Figure 4-2 illustrates the essential characteristics of the federal channel and berth areas applicable to Unit 1C of the Outer Waterway. The water depths are maintained at or slightly below the "project depth" of 30 feet in the federal channel areas. The federal channel boundaries are offset from the wharf areas by approximately 50 feet. This "berth" area is defined along the inshore edge by the "pierhead line" and along the offshore edge by the federal channel boundary. Depths in this area are maintained by local interests. Construction is generally prohibited in areas offshore of the pierhead line, and is regulated by the Corps of Engineers and the Coast Guard.

As shown in Figure 4-2, the maintenance of water depths and navigation access in the Unit 1C berth area requires maintenance of substantial shoreline infrastructure. That infrastructure includes bulkheads, engineered armored slopes and over-water wharves that provide for mooring and loading/unloading of vessels moored at the berths. In order to meet the economic needs test of the Corps of Engineers maintenance dredging program, upland land uses are restricted and are designated in Unit 1-C for appropriate water-dependent uses, consistent with the federal channel designation.

The Bellingham Shipping Terminal has been used since the early 1900s for cargo shipping and warehousing activities. The Port recently completed an analysis of federal channel and infrastructure issues in development of Port Commission Resolution 1230 in May of 2006. That Resolution affirmed the intent of the Port to preserve and maintain the current federal channel dimensions in the Outer Waterway area to support deep draft navigation and commercial uses (e.g., use by appropriate institutional users such as the Coast Guard or NOAA). The shoreline infrastructure required for operation of a shipping terminal is present in this area, though significant maintenance and potential upgrades may be required prior to resumption of deep draft uses.

4.1.3 Natural Resources

The areas of the Outer Waterway are composed largely of deepwater aquatic areas. No areas of existing premium nearshore aquatic habitat (shallow-water habitat with appropriate elevation, substrate, wave energy and other characteristics to maximize the benefits of the habitat to juvenile salmonids) are located in the Outer Waterway area. Shallow-water nearshore habitats in the Outer Waterway area are limited to under-dock areas along the Bellingham Shipping Terminal.

4.1.4 Contaminant Distribution

Surface sediments within the Outer Waterway comply with the SMS. All of the surface samples collected recently in this area have passed bioassay testing

(Figure 2-3), and no exceedances of the site-specific BSL for mercury were noted in the most recent sampling round.

Subsurface sediment concentrations in the Outer Waterway are generally quite low (Figures 2-4 and 2-5). As described in Section 7.2 of the RI Report, previous sediment testing suggests that the sediments in Units 1A and 1B may be suitable for open-water disposal or beneficial reuse. In the areas of Unit 1C, sediment contaminant levels are higher, likely precluding these sediments from open water disposal.

4.2 Inner Whatcom Waterway (Units 2 and 3)

The Inner Waterway extends from the Bellingham Shipping Terminal to the head of the Waterway at Roeder Avenue. The Roeder Avenue Bridge crosses the waterway at that location and precludes navigation further upstream. The Inner Waterway has been subdivided into two units designated “Unit 2” and “Unit 3.” Each of these site units has been further subdivided:

- **Unit 2A:** Shoaled areas at the head of the 30-foot portion of the 1960s federal navigation channel
- **Unit 2B:** An area between the Whatcom Waterway and the ASB that has been considered for future construction of an access channel as part of ASB marina reuse
- **Unit 2C:** Deep areas of Unit 2, including portions of the federal channel where water depths currently exceed 24 feet below MLLW
- **Unit 3A:** An emergent tideflat area located at the head of the Waterway, adjacent to the Roeder Avenue Bridge
- **Unit 3B:** The shoaled area of the 18ft federal channel in between the emergent tideflat of Unit 3A and Unit 2A.

The characteristics of these Inner Waterway areas are described below.

4.2.1 Physical Factors

The water depths within the Inner Waterway vary greatly. Existing water depths range from greater than 30 feet below MLLW, to intertidal areas that are exposed at low tide. Areas of shallow-water habitat are predominantly located in Unit 3A at the head of the channel and along the berth areas on either side of the federal channel.

The bathymetry of the federal channel is relatively flat. However, sideslopes along either side of the waterway steepen in the berth areas. Historically these side-slopes were hardened with infrastructure for industrial water-dependent uses. Most shorelines include armored slopes, bulkheads and over-water wharves. However, much of the Inner Waterway shoreline infrastructure is in fair to poor condition. In portions of the Central Waterfront, bulkheads have failed in part or in full, and portions of wharves have collapsed. The state of repair for shoreline infrastructure varies parcel by parcel along the waterway.

Currently, the effective water depths for the Inner Waterway are controlled by the restrictions of the federal navigation channel. Construction is not allowed past the pierhead line, so the water depths at the pierhead line establish the effective water depth for the Inner Waterway. That effective water depth varies from less than zero (in areas where sediments at the pierhead line have shoaled and are exposed at low tide) to a maximum of approximately 22 feet below MLLW. Though the project depth for portions of the federal channel is 30 feet, this depth is not currently maintained in any berth areas, and is not supported by requisite shoreline infrastructure in most areas. Most of the shoreline infrastructure in the Central Waterfront area and near the head of the waterway was established when the waterway project depth was 18 feet. The ability to establish and maintain the full project depth is restricted by the relatively narrow width of the waterway and the existing shoreline conditions.

Sediment texture in the Inner Waterway is generally dominated by fine sediments. The total fines content of Inner Waterway sediments is generally in excess of 80 percent. However, berth areas are armored with rubble, asphalt debris and armor stone in most areas. Sand and gravel are present in some emergent tideflat areas at the head of the waterway, and in beach areas alongside portions of the waterway.

Whatcom Creek enters the Whatcom Waterway upstream of the Roeder Avenue Bridge. Salinities of the inner waterway vary with tide stage and flood level of Whatcom Creek, as freshwater discharges from the creek and mixes with saline waters of Bellingham Bay.

4.2.2 Land Use and Navigation

Like the Outer Waterway, the Inner Waterway has historically been used for industrial water-dependent uses. As described in the RI Report (Section 3.3.3) the federal navigation channel was initially established in the early 1900s, and was updated most recently in 1958 in support of industrial waterfront uses. Portions of the Inner Waterway were deepened in the 1960s to comply with the updated channel dimensions, but other portions were never deepened due to the lack of supporting berth area water depths and requisite shoreline infrastructure. The width of the Waterway is constrained by developed fill areas and upland features adjacent to the Waterway.

As described in the RI Report, the Port recently completed an analysis of federal channel and infrastructure issues in development of Port Commission Resolution 1230 during May of 2006. That Resolution was developed in response to inconsistencies between the community revitalization objectives as articulated in the Waterfront Futures Group Vision and Framework Plan, and the land use constraints associated with the federal channel within the Inner Waterway area. Specifically, the Resolution stated that the development of new industrial land uses, deep berthing areas, shoreline bulkheads and deep draft navigation infrastructure as required to establish a federal interest in future channel maintenance in this area is inconsistent with the community vision for multiple waterfront uses in the Inner Waterway area, including public shoreline access, habitat enhancement, transient moorage and mixed-use redevelopment. The Resolution articulated that greater benefits could be achieved through operation of a locally-managed, multi-purpose channel in the Inner Waterway, in a manner responsive to the community vision. The Port Resolution followed a previous Port and DNR Memorandum of Understanding completed during 2005, including a proposal to update harbor area and Whatcom Waterway channel dimensions.

Port Resolution 1230 proposed that the portion of the federal navigation channel within the Inner Waterway be de-authorized, and subsequently managed as a locally managed multi-purpose channel from the Bellingham Shipping Terminal inward to the Roeder Avenue Bridge. The Port formally requested the Washington State Congressional Delegation to include language in appropriate legislation to de-authorize the Inner Waterway portion of the Whatcom Waterway federal channel. Congressional approval of de-authorization is expected to occur during late 2006. The de-authorization will not affect the Outer Waterway (i.e., the area at and offshore of the Bellingham Shipping Terminal).

Figure 4-3 illustrates the type of shoreline infrastructure that has been considered for the Inner Waterway as part of Port marine infrastructure planning efforts. The figure was developed by the Port as part of the federal channel and marine infrastructure review activities during 2005 and 2006. The design concept (Figure 4-3) includes shoreline public access and navigation improvements compatible with area mixed use zoning and redevelopment planning. The use of softened shorelines along the sides of the waterway, rather than industrial wharves and bulkheads, has been proposed to help restore natural shoreline functions where compatible with planned navigation uses. Navigation depths within the Inner Waterway are to be maintained appropriate to the channel widths and updated shoreline infrastructure, and would most likely range between 18 to 22 feet below MLLW. During the Bellingham Demonstration Pilot, the area within Unit 3A was identified as a priority location for maintenance and enhancement of premium shallow-water habitat. A former wharf structure was removed by the City as part of cleanup and restoration actions in this area. Preservation of the emergent tideflat in this area was proposed as part of the preferred alternative from the 2000 EIS, and its preservation was referenced as part of the materials supporting Port Resolution 1230.

Throughout much of the Inner Waterway, the historic industrial infrastructure present along the shorelines results in lower-value habitats in nearshore areas, due to the presence of shading, over-water structures, bulkheads and steep armored slopes. The stated objectives of Port Resolution 1230 and its supporting materials were to support the implementation of habitat enhancement and salmon recovery efforts within the Inner Waterway, including the replacement of industrial shoreline infrastructure with shoreline treatments such as those in Figure 4-3 where practicable.

The navigation needs associated with Unit 2B are controlled by the future reuse of the ASB. As described below, the ASB area has been identified in Port and City planning efforts for development of a new waterfront marina. Planning efforts have focused on the ability to develop an environmentally sustainable marina, including integrated public access and habitat enhancement elements in the design concept. All of the recent design concepts for the marina (Figure 4-4) have identified Unit 2B as the optimum location for construction of a marina access channel. This location is preferred because it minimizes the disruption of shallow-water habitat areas (current features and potential future habitat enhancements) offshore of the ASB, and it would make use of existing navigation infrastructure within the Whatcom Waterway.

4.2.3 Natural Resources

The Inner Waterway includes a mixture of deepwater areas, and areas of emergent shallow-water habitat. Shallow-water habitat areas at the head of the Waterway and along portions of its sides are valuable forage and refuge areas as part of migration corridors for juvenile salmonids.

The preservation and enhancement of these areas was identified as a priority action under the Demonstration Pilot. However, the ability to accomplish this action is subject to balancing of habitat needs with infrastructure and navigation requirements.

4.2.4 Contaminant Distribution

With the exception of localized areas adjacent to the Colony Wharf site, surface sediments within the Inner Waterway comply with SMS bioassay criteria. Mercury concentrations are in most cases below the site-specific BSL (see Figure 2-3). While subsurface contaminant concentrations are relatively low (Figure 2-4 and 2-5), previous testing has indicated that sediments removed from the Inner Waterway are unlikely to be suitable for open water disposal or beneficial reuse (RI Report, Section 7.2).

4.3 Log Pond (Unit 4)

The Log Pond area was remediated as part of an Interim Remedial Action, completed by GP in 2000 and early 2001. The Log Pond action included placement of a sediment cap to remediate site sediments, and additional actions to enhance nearshore aquatic habitat in that area. Multiple rounds of monitoring have been performed, documenting the success of that action, including Year 1, Year 2 and ongoing Year 5 monitoring. However, some enhancements to shoreline edges of the Interim Action cap are required to minimize potential cap erosion, and enhance the long-term stability of the cap. These additional actions are described in Appendix D of this Feasibility Study.

4.3.1 Physical Factors

The Log Pond was created as various fills were placed around the area. It was used for log handling and was the location of the original wastewater outfall from the GP chlor-alkali plant to Bellingham Bay, prior to construction of the ASB. An interim cleanup action consisting of the construction of a combination sediment cap and habitat enhancement was completed in the GP Log Pond in 2001.

Prior to the Interim Action, the Log Pond had a bottom elevation that was typically approximately -10 feet MLLW, with slopes up to the shorelines, and down to approximately -26 feet MLLW at the intersection with the Whatcom Waterway. During the Interim Action, approximately 42,000 cubic yards of sediment were placed, with thicknesses ranging up to 6 feet, with a typical design thickness of greater than 3 feet, and an average thickness as placed of 3 to 4 feet. This brought the bottom elevation up so that it was generally on the order of -3 to -4 feet MLLW, and sloped up to the shorelines, and down to the Whatcom Waterway.

Currently, there are very few structures within the Log Pond. A pile-supported conveyor system exists along the Bellingham Shipping Terminal shoreline, a dolphin (i.e., cluster of pilings) is located within the log pond, and there are numerous pilings along the shoreline. A wharf extends to the southwest, in front of the Log Pond along a portion of the Waterway.

The shoreline prior to the interim action was generally composed of riprap and concrete rubble slopes and wooden and steel sheet-piling bulkheads down to a depth of approximately -5 feet MLLW. These shorelines were left in place through construction.

The sediments in the GP Log Pond prior to the interim action ranged from sandy to very sandy organic silt and clay with a slightly clayey sand with some gravel near the shoreline. The solids content of the sediments ranged from approximately 25 to 40 percent, with an average around 30 to 35 percent. In the northeast end of the pond, a large (>50 percent) content of shell fragments was noted.

The material placed as part of the Interim Action consisted of beneficially reused dredge materials from two sources. The first was navigational dredging spoils from the Swinomish Channel near La Conner, Washington. This material was a sand, with less than 4 percent fines, and 1 to 8 percent gravel. The other material used was dredge material from the Squalicum Creek Waterway in Bellingham. This material was generally classified as a silty clay. A grab sample taken during the 2001 construction indicated that the material was an organic clay, and contained 5 percent sand, 78 percent silt, and 17 percent clay.

TOC concentrations in the GP Log Pond prior to the interim action ranged from 2.7 to 15 percent, with an average of approximately 6 to 10 percent. TOC measurements were not made of the Swinomish Channel materials. The Squalicum Creek materials were approximately 1.5 to 1.7 percent TOC. The current surface in the GP Log Pond is largely these Squalicum Creek materials.

As described in Appendix D, the Log Pond is partially sheltered from prevailing winds. However some westerly winds can enter the Log Pond and subject portions of the shoreline to erosive forces. Remaining areas of the shoreline are protected from these wind and wave forces, though northerly winds and vessel wakes can produce some smaller waves. Cap monitoring has shown good long-term stability for the majority of the cap area. Some erosion effects have been noted in limited shoreline areas of the cap. Enhancements to the shoreline conditions to provide for long-term stability of these areas under site wind and wave conditions are presented in Appendix D and will be implemented as part of the final remedial action for the site.

4.3.2 Land Use and Navigation

As its name implies, Unit 4 was historically used as a log pond for lumber and pulp mill operations. These uses have been discontinued since the Interim Remedial Action.

The Log Pond has been designated for cleanup and habitat restoration uses. Some public access enhancements to upland shoreline areas are likely as part of future New Whatcom redevelopment activities. These uses would likely include development of a shoreline promenade along portions of the Log Pond. No in-water navigation uses are contemplated for the Log Pond, with the exception of potential use by small hand-carry boats (i.e., kayaks).

4.3.3 Natural Resources

Monitoring of the Log Pond Interim Action cap has confirmed the use of the restored area by juvenile salmonids, juvenile Dungeness crabs and other aquatic organisms and marine mammals.

Some eel grass colonization has occurred since implementation of the Interim Action. However, the colonization has been limited to date to a relatively small number of established blades. A pilot program has been funded under the Bellingham Bay Demonstration Pilot to enhance natural colonization rates through seeding of the area with eel grass. This pilot test is ongoing.

4.3.4 Contaminant Distribution

As described in Appendix I of the RI Report, the Log Pond Interim Action has attained compliance with surface sediment cleanup levels throughout most of the area. No migration of contaminants upward through the cap or through cap porewater has been observed.

A localized area of recontamination was noted in the southwest corner of the Log Pond, adjacent to an area of shoreline not included in the Interim Action cap boundaries. As described in Appendix D, shoreline enhancements to this area will be performed as part of the final remedial action, including extension of the cap area to include this adjacent area, and placement of appropriately-graded materials to ensure long-term stability of the cap edges.

4.4 Areas Offshore of ASB (Unit 5)

The area offshore of the ASB is a relatively shallow-water area, the majority of which has not been dredged for navigation uses. This area of the site is designated as Unit 5. Unit 5 is subdivided in to three subareas:

- **Unit 5A:** Deeper water areas offshore of the ASB
- **Unit 5B:** High-energy nearshore areas on the "shoulder" of the ASB. Some sediments within this area have mercury concentrations that remain above site cleanup levels
- **Unit 5C:** Shallow-water areas along the southeastern shoulder of the ASB, adjacent to the Inner Waterway.

4.4.1 Physical Factors

Water depths within Unit 5 vary by area. In Unit 5B the depths are shallow, ranging from approximately 6 feet to approximately 12 feet below MLLW. Similarly, Unit 5C water depths are shallow, ranging from approximately 2 feet below MLLW along the edge of the ASB, to depths of approximately 18 feet below MLLW along the Whatcom Waterway.

Water depths in Unit 5A vary from relatively deepwater (up to 26 feet below MLLW) offshore areas, to shallow water areas adjacent to the ASB (as shallow as 4 feet below MLLW. Depths shoal gradually, consistent with natural bathymetric conditions within the Bay. The depth contours along the Whatcom Waterway edges of these areas have been affected by historic dredging patterns within the Waterway.

The sediments within Unit 5 range from fine-grained sediments in deepwater areas, to sandy sediments with some gravel in shallow-water, high-energy areas of Unit 5B. The particle size distribution is controlled by area wave energies as described in Appendix C.

Current wave energies in Unit 5C are lower due to the partial sheltering of this area by the ASB structure and the Bellingham Shipping Terminal.

4.4.2 Land Use and Navigation

The shoulder areas of the ASB were historically used for log rafting, prior to construction of the ASB. Future navigation use of these areas is considered limited by water depths and the lack of available upland adjacent to these areas.

The Port plans to develop an environmentally sustainable marina within the ASB. The marina has been included in the Port's Comprehensive Scheme of Harbor Improvements as described below (Section 4.7). However, navigation features within Unit 5 are not contemplated due to anticipated conflicts between such uses and habitat preservation and enhancement objectives. The priority uses within Unit 5 are those associated with habitat enhancement opportunities.

The modification of this area to construct nearshore habitat benches along this portion of the shoreline was considered as part of the 2000 Comprehensive Strategy EIS, and has been incorporated into design concepts for the ASB marina (Figures 4-4 and 4-5). However, no modifications to this area have been completed to date.

4.4.3 Natural Resources

The Habitat Restoration Documentation Report (BBWG, 1999) identified Unit 5 shoreline areas as salmonid migration corridors, though depths and wave energies are not currently optimal for the development of premium nearshore habitat quality.

4.4.4 Contaminant Distribution

Throughout most of Unit 5 the surface sediments comply with the SMS. Subsurface sediment concentrations are relatively low as shown in Figures 2-4 and 2-5. However, wave energies within Unit 5B are higher than in other areas and recent sampling in 2002 indicates that, while sediments in this area do not exceed bioassay criteria established under SMS, the site-specific mercury BSL is exceeded in Unit 5B (Figure 2-3).

4.5 Areas Near Bellingham Shipping Terminal (Unit 6)

Unit 6 consists of the aquatic lands to the south and southeast of the Whatcom Waterway and Bellingham Shipping Terminal. This area has been subdivided into three subareas:

- **Unit 6A:** Deepwater areas of Unit 6 that comply with sediment cleanup levels

- **Units 6B and 6C:** Deepwater and intermediate-depth areas near the former barge dock where exceedances of bioassay criteria were noted during recent sampling in 2002.

4.5.1 Physical Factors

Most of Unit 6 consists of deepwater areas, with elevations greater than 18 feet below MLLW. However, shallow-water areas are located immediately adjacent to the Bellingham Shipping Terminal. The shorelines in this area consist of engineered slopes, armored to resist wind and wave erosion.

Sediments in deepwater areas of Unit 6 consist of fine-grained sediments typical of the Whatcom Waterway site. The total fines content typically exceeds 80 percent. TOC levels range from 1 to 5 percent, consistent with average Whatcom Waterway site conditions.

4.5.2 Land Use and Navigation

Navigation uses in Unit 6 have historically included log rafting, barge traffic and tug boat mooring. Some prop wash effects may be significant in this area, depending assuming future barge and tug uses.

Two docks are located within Unit 6, including the barge dock and the former GP Chemical dock. The northern side of Unit 6 is bounded by the back side of the Bellingham Shipping Terminal wharf structure.

Some dredging activities have historically been performed in Unit 6, including dredging for establishment of cargo terminal berth areas, as well as dredging to obtain fill material for use in development of the Bellingham Shipping Terminal. Regular maintenance dredging such as that considered for the Whatcom Waterway areas is not expected. As described above for the Outer Waterway, the Bellingham Shipping Terminal will likely remain under industrial water-dependent use for the foreseeable future, including potential reuse by institutional users and/or cargo operations.

4.5.3 Natural Resources

Like Unit 5, the area within Unit 6 was identified in the Habitat Restoration Documentation Report (BBWG, 1999) as a salmonid migration corridor, though depths, wave energies and substrates were not optimal. Habitat values in this area are also constrained by navigation infrastructure needs of the Bellingham Shipping Terminal, including the presence of over-water wharves and armored shorelines.

4.5.4 Contaminant Distribution

The principal contaminants historically identified in the Unit 6 area are phenolic compounds. The primary sources of these compounds appear to be from historical log rafting activities. Natural recovery processes for these materials include both deposition and burial, as well as biodegradation (phenolic compounds are biodegradable under both aerobic and anaerobic conditions).

During sediment testing in 2002, a single failure was noted in an amphipod bioassay test performed at station AN-SS-30 (see Figure 2-5). Mercury levels were below the numeric SQS in this sample. No bioassay exceedances or elevated mercury levels were noted in other areas of Unit 6 during 2002 sampling activities.

4.6 Starr Rock (Unit 7)

Starr Rock consists of a sediment disposal area used for management of sediments dredged from the Whatcom Waterway and adjacent berth areas during the late 1960s. The area was designated for sediment disposal under project Corps of Engineers permits. The area is located in submerged offshore areas near the natural Starr Rock navigation obstruction. This area is designated as Unit 7.

4.6.1 Physical Factors

Water depths in Area 7 range from a low of approximately 20 feet below MLLW to a maximum of approximately 40 feet. Due to its deepwater location, Unit 7 is not subject to significant wave energies. Sediments in this area are predominantly fine-grained materials, with total fines contents of greater than 80 percent. Like most areas of the Whatcom Waterway, the TOC content of sediments in this area is generally between 1 and 5 percent. Localized deposits of woody materials were noted, with some TOC contents exceeding 5 percent.

4.6.2 Land Use and Navigation

Historic navigation uses in Unit 7 were limited to log rafting. These uses were discontinued in the 1970s with the development of Boulevard Park nearby. Future navigation uses in Unit 7 are not anticipated other than transit uses by recreational vessels. Deepwater navigation is restricted in this area due to the proximity of the natural shallow-water obstruction at Starr Rock, and by the lack of adjacent upland navigation support facilities.

4.6.3 Natural Resources

Unit 7 consists of a deepwater habitat area and has not been identified as premium habitat for salmonids or other aquatic species.

4.6.4 Contaminant Distribution

The surface sediments within Unit 7 comply with the SMS. Surface sediments in this area do not contain any exceedances of the site-specific mercury BSL, and no exceedances of SMS criteria were noted in sediment bioassays during the 2002 sampling event (Figure 2-3).

4.7 ASB (Unit 8)

Unit 8 consists of the interior of the ASB. This facility was constructed by GP in 1978 for treatment of wastewater from pulp and tissue mill operations.

4.7.1 Physical Factors

The ASB is approximately 1,000 feet wide north-south, and varies from approximately 1,000 to 1,400 feet wide east-west. The ASB berms enclose Unit 8 and separate it from Bellingham Bay. The ASB berms enclose an area of approximately 28 acres.

Figures 2-2 and 4-5 show schematic cross-sections of the ASB berm. Additional cross-sections of the ASB area are included in the RI Report (RI Figures 3-6 and 3-8). The berm was constructed of quarried sand and stone materials placed at the time of construction. The interior of the ASB was dredged to depths approximately 15 feet below MLLW. A bentonite material was used to reduce the permeability of the berm and make it suitable for wastewater containment uses. An asphalt surface was placed around the berm interior edges to prevent wind and wave erosion of the berm structure. The outer edges of the berm are armored with stone to protect against wave erosion. Wastewater elevations within the ASB are maintained by active pumping at approximately 19 to 20 feet above MLLW. This elevation is significantly higher than the water elevations in Bellingham Bay, and provides hydraulic head necessary to discharge treated wastewater by gravity flow through the GP-owned, NPDES-permitted outfall.

Since construction of the ASB facility, biotreatment sludges have accumulated in the ASB. These sludges are soft, wet and are extremely high in TOC content. The solids content of these materials is less than 30 percent and averages about 14 percent. The TOC content is very high, averaging between 30 and 50 percent. The sludges consist of pulp solids and microbial biomass produced during biotreatment of facility wastewaters.

In contrast to the ASB sludges, the berm materials consist primarily of clean coarse sand obtained from quarry sites during ASB construction. These materials were tested for physical properties and chemical properties as part of the Remedial Investigation activities. Sediments underlying the ASB also consist of sandy materials.

The exterior of the ASB was constructed with a final cover of large armoring rock, generally of 300 to 4,400 pounds. These exterior slopes were constructed between 2.5 and 3:1 (H:V). The interior slopes are finished at slopes of approximately 2.5:1 (H:V).

4.7.2 Land Use and Navigation

The ASB facility was constructed by GP for treatment of wastewater and stormwater. It also provides cooling water management for the Encogen energy production facility. These uses are expected to continue through June of 2008, consistent with Port-GP agreements. After that time these uses are likely to be discontinued.

The ASB has been identified by the Port as the preferred site in Bellingham Bay for construction of a new marina facility (Makers, 2004). The preference for the site was based on several factors, including the ability to develop a marina with net gains in both habitat and public access opportunities. The development of a marina in the ASB was included in the 2004 Waterfront Futures Group Vision and Framework Plan, and in the Port's 2004 update to its Comprehensive Scheme of Harbor Improvements. The development of a marina in the ASB was a key element of the Port's purchase of the GP properties in 2005, and is also a key element of Port-City plans for redevelopment of the New Whatcom redevelopment area, as stated in the Port-City Interlocal Agreement of May 2006. Preliminary design concepts for a marina have been developed between 2004 and 2006, incorporating public access and habitat enhancements. Some of these concepts are illustrated in Figures 4-4 and 4-5.

The earliest marina design concepts shown in Figure 4-4 were developed as part of the Waterfront Futures Group. The community preference was that public access features to be located on portions of the breakwater surrounding the new marina. A modified design concept was developed by the Port integrating the Waterfront Futures Group concepts with modifications to the original concept made after consultations with resource agencies and project stakeholders. Modifications included relocation of the marina entrance, and the incorporation of habitat enhancement and fish passage features in subaqueous portions of the breakwater. Additional analyses were conducted as part of a waterfront design charette during March of 2006. That charette included resource agencies and community representatives, and resulted in further development of the design concept for integrated marina, public access and habitat enhancement uses. Some of the design concepts developed at the design charette are included in Figure 4-4.

Figure 4-5 illustrates some of the changes that have been contemplated for the ASB berm structure as part of marina reuse. These changes assume that Waterway cleanup activities remove the ASB sludges from the site. The clean berm materials can then be partially removed from the area for reuse in cleanup and habitat enhancement activities. The berms would be modified to reduce overall height and width consistent with marina breakwater requirements. Public access amenities may be included in the berm, potentially including a shoreline promenade, landscape features and other enhancements. Habitat enhancements may be included in the berm including nearshore habitat benches on either the inner or outer areas of the berm. Marina facilities would be located in deepwater areas inside the ASB area. The final design will depend on optimization of navigation, public access and habitat uses and will be developed in future design and permitting for area reuse.

The City also evaluated the ASB for potential future stormwater or wastewater treatment uses, but it determined that it is not well suited for these uses due to its location, elevation, and the operational characteristics of the current GP-owned outfall structure.

4.7.3 Natural Resources

Currently the ASB is used as a wastewater treatment lagoon, and the area has no significant existing natural resources or habitats. The area is segregated from the marine environment by the ASB berms. The water within the ASB consists of industrial wastewater, and the ASB interior shorelines are lined with asphalt.

4.7.4 Contaminant Distribution

As described in the RI Report, the ASB sludges contain the highest contaminant levels of all of the materials requiring remediation. Contaminant levels include elevated mercury levels from chlor-alkali plant wastewaters, but also contain very high levels of phenolic compounds and other inorganic and organic contaminants including cadmium, zinc, phthalates and polynuclear aromatic hydrocarbon (PAH) compounds. Average subsurface sediment quality data for the ASB sludges (0.4-4 ft depth interval) are summarized in Figures 2-4 and 2-5.

As described in section 4.7.1, the ASB sludges are soft, wet and have very high TOC contents.. In portions of the ASB, a layer of contaminated sediments is located at the transition between the ASB sludges and underlying clean sediments.

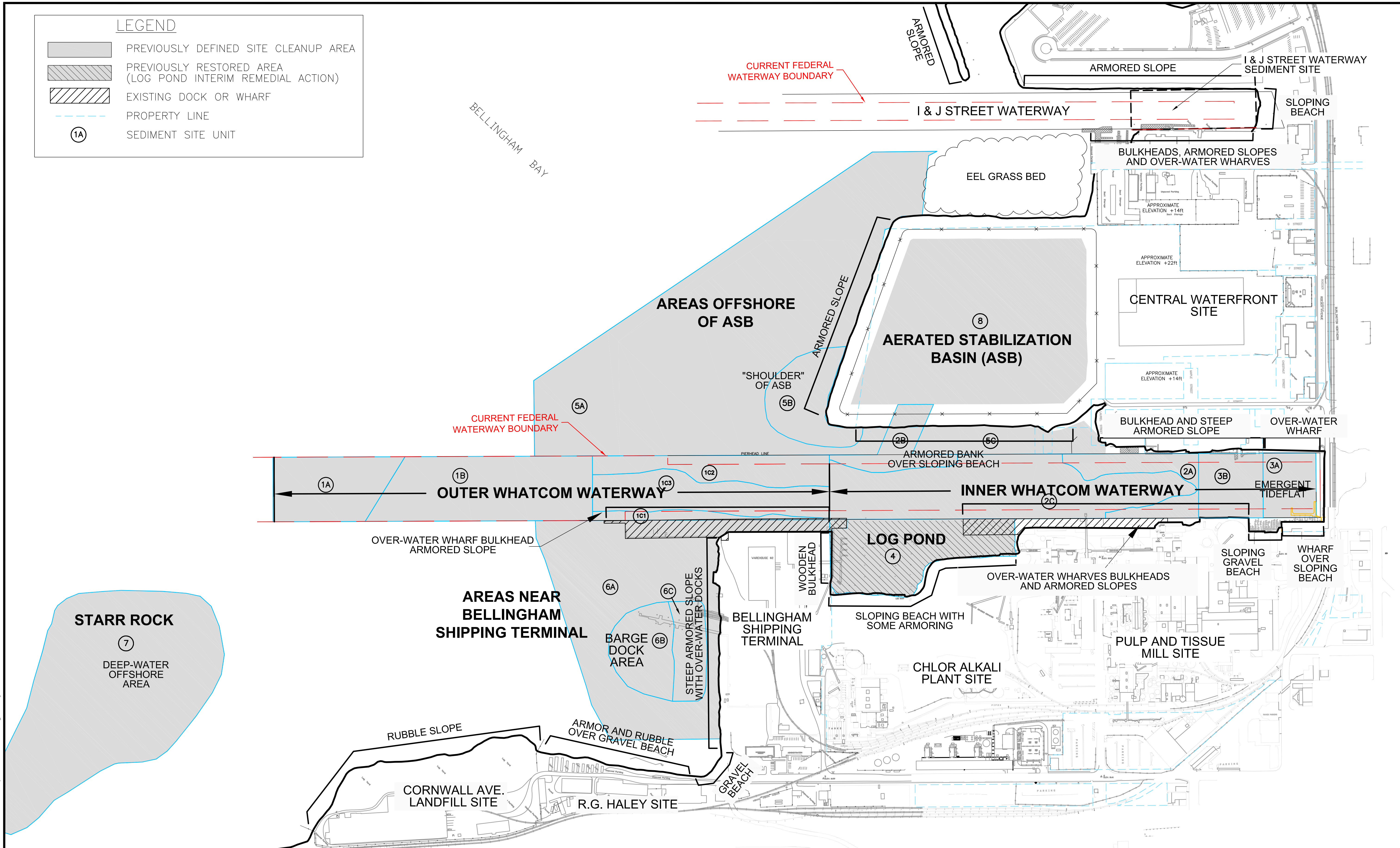
Materials in the ASB berms were directly tested as part of Remedial Investigation Activities. The berm sands were free from anthropogenic contaminants and were suitable for material reuse, provided that ASB sludges are first removed so that the materials can be safely accessed. Some contaminated sediments are present in a thin layer of sediments at the pre-construction mud-line, beneath the ASB berm materials as shown in Figure 2-2.

4.8 I&J Waterway Sediment Site

The I&J Waterway sediments were sampled as part of the RI activities. Mercury associated with the Whatcom Waterway site is present at low levels in subsurface sediments in this area (Figure 2-4). However, testing as part of the RI showed that mercury concentrations did not exceed SMS biological criteria in surface sediments, and characterization of subsurface sediments has shown that the mercury levels do not exceed allowable levels for open-water disposal or beneficial reuse. In contrast, contamination of surface sediment with phthalates, nickel, wood waste and other contaminants from localized historical releases has been shown to be present in excess of SMS standards in the I&J Waterway area.

During 2003 and 2004, Ecology determined that the sediments at the head of the I&J Waterway represent a distinct contamination area that was best managed as a separate sediment cleanup site. As described in the RI Report (RI Section 6.1.3) a separate RI/FS is being conducted for this area under an Agreed Order between the Port and Ecology. Based on its management as a separate site, the I&J Waterway is not carried forward as a site unit for the Whatcom Waterway FS.

Outside of the I&J waterway sediment site, the sediments within the I&J waterway are not subject to further remedial action, because surface sediments do not exceed SMS cleanup levels, and further remedial action is not required to address impacted subsurface sediments. Testing performed during the Remedial Investigation showed that subsurface sediments within the outer portion of the federal navigation are suitable for open-water disposal. Ongoing channel maintenance activities conducted by the Corps of Engineers includes material characterization provisions that address future management of the sediments in this area.



WHATCOM WATERWAY
FEASIBILITY STUDY
PORTB-18876-240

DATE: 09/29/06 DRWN: E.M./SEA

SEDIMENT SITE UNITS

FIGURE 4-1

Figure 4-2
Shoreline Infrastructure and Dredging Patterns in the Outer Waterway

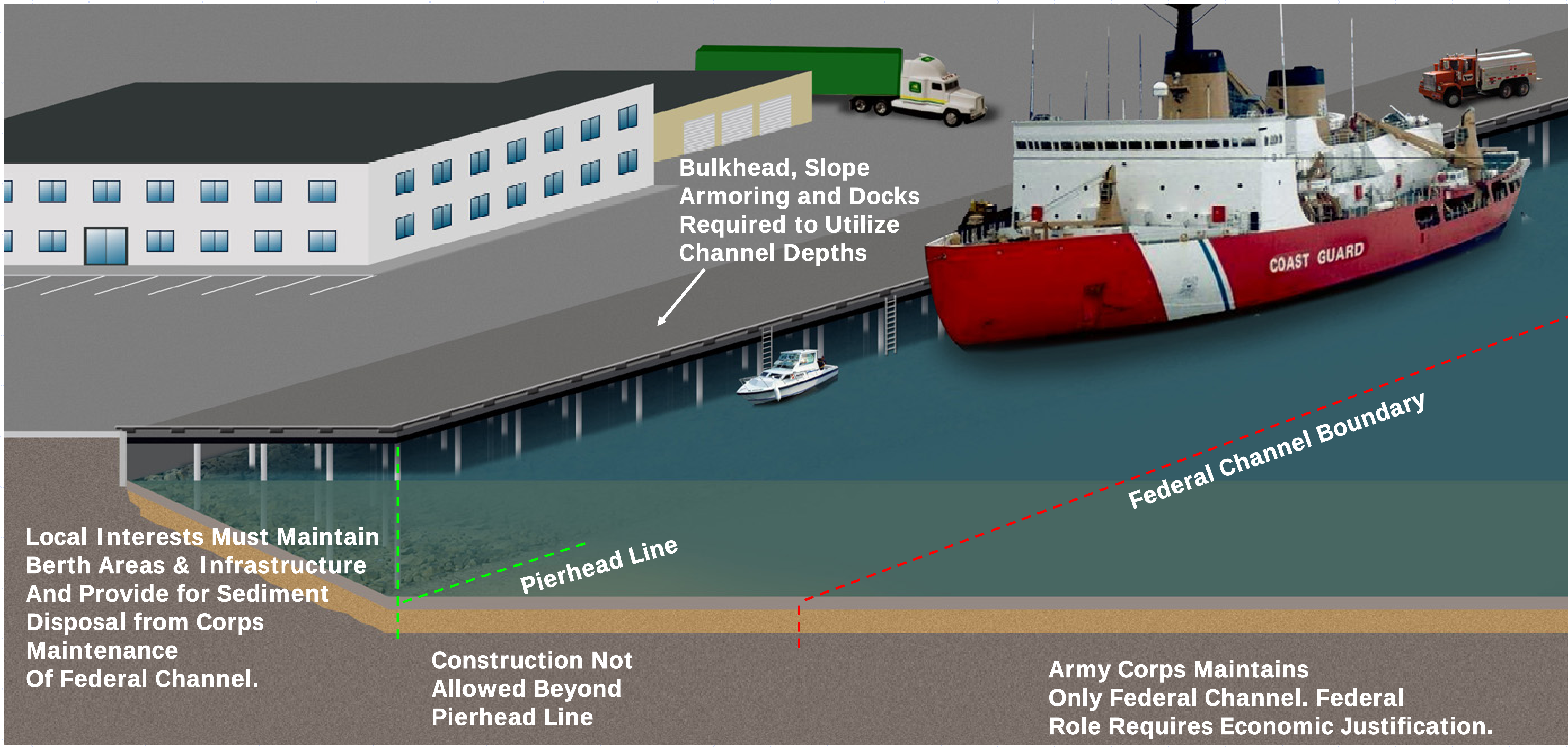
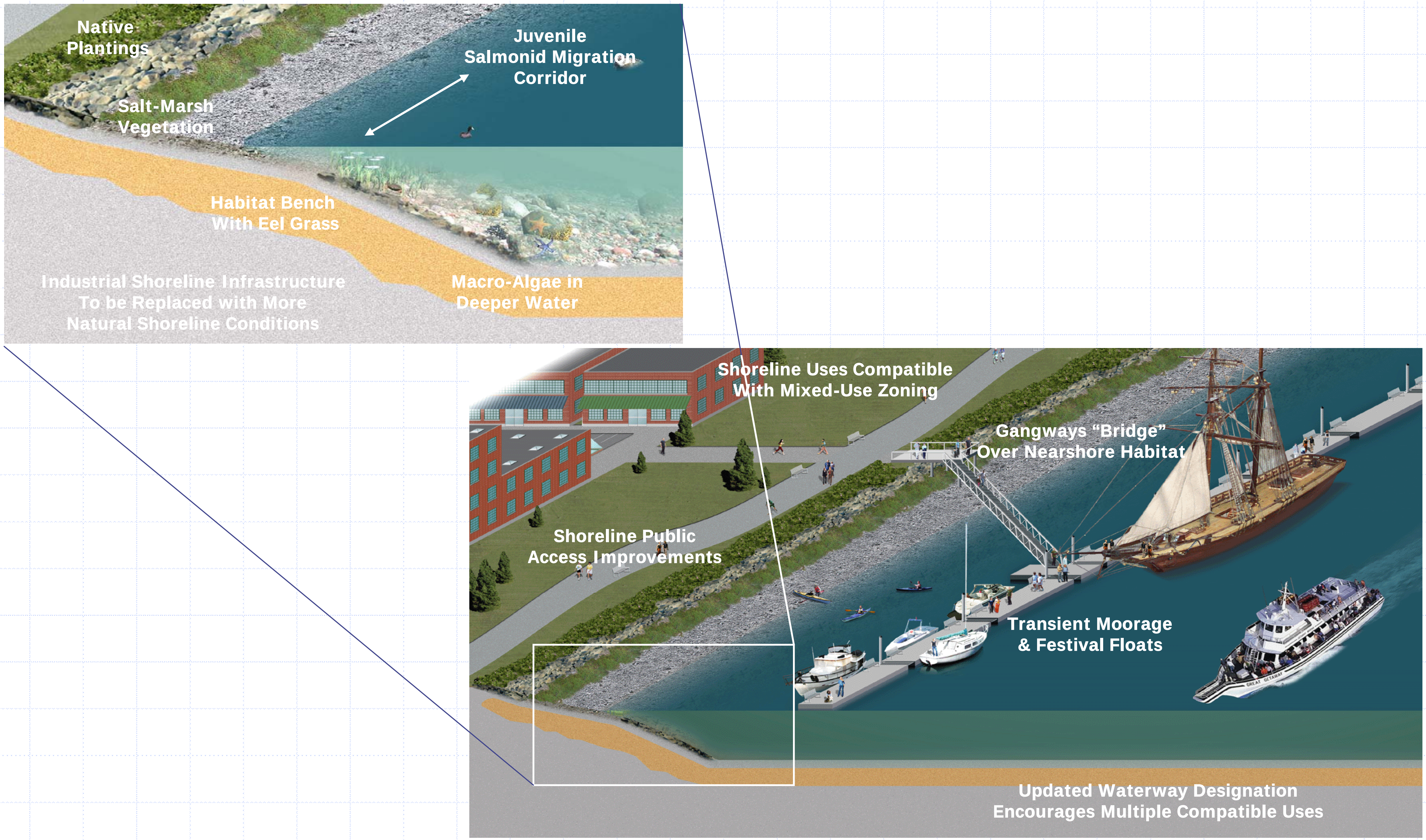


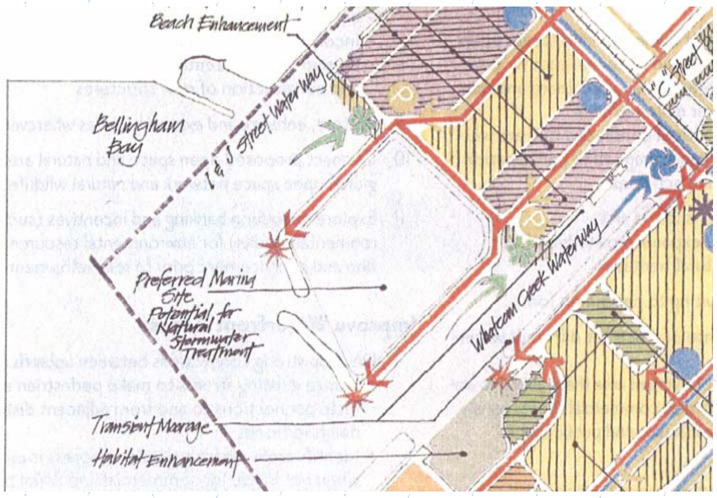
Figure 4-3
Shoreline Infrastructure Design Concept for Multi-Purpose Inner Waterway



RETEC

Figure 4-4
ASB Marina Design Concepts

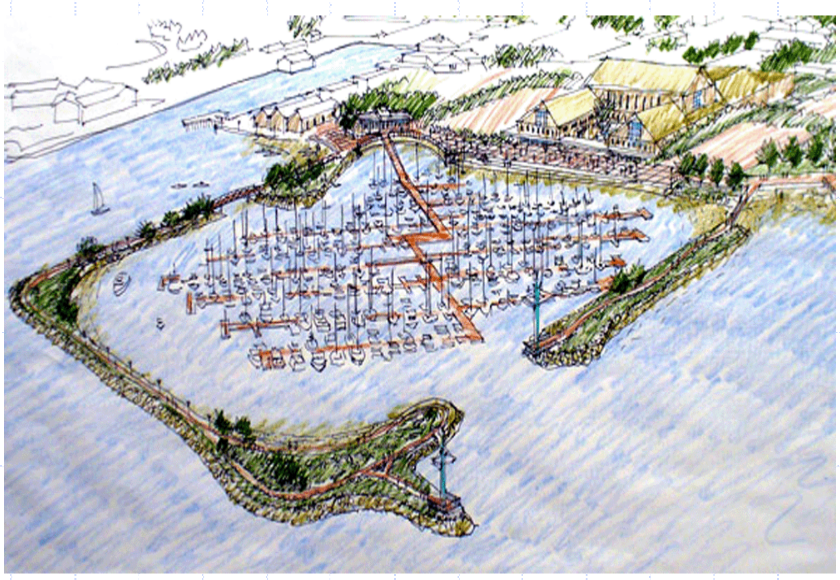
Early Design Concepts



Waterfront Futures Group Concept Drawing

Initial Concept at Time of Port Update to Comprehensive Scheme of Harbor Improvements

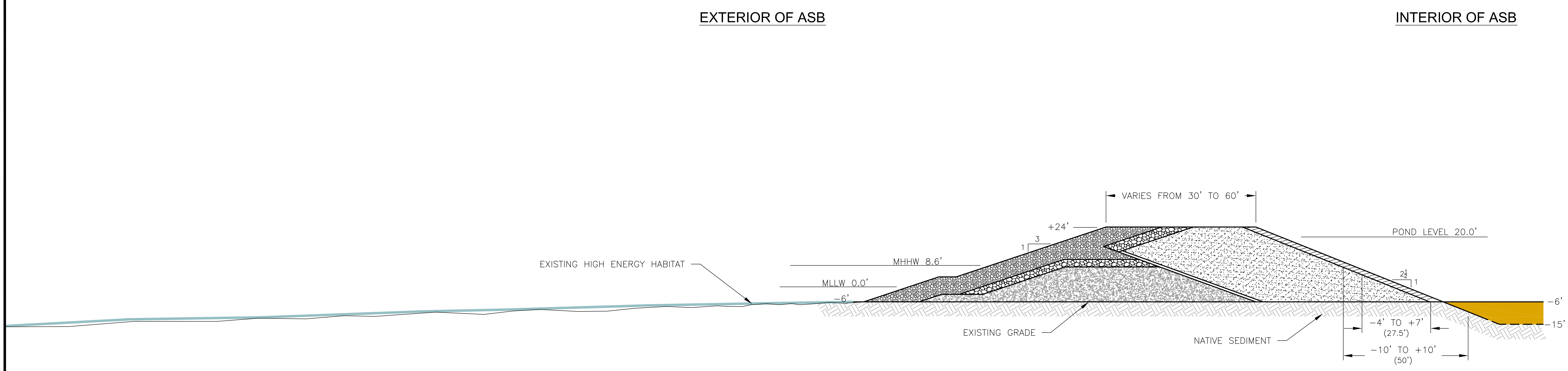
Updated Concepts from 2006 Waterfront Design Charette



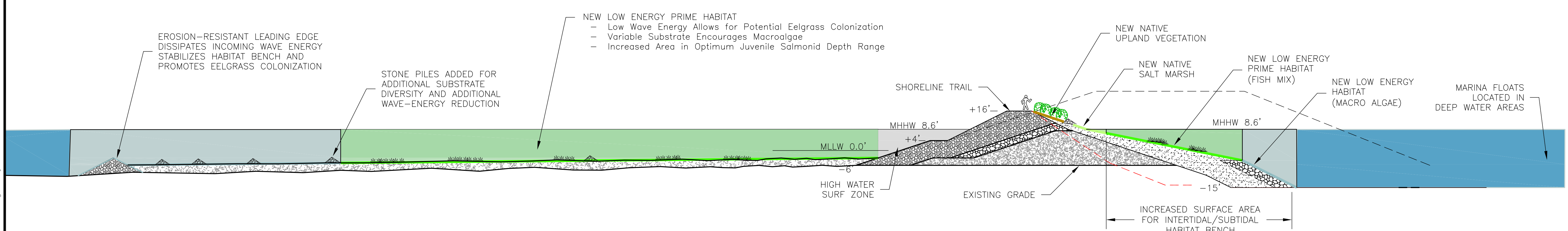
Overview Showing Public Access And Habitat Enhancements Along Breakwater

Design Concepts for Waterfront Trail System

Illustration of Linkages Between Marina and Other Waterfront Revitalization Efforts Along the Inner and Outer Whatcom Waterway



EXISTING CONDITIONS



20 0 40

SCALE IN FEET

PRELIMINARY DESIGN CONCEPT

RETEC

WHATCOM WATERWAY FEASIBILITY STUDY	PRELIMINARY DESIGN CONCEPT ASB BERM RECONFIGURATION
DATE: 08/21/06 DRWN: A.S./SEA	FIGURE 4-5

5 Screening of Remedial Technologies

Under MTCA, the development of a cleanup plan requires that technologies capable of meeting cleanup objectives are screened, and then assembled into remedial alternatives. These are then evaluated, compared and preferred alternative(s) are identified. Section 3 presented the site cleanup goals and remedial action objectives for the Whatcom Waterway site. This section reviews available cleanup technologies, and selects a range of technologies to be retained for development of cleanup alternatives as described in Section 6.

The screening of remedial technologies provided in this section is performed using the process defined in the SMS guidance (Ecology, 1991). First, the range of potential technologies available for remediation of site contaminants is reviewed. Then, available technologies are screened for overall effectiveness, implementability and relative cost to identify a short-list of potentially applicable technologies for further evaluation.

The technologies that can be used to address contaminated sediments, as discussed in the SMS guidance (Ecology, 1991), and the ARCS (USEPA, 1994) are described in the following sections:

- Institutional Controls (Section 5.1)
- Natural recovery (Section 5.2)
- Containment (Section 5.3)
- Sediment Removal (Section 5.4)
- Sediment Disposal and/or Reuse (Section 5.5)
- *Ex situ* Treatment (Section 5.6)
- *In situ* Treatment (Section 5.7)

MTCA regulations place a preference on the use of permanent cleanup methods such as removal, disposal or treatment relative to those that manage contaminants in place using institutional controls, natural recovery and/or containment. This preference is reflected in regulatory evaluation criteria which are described and applied in Sections 6 and 7.

Sections 5.1 through 5.7 describe each of the technologies evaluated during technology screening, including information on the technology effectiveness, implementability and cost. Retained technologies to be carried forward in development of remedial alternatives are summarized in Section 5.8.

5.1 Institutional Controls

Institutional controls are mechanisms for ensuring the long-term performance of cleanup actions. They are applicable to most remedies where contaminants are not completely removed from the site. Institutional controls involve administrative/legal tools to document the presence of contaminated materials, regulate the anthropogenic disturbance/management of these materials, and provide for long-term care of remedial actions including long-term monitoring. Institutional controls have been successfully applied during remediation projects at Puget Sound sites including the Foss Waterway in Tacoma, the Lockheed and Todd Shipyards Operable Units at Harbor Island.

For sediment remediation projects, permitting review procedures constitute institutional controls. For any aquatic construction project (e.g., dredging in a berth area) environmental reviews are conducted by permitting agencies including the Corps of Engineers, the Department of Ecology, and other resource agencies. These reviews include a review of area files relating to sediment conditions, and requirements to address materials management and water quality.

Additional institutional controls may be implemented as appropriate, depending on the preferred remedial alternative ultimately selected by Ecology. Such additional controls could include restrictive covenants for platted tidelands, use authorizations for state-owned aquatic lands, and/or documenting the site remedial action in County property records, Corps and regulatory agency permit records and/or records maintained by the State of Washington for state-owned aquatic lands.

Institutional controls can be highly effective, implementable, and cost-effective provided that the remedial action for which the institutional controls are implemented is consistent with area land and navigation uses. In cases where the proposed remedial action is in conflict with land use and navigation uses, conflicts can result that jeopardize the effectiveness of institutional controls or that require mitigation.

Institutional Controls have been carried forward in the Feasibility Study for alternatives development.

5.2 Natural Recovery

Natural recovery of contaminated sediment may occur over time and may lower the surface concentrations of sediment contaminants. Natural recovery of sediments in the Whatcom Waterway area has been well documented by the historical record of declining surface concentrations of mercury over the past 25 years. Section 6.2 of the RI Report contains a discussion of site natural recovery data. Natural recovery includes three processes that contribute to the cleanup of surface sediments. These processes include the following:

1) Physical processes, such as sedimentation/deposition and mixing

2) Biological degradation processes that cause reductions in the mass, volume, and/or toxicity of contaminants through biodegradation or biotransformation

3) Chemical processes, including oxidation/reduction and sorption.

As discussed in the Remedial Investigation report, natural recovery through the physical process of sediment deposition has been highly effective at restoring sediment quality in the bioactive zone throughout much of the Whatcom Waterway site.

Biological processes include bacterial or fungal degradation or transformation of organic chemicals into less toxic forms. These processes may be effective for volatile and semivolatile organic compounds in well-aerated sediments. Metals concentrations would not be expected to decrease through biological processes, although the natural production of sulfides may result in the formation of metal-sulfide complexes, thereby limiting the bioavailability of certain metals (EPA 2000e). Biological processes may produce long-term reductions of organic constituents, such as phenolic compounds.

Chemical processes include the preferential sorption of organic compounds to naturally occurring carbon and humic sources within the sediments, as well as changes in redox potential and chemical precipitation reactions that chemically bind contaminants to sediments and reduce their toxicity. For example, many metal compounds form stable precipitates with hydrogen sulfides in sediments.

All of these processes (physical, biological, chemical) can occur together and contribute to overall recovery of sediment systems.

5.2.1 Monitored Natural Recovery

Monitored natural recovery (MNR) relies on natural recovery processes coupled with monitoring to ensure that recovery achieves stated cleanup levels and remedial action objectives. Natural recovery is defined as the effects of natural processes that permanently reduce risks from contaminants in surface sediments (Apitz et al. 2002) and that effectively reduce or isolate contaminant toxicity, mobility, or volume. Monitoring of these processes is conducted to determine their effectiveness within a prescribed time frame.

MNR is a risk management alternative that relies upon natural environmental processes to permanently reduce exposure and risks associated with contaminated sediments (Davis et al. 2004) MNR can be implemented as a sole alternative, but is more frequently combined with other active measures and institutional controls. MNR differs from No Action in that, by definition, it must include source control, appropriate assessments including modeling, and long-term monitoring to verify the remedy effectiveness (Palermo 2002; Apitz et al. 2002).

The potential for natural recovery of sediment is determined through multiple lines of evidence related to the biological, physical, and chemical processes described above. A thorough assessment of natural recovery was performed as part of the 2000 RI/FS (Hart Crowser and Anchor Environmental, 2000). This assessment showed that natural recovery was occurring at the site, which has since been verified during additional sampling events in 2002, as evidenced by the decreasing surface sediment concentrations.

Where MNR has been applied successfully, the demonstration of sediment deposition (burial) and contaminant attenuation (reduction) processes have been major determinants of MNR. MNR has been applied as a portion of the remedy in conjunction with active remedies at many Puget Sound sites, including the Puget Sound Naval Shipyard site in Bremerton, Washington (Palermo 2002) and portions of the Commencement Bay site in Tacoma, WA (EPA 1989). Performance at these sites have shown the technology to be effective and implementable when applied in suitable areas. Costs of the technology are primarily associated with implementation of institutional controls and long-term monitoring.

5.2.2 Enhanced Natural Recovery

ENR involves the placement of a thin layer of clean material over areas with relatively low contaminant concentrations to speed up, or enhance, the natural recovery processes already demonstrated to be occurring at a site. Under ENR, thin layers of clean sand or sediments are placed over areas where natural recovery processes are occurring. The new material reduces the restoration time-frame required for natural recovery to be effective and comply with site cleanup levels (OSWER 2004). ENR has been used in Puget Sound both as a sole remedy and in conjunction with removal actions to aid in the management of post-dredging contaminant residuals. ENR frequently also includes a long-term monitoring component as with MNR. ENR has been selected as a remedy component at Superfund sites in Commencement Bay (Tacoma, Washington) and Eagle Harbor (Bainbridge Island, Washington) (Thompson et al. 2003).

Enhanced natural recovery has been highly effective in managing residual sediment left following dredging. In this case, the dredging operation is designed to remove the majority of the contaminated sediment. However, all dredging technologies leave some residual materials on the dredged surface, at times resulting in short-term non-compliance with the site cleanup level. ENR can be used to address this residual provided that the quantity of the residuals is minimized through the use of best practices during dredging.

For purposes of the Feasibility Study, only MNR has been carried forward for alternatives development. ENR is retained in the context of post-dredge residuals management, but not as a discrete remedial technology.

5.3 Containment

Containment involves either confining the contaminated sediments in place or confining dredged materials within a disposal facility after removal.

Containment technologies have been used extensively in remediation of contaminated sediments elsewhere in Puget Sound.

5.3.1 Sediment Capping

Capping is a well-developed and documented cleanup alternative in the Pacific Northwest and nationally. One of the first, and best-documented, examples of capping occurred in 1984, when contaminated fine-grained sediment dredged from the LDW navigation channel between Kellogg Island and the Duwamish Diagonal CSO and storm drain was disposed of in a borrow pit in the West Waterway; that material was capped with clean sand dredged from the LDW's upper turning basin (Sumeri 1984, 1989; USACE 1994). As recently as 1995, monitoring demonstrated that the capped contaminated sediment remained effectively isolated (USACE et al. 1999). Numerous other caps have been successfully placed in Puget Sound, including the capping of the Log Pond during the Interim Remedial Action at the Whatcom Waterway site.

Capping isolates contaminants from the overlying water column and prevents direct contact with aquatic biota. Cap placement as a remedial alternative assumes source control to protect against cap recontamination. If the potential for scour from river currents or propeller wash exists, the cap must be designed in a way that protects it from these disruptive forces.

Caps may be used in different ways as part of a remedial action:

- ***In Situ* Capping** is defined as the placement of an engineered subaqueous cover, or cap, of clean isolating material over an *in situ* deposit of contaminated sediment (EPA 1994, 2002; NRC 1997, 2001; Palermo et al. 1998a, 1998b). Such engineered caps are also called isolation caps. *In situ* caps are generally constructed using granular material, such as clean sediment, sand, or gravel. Composite caps can include different types and multiple layers of granular material, along with geotextile or geomembrane liners. Reactive caps can include the addition of contaminant-sorbing or blocking materials. *In situ* capping may be considered as a sole remedial alternative or may be used in combination with other remedial alternatives (e.g., removal and MNR).

- ***In Situ* Capping After Partial Removal** is an option involving placement of an *in situ* cap over contaminated sediments that remain in place following a partial dredging action that removes contaminated sediment to some specified depth. This can be suitable in circumstances where capping alone is not feasible because of habitat, navigation or land use requirements that necessitate a minimum water depth. *In situ* capping with partial dredging can also be used when it is desirable to leave deeper contaminated sediment capped in place so as to preserve bank or shoreline stability, or where dredging of the materials creates excessive disruption or water quality impacts. When *in situ* capping is used with partial dredging, the cap is designed as an engineered isolation cap, because a portion of the contaminated sediment deposit is not dredged.

Cap Construction Methods

Various equipment types and placement methods have been used for capping projects, including placement using hopper barges at larger, open-water sites and both hydraulic and mechanical systems for placement at nearshore or shallow-water sites.

An important consideration in the selection of placement methods is the need for controlled, accurate placement of capping materials. Slow, uniform application that allows the capping material to accumulate in layers is often necessary to avoid displacement of or mixing with soft underlying contaminated sediments. Slow application also minimizes the resuspension of contaminated material into the water column (Cunningham et al. 2001).

Granular cap material can be handled and placed in a number of ways. Mechanically dredged materials that have been dewatered and soils that have been excavated from an upland site or quarry have relatively little free water. These materials can be handled mechanically in a dry state until released into the water over the contaminated site. Mechanical methods (such as clamshells or release from a barge) rely on gravitational settling of cap materials in the water column and are highly effective at shallow and intermediate depths such as those within the Whatcom Waterway site. Granular cap materials can also be entrained in a water slurry and carried wet to the contaminated site, where they are discharged into the water column at the surface or at depth. These hydraulic methods offer the potential for a more precise placement, although the energy required for slurry transport must be controlled at the point of release to prevent resuspension of contaminated sediment. Armor layer materials (stone materials placed to resist cap erosion) can be placed from barges or from the shoreline using conventional equipment, such as clamshells.

Capping Decision Factors

The principal design considerations for capping as a remedial alternative for contaminated sediments are that the cap must remain physically stable, and that the contaminants are effectively isolated. The National Research Council (NRC 1997) provided additional decision factors that encourage use of capping as a cleanup technology include the following

- Contaminant sources have been sufficiently abated to prevent re-contamination of the cap

- Contaminants are of moderate to low toxicity and mobility

- MNR is too slow to meet remedial action objectives (RAOs) in a reasonable time frame
- Cost and/or environmental effects of removal are very high
- Suitable types and quantities of cap materials are available
- Hydrologic conditions will not compromise the cap if designed appropriately
- Weight of the cap can be supported by the physical properties of the underlying sediments
- The application of the cap is compatible with current and/or future navigation and land uses in the cap area
- Site conditions do not necessitate removal of contaminated sediment.

A well-designed, properly constructed and placed cap over a contaminated surface, along with effective long-term monitoring and maintenance, can prevent direct contact by aquatic biota by providing long-term isolation of contaminated sediments. The cap can also prevent contaminant flux into the surface water. Incorporation of habitat elements into the cap design can provide an improvement or restoration of the biological community.

One advantage of capping is that the potential for contaminant resuspension and the risks associated with dispersion of contaminated materials during construction are relatively low. With capping, the sediments are contained in-place, and do not require additional treatment and/or offsite disposal. Most capping projects use conventional and locally-available materials, equipment, and expertise. For this reason, in certain cases the *in situ* capping option may be implemented more quickly and may have much lower short-term risks than options involving removal and disposal or treatment. Depending on the location of the cap, the type of construction, and the availability of materials, a cap may be readily repaired, or enhanced if necessary.

Capping designs must anticipate and protect against potential disturbance events such as storm events and propeller wash. These events are factored into the remedy selection, design, institutional controls, and monitoring to ensure long-term integrity of the cap. To provide erosion protection, it may be necessary to use cap materials that are different from native bottom materials. This can benefit or improve the habitat quality in the cap areas, and the project design and permitting must consider these potential habitat impacts and/or benefits.

Palermo et al. (2002) and the EPA (OSWER 2004) provided additional considerations to ensure effective and implementable design, placement, and long-term maintenance of a cap over contaminated sediments that include:

- Evaluation of navigation and land use priorities in the cap area
- The impacts and/or benefits to habitat by cap placement should be considered, including changes to depth and substrate type
- The composition and thickness of the cap components comprise the cap design. A detailed design effort for any selected capping remedy should address all pertinent design considerations
- The cap should be designed to provide physical and chemical isolation of the contaminated sediments from benthic organisms
- The cap should be physically stable from scour by hydraulic conditions including currents, flood flow, propeller wash, etc.
- The cap should provide isolation of the contaminated sediments from flux or resuspension into the overlying surface waters
- The cap design should consider operational factors such as the potential for cap and sediment mixing during cap placement, resuspension during placement, and variability in the placed cap thickness
- The cap design should incorporate an appropriate factor of safety to account for uncertainty in site conditions, sediment properties, and migration processes.

Capping costs vary with the design of the cap. Costs of capping are associated with cap design, construction, institutional controls and long-term monitoring. Capping has been carried forward in the Feasibility Study for alternatives development.

5.3.2 Confined Nearshore Disposal

A Confined Nearshore Disposal (CND) facility or a "nearshore fill" is an engineered containment structure that provides for dewatering and permanent storage of dredged sediments. CNDs feature both solids separation and landfill characteristics (EPA 1994a). Containment of contaminated sediments in CNDs is generally viewed as a cost-effective remedial option at Superfund sites (EPA 1996b). Interest in CNDs for disposal of contaminated dredged sediment has led both the USACE and the EPA to develop detailed guidance documents for their construction and management (USACE 1987, 2000; EPA 1994, 1996; Averett et al 1988; Brannon et al 1990).

CND facilities involve creation of a sediment containment area that has a final filled surface located above tidal elevations. CNDs are commonly known as nearshore fills, because they involve filling of aquatic areas and conversion of those areas to upland use.

CNDs have a good performance record in Washington State. These include the Milwaukee Waterway, Eagle Harbor East Operable Unit, and the recent Blair Waterway Slip 1 Nearshore CND. However, their use has been declining due to habitat considerations, and the availability of other options such as Confined Aquatic Disposal that accomplish sediment containment without eliminating aquatic habitat.

Potential CND facilities were evaluated in the Final Disposal Siting Documentation Report (Siting Documentation Report; BBWG, 1998) during the work of the Bellingham Bay Pilot. The Pilot analysis concluded that use of a CND site would be implementable and effective. The area offshore of the Cornwall Avenue Landfill and the GP Log Pond were evaluated in this report as potential locations for a CND.

Use of the Aerated Stabilization Basin (ASB) as a CND was not included in the original Siting Documentation Report because it was anticipated that the ASB would indefinitely continue use as a wastewater treatment basin. Since that time, GP has substantially reduced its operations in Bellingham, including closure of its pulp mill, chemical plant and chlor-alkali plant. In 2001, GP identified a portion of the ASB as being available for siting of a CND facility for containment of dredged sediments from the Whatcom Waterway. The use of the ASB for construction of a CND facility was identified as an element of a preferred remedial alternative in a Supplemental Feasibility Study (Anchor, 2002).

If the ASB was used for construction of a CND, a berm would be constructed across the CND, segregating a portion of the CND which would continue to be used for wastewater treatment from the portion which would be used for disposal of sediments. Dredged sediments would be placed inside the disposal section of the ASB, along with any ASB sludges from the “outer” portion of the facility. Cleaner sediments and new structural fill soil would be placed above the sediments to form a cap and working surface above the sediments. The 2002 Supplemental Feasibility Study identified a proposed fill area that would occupy approximately 20 acres. The ASB CND option received significant comment during public review of the 2002 Supplemental Feasibility Study, including opposition from the Port and City due to land use considerations.

The ASB nearshore fill option has been carried forward in the Feasibility Study for evaluation as part of the current Feasibility Study. As described in Section 4.7.1, the ASB sludges are soft, wet and have very high TOC contents. If managed as part of a nearshore fill, these sludges would be subject to primary and secondary consolidation, and would likely produce methane during anaerobic decomposition.

5.3.3 Confined Aquatic Disposal

Confined Aquatic Disposal (CAD) facilities are similar to CNDs. Like CND facilities, CAD facilities are constructed in in-water areas and are used to contain sediment dredged from other areas. However, the surface of the CAD facility is constructed so that its final elevation retains overlying aquatic uses. In some cases the CAD surface is designed with a surface that provides enhanced habitat conditions.

CAD sites have been successfully applied in the Duwamish West Waterway for dredged sediments in 1984. In addition, a CAD was recently used as for the disposal of contaminated sediments dredged from Pier D at the Puget Sound Naval Shipyards in Bremerton, Washington.

Potential Confined Aquatic Disposal options were evaluated in the Siting Documentation Report of the Bellingham Bay Demonstration Pilot (BBWG, 1998). This report determined that CADs for contaminated sediments from Bellingham Bay would be implementable and effective. Three potential CAD sites were identified, an area offshore of the Cornwall Avenue landfill, the area within the Log Pond, and an area in sediment Unit 5 offshore of the ASB facility.

The evaluation of disposal siting alternatives conducted during the Bellingham Bay Demonstration Pilot developed an option for a CAD facility located adjacent to the Cornwall Avenue Landfill. Properly constructed, the CAD option provided a potential method of enhancing the quantity of premium nearshore habitat in the facility area. If this site were selected, a containment berm would be constructed near the subtidal portions of the Cornwall Avenue Landfill. Dredged sediments would be placed behind the berm, and the site would be capped with approximately three feet of clean fill. The finished grade of the area inside the berm could range from approximately -10 to -2 feet MLLW elevation, which would be suitable for use as subtidal habitat. The CAD surface would be protected from erosion using a hard leading edge that would reduce the energy of incoming waves, and allow for potential colonization of the cap surface by eel grass.

A range of CAD facility sizes for the Cornwall area was evaluated, including containment volumes ranging from approximately 260,000 to 1,000,000 cubic yards of sediment. The final footprint, costs and habitat benefits of a facility would vary with its size. The smaller size facilities were generally less cost-effective than those with larger (i.e., at least 500,000 cubic yard) capacities. The use of a Cornwall CAD site for containment of sediments dredged from the Whatcom Waterway was identified as a preferred alternative during the 2000 EIS process.

The Cornwall CAD option is retained for further consideration as part of the current Feasibility Study.

5.4 Sediment Removal

Contaminated sediments can be removed, typically through dredging or excavation. After removal, the sediments must be managed, a process that can include dewatering, treatment and/or disposal. In some cases, the physical and chemical properties of sediments allow them to be beneficially reused.

Dredging is commonly used for both maintenance of navigation channels and removals of contaminated sediments. Dredging is typically either mechanical dredging, which removes sediments by digging them using a bucket, or hydraulic dredging, which mechanical means to loosen sediments and then uses water suction to remove and transport the loosened sediments. Excavation of sediments is a variant of mechanical dredging, and is typically used in certain situations where it may be more effective than other means of dredging.

Dredging is such a commonly used technology, and has been applied to multiple sediment remediation projects in Puget Sound, such as the Hylebos Waterway in Tacoma and the Duwamish Waterway in Seattle. After removal of sediments, the sediments must be appropriately managed using containment, beneficial reuse, disposal, or treatment.

Removal refers to excavation or dredging of sediments. The discussion of removal process options herein integrates site knowledge, practical dredging experience, dredging sediment case studies, and demonstrated successful application under similar conditions. The following documents include practical information relating to sediment remediation projects in the United States:

- Assessment and Remediation of Contaminated Sediments (ARCS) Program, Remediation Guidance Document (EPA 1994b)

- Review of Removal, Containment and Treatment Technologies for Remediation of Contaminated Sediment in the Great Lakes (Averett et al. 1990)

- Removal of Contaminated Sediments: Equipment and Recent Field Studies (Herbich 1997)

- Innovations in Dredging Technology: Equipment, Operations, and Management, USACE DOER Program (McLellan and Hopman 2000)

- Dredging, Remediation, and Containment of Contaminated Sediments (Demars et al. 1995).

Dredging has been used for remediation at many Puget Sound projects of a similar scale to the Whatcom Waterway Site. Some recent projects include: the 2004 Duwamish/Diagonal Way Combined Sewer Overflow (CSO) and Storm Drain Early Action Removal Project, the 1999 Norfolk CSO Early Action Removal Project, both located in the Duwamish Waterway, and the 2004 Harbor Island East Waterway Sediment Phase 1 Cleanup Project, located at the mouth of the Duwamish. The latter project was a relatively large-scale removal project, dredging from a 20-acre area, with disposal of 200,000 cubic yards (cy) of sediment to an upland landfill and another 59,000 cy to the Elliott Bay Disposal Area. Two additional sediment remediation projects located within the Harbor Island Superfund Site involve dredging contaminated sediments using a closed bucket, with landfill disposal of wet sediments. These are the Lockheed Shipyard Sediment Operable Unit (dredging 130,000 cy with disposal at an upland landfill and capping of deeper sediments) and the Todd Shipyard Operable Unit (dredging 200,000 cy with disposal at an upland landfill and capping of under-pier areas). Finally, the cleanup of the Hylebos Waterway within the Commencement Bay Superfund site includes dredging combined with multiple forms of sediment management including upland disposal and confined nearshore disposal.

5.4.1 Overview of Removal Options

For the purposes of this FS, dredging is defined as the removal of sediment in the presence of overlying water (subtidal and intertidal) utilizing mechanical or hydraulic removal techniques and operating from a barge or other floating device. Excavation is defined as the dry or shallow-water removal of sediment using typical earth moving equipment such as excavators and backhoes operating from exposed land or wharves. Depending on the location of the sediments being removed, there may be some overlap in the equipment used for dredging and excavation. For example, a barge mounted excavator could reach over into a shallow area to remove sediments, or a shore-based crane with a long boom could reach out into deeper water and dredge these sediments.

There are two major types of dredges, mechanical and hydraulic. Mechanical dredges function by digging into the sediments with a bucket, similar to a land-based process. Hydraulic dredges function by loosening sediments with a mechanical device, and then “vacuuming” the sediments along with large quantities of entrained water, and transporting the resulting dredge slurry in a pipeline to an area where the solids and liquids can be separated for subsequent management.

Mechanical dredges remove material at near *in situ* conditions, with lower levels of water entrainment. The dredged material is taken up through the water column to a barge for transport. Mechanical dredges may be used for a wide range of material types (loose to hard consolidated and compacted material). A subset of mechanical dredges, excavators, are often used to preremove large debris prior to dredging, or are used in difficult to access, shallow, and backwater areas.

Hydraulic dredges remove material as a low-density slurry; with water entrainment ratios commonly exceeding 10 to 1 (i.e., 10 cubic yards of water are entrained during the removal of 1 cubic yard of in-place sediment). The slurried dredged material is transported through a pipeline to a selected land-based dewatering facility. Hydraulic dredges are typically used for relatively loose, unconsolidated material with little debris, and where the slurry can be separated and the generated water can be managed in a cost-effective and environmentally sound manner.

Dredging in the United States is typically conducted by one of these basic methods (i.e., mechanical, hydraulic or excavation) depending upon accessibility, the volume of sediment to be removed, the disposal option selected, and site conditions. Dredging operations use not only the dredging equipment, but also significant other equipment for work over the water and management of the removed sediment. A typical dredge system includes:

- Point of dredging components include the cutterhead, auger screw, dustpan, and matchbox of hydraulic dredging systems, as well as various mechanical means, such as clamshell or backhoe excavator buckets for mechanical dredging systems.

- Support components include the support barge or pontoon, jack-up platforms, amphibious systems, monitoring and confirmation sampling equipment, and positioning systems.

- Discharge components include pumps, pipelines, dewatering and water treatment facilities, barges, and transport.

Selection of dredging equipment and methods used for a site depend on several factors, including: physical characteristics of the sediments to be dredged, the quantity and dredge depth of material, distance to the disposal area, the physical environment of the dredge and disposal areas (especially tidal range), contaminant concentrations in the sediment, method of disposal, production rates required for removal, equipment availability, amount and type of debris present, ability to manage produced waters, and cost (EPA 2004).

5.4.2 Mechanical Dredging

A mechanical dredge typically consists of a suspended or manipulated bucket that bites the sediment and raises it to the surface via a cable, boom, or ladder. The sediment is deposited on a haul barge or other vessel for transport to disposal sites. Mechanical dredges have been the principal tool used for environmental dredging in Puget Sound.

Under suitable conditions, mechanical dredges are capable of removing sediment at near *in situ* densities, with almost no additional water entrainment in the dredged mass and little free water in the filled bucket. A low water content is important if dewatering is required for ultimate sediment treatment or upland disposal, as well as to minimize water quality impacts at the point of dredging.

Clamshell buckets (open, closed, hydraulic-actuated), backhoe buckets, dragline buckets, dipper (scoop) buckets, and bucket ladder are all examples of mechanical dredges. Dragline, dipper (scoop), and bucket ladder dredges are open-mouthed conveyances and are generally considered unsuitable where sediment resuspension must be minimized to limit the spread of sediment contaminants (EPA 1994a).

- **Clamshell Dredges:** The clamshell bucket dredge, or grab dredge, is widely used in the United States and throughout the world. It typically consists of a barge-mounted floating crane maneuvering a cable-suspended dredging bucket, with or without teeth. A heavy bucket with teeth can dig harder sediments than can a lighter bucket without teeth. The crane barge is held in place for stable accurate digging by deploying vertical spuds into the sediment. The operator lowers the clamshell bucket to the bottom, allowing it to sink into the sediment on contact. The bucket is closed, then lifted through the water column to the surface, swung to the side, and emptied into a waiting haul barge. When loaded, the haul barge is moved to shore where a second clamshell unloads the barge for rehandling and/or transport to treatment or disposal facilities. Clamshell dredges work best in water depths less than 100 feet to maintain production efficiency. Using advanced positioning equipment (e.g., differential global positioning systems [DGPS]), dredging accuracy is on the order of 1 foot horizontally and 0.5 foot vertically. Clamshell buckets are designated by their digging capacity when full and range in size from less than 1 cy to more than 50 cy. A conventional clamshell bucket may not be appropriate for removal of contaminated sediments in some areas. Conventional buckets have a rounded cut that leaves a somewhat “cratered” sediment surface on the bottom. This irregular bottom surface increases the need to overdredge to achieve a minimum depth of cut, and multiple passes to achieve adequate removal. Furthermore, the conventional open clamshell bucket is prone to sediment losses during retrieval. Recent innovations in bucket design have reduced sediment resuspension potential by enclosing the bucket top. Also, buckets can be fitted with tongue-in-groove rubber seals to limit sediment losses through the bottom and sides. Finally, local Puget Sound dredging contractors have recognized the need to minimize resuspension while using a clamshell bucket, and have developed modifications to both their equipment and to the operations to reduce sediment loss.

- **Environmental Dredge:** A recent development in the environmental dredging field has been the advent of specialty level-cut buckets. These buckets offer the advantages of a large footprint, a level cut, the capability to remove even layers of sediment, and, under careful operating conditions, reduced resuspension losses to the water column. A level-cut bucket reduces the occurrence of ridges and winnows that are typically associated with conventional clamshell buckets. The Cable Arm™ bucket is one such environmental bucket that has been successfully demonstrated for contaminated sediment removal. Several of the Puget Sound area dredging companies own and use Cable Arm closed buckets (Wang et al. 2003). Local projects where the closed buckets have been used include Pier D at the Puget Sound Naval Shipyard in Bremerton, and at the East Waterway of the Duwamish River. Environmental buckets have been shown to be effective in loose sands and in low-solids soft-sediments. The light construction of the bucket makes it unsuitable for dredging dense or native material (Wang et al. 2003).

- **Excavator Dredges:** This is a subset of mechanical dredges, which includes barge-mounted backhoes and/or excavators, both of which have limited reach capability (maximum depth typically less than 40 feet). Excavators can also be used for dry excavation after the overlying water is removed. Special closing buckets are available to reduce sediment losses and entrained water during excavation. A conventional excavator bucket is open at the top, which may contribute to sediment resuspension and loss during dredging, although careful operation can minimize losses. Various improved excavating buckets have been developed that essentially enclose the dredged materials within the bucket prior to lifting through the water column. A special enclosed digging bucket, the Horizontal Profiling Grab (HPG), was successfully used on the large excavator – the Bonacavor (C. F. Bean Corp.) for remediation of highly contaminated sediment at the Bayou Bonfouca Site (Slidell, Louisiana) (NRC 1997), and was recently used for dredging contaminated sediments in the Hylebos Waterway in Tacoma. The bucket has a capacity of 4.5 cubic meters and can operate in water depths up to 13 meters. Dredged material removed by backhoe exhibits much the same characteristics as for clamshell dredging, including near *in situ* densities and limited free water.

5.4.3 Hydraulic Dredging

Hydraulic dredges remove and transport large quantities of dredged materials as a pumped sediment-water slurry. The sediment is dislodged by mechanical agitation, cutterheads, augers, or by high-pressure water or air jets. The loosened slurry is then vacuumed into the intake pipe by the dredge pump and transported over long distances through the dredge discharge pipeline. A key difference between hydraulic dredging and mechanical dredging is the generation of a high volume of contaminated water during hydraulic dredging. That water must treated before discharge to ensure that the quality of the surface-water body is not compromised by the dredging activity, and to protect against sediment recontamination.

Common hydraulic dredges include three main categories: the conventional pipeline dredge (round cutterhead, horizontal auger cutterhead, open suction, bucket wheel, dust pan, etc.), the self-propelled hopper dredge, and sidecasting dredge (EPA 1994; Herbich 2000). A sidecasting dredge takes dredged material excavated from the sediments and “side casts” the material from the dredge to adjacent shoreline areas. It can be used to replenish beaches, but is not used for environmental dredging.

Hydraulic dredges have four key components: the dredgehead, which is in contact with and digs the sediment, a support structure (wire or ladder) for the head assembly, the hydraulic pump to provide suction, and the pipeline that carries sediment slurry away from dredging operations. Specialty hydraulic dredges are available that limit resuspension losses at the dredgehead and increase the solids content of the dredged slurry. These include the auger-, cleanup-, airlift-, and refresher-type dredges. Hydraulic dredges are rated by discharge pipe diameter, ranging from smaller portable machines in the 6- to 16-inch category, to large 24- to 30-inch dredges. Two commonly used hydraulic dredges are the pipeline and cutterhead types.

- **Suction Dredge:** Suction dredges are open-ended hydraulic pipes that are limited to dredging soft, free flowing, and unconsolidated material. Because suction dredges are not equipped with any kind of cutting devices, they produce very little resuspension of solids during dredging. However, the presence of trash, logs, or other debris in the dredged material will clog the suction and greatly reduce the effectiveness of the dredge (Averett et al. 1990). Suction dredges have been used with limited success in the Northwest for difficult access areas such as the underpier areas of the Sitcum Waterway Superfund Site (Tacoma, Washington) and at the Port of Portland T4 Pencil Pitch Removal Project (Portland, Oregon), often with diver assistance.

- **Cutterhead Dredge:** The hydraulic pipeline cutterhead suction dredge is the most commonly used method in the United States, with approximately 300 operating nationwide. The cutterhead is considered efficient and versatile (Averett et al. 1990). It is similar to the open suction dredge, but is equipped with a rotating cutter surrounding the intake of the suction pipe. The combination of mechanical cutting action and hydraulic suction allows the dredge to work effectively in a wide range of sediment environments. Resuspension of sediments during cutterhead excavation is strongly dependent on operational parameters such as thickness of cut, rate of swing, and cutter rotation rate. Proper balance of operational parameters can result in suspended sediment concentrations as low as 10 milligrams per liter (mg/L) in the vicinity of the cutterhead. More commonly, cutterheads produce suspended solids in the 50 to 150 mg/L range (10 to 20 percent solids by weight) (EPA 1994b). Slurry uniformity and density are controlled by the cutterhead and suction intake design and operation. By pivoting the spuds used to anchor the barge in place, the dredge "steps" or "sets" forward for the next swing. Cutterhead dredges have been used at numerous sites in the Northwest and nationally, including the Sitcum Waterway Superfund Site (Washington), Lower Fox River (Wisconsin), and New Bedford Harbor (Massachusetts). Dredge residuals with cutterheads can be as much as a foot in thickness, and are frequently greater than ½ foot.

- **Auger Dredge:** The horizontal auger dredge is a relatively small portable hydraulic dredge designed for projects where a small (50 to 120 cy/hr) discharge rate is desired. In contrast to a cutterhead, the auger dredge is equipped with horizontal cutter knives and a spiral auger that cuts the material and moves it laterally toward the center of the auger, where it is picked up by the suction. There are more than 500 horizontal auger dredges in operation. A specialized horizontal auger dredge has been used at the Manistique Harbor Superfund site (Manistique, Michigan), the Marathon Battery Superfund site (Massena, New York), and the Lake Jarnsjon sediment remediation site (Sweden)

- **Specialty Dredges:** A number of specialty hydraulic dredges have been used at cleanup sites, including but not limited to the following:

  - The Toyo™ pump is a proprietary electrically driven compact submerged pump assembly that is maneuvered into position using a derrick barge. This pump is capable of high solids production in uncohesive sediment and can be equipped with a rotating cutter or jet ring to loosen sediment. This is a lower head pump that typically discharges through 6- to 12-inch-diameter pipes and may require a booster pump for long pipeline distances. Typically, slurry discharges are at a density of approximately one-third the *in situ* density. This specialty dredge was used at the mouth of the Hylebos Waterway (Tacoma, Washington, Area 5106) to remove 32,000 cy of contaminated sediment and pumped into the Blair Slip 1 CND between October 2002 and March 2003.

- The Pneuma™ pump is a proprietary pump developed in Italy that uses a compressed air and vacuum system to transport sediments through a pipeline. It may be suspended from a crane or barge and generally operates like a cutterhead dredge. This specialty pump was used at the Collingwood Harbor Project (Ontario, Canada) demonstration dredging project (EPA 1994a).

- The Mudcat™, a proprietary dredge device, was fitted with a vibrating auger head assembly and positive displacement pump specifically designed to excavate difficult, very soft material from the Sydney Tar Ponds (Nova Scotia). The dredge unit was modified to float in very shallow water and was moved using onshore winching cables and pulleys. Mudcats™ are one of the most commonly employed dredging units in the country, and have been used at various environmental dredging projects including the Manistique Harbor, Michigan; SMU 56/57 in the Lower Fox River Wisconsin; and at the New Bedford PCB remedial action site.

5.4.4 Dewatered Excavations

Excavation refers to the removal of sediments in the absence of overlying water, as with upland excavation. This often involves the use of conventional excavating equipment, and is generally restricted to removal of contaminated sediment and debris in shallow-water environments, dry excavations (areas that are bermed, then dewatered for access by land-based equipment), or during low tides. Dewatering of an area for dry dredging involves hydraulic isolation/removal of surface water using: (1) earthen dams, (2) sheet piling, or (3) rerouting the water body. Although normally land based, excavators can be positioned on floating equipment (e.g., spud barge) for dredging in shallow environments.

Various track-mounted excavators have been developed to access shallow water marsh environments for dike construction, dredge material disposal operations, pipeline crossings, and have been adapted for intertidal dredging excavation. Conventional backhoes, crane buckets, dragline, and other excavator types have been adapted to self-propelled, tracked assemblies that can travel over low bearing capacity soils and shallow water environments. These systems work optimally in shallow water depths and emergent shoreline and tide flats. The production capacity of these excavators is generally limited, and depends upon the bearing capacity of the intertidal sediments and the size equipment needed for the dredge areas.

Two specialty excavators are the Amphibex and Aquarius amphibious excavators. These are barge-mounted backhoes, capable of turning 360 degrees. These systems work optimally in water depths of 8 to 13 feet, but can also work on emergent shoreline and tide flats, according to the manufacturers. The excavators are mounted atop barges that have been fitted with "legs" with cylindrical wheels that provide mobility. The Amphibex amphibious excavator can operate in either straight mechanical or hydraulic transport modes. The Aquarius amphibious excavator only operates in mechanical dredging and transport modes. The DRE Technologies – Dry Dredge integrates a closed bucket mechanical dredge with a positive displacement pump for high solids dredged material transport.

5.4.5 Dredging Decision Factors

Selection of the appropriate type of dredging technologies and their potential effectiveness is dependent upon more than one variable. Significant operating parameters and constraints considered in selecting and applying appropriate dredging equipment include sediment characteristics, site conditions, potential for sediment resuspension and transport, use of turbidity barriers, amount and type of debris, equipment availability, and removal accuracy. As noted previously, production rates, and water management will be key in determining the size of equipment selected. Work sequencing and management are also important factors to consider during the remedial design. Each of these variables is discussed below.

Sediment Characteristics

The physical characteristics of the sediments, including particle size, density, cohesion (strength), and plasticity (stickiness), interact and affect dredge performance and efficiency (USACE 1995). These factors should be considered when selecting dredge types, designing sediment dewatering facilities, calculating settling rates, and planning other aspects of remedial activities. Rocks and debris, if present, can interfere with dredging and delay the cleanup process, often creating more water quality resuspension problems. A combination of hydraulic and mechanical dredging has been used for some cleanup projects (Sitcum Waterway, Washington; Black River, Ohio; Marathon Battery, St. Lawrence River, New York; Lake Jarnsjon, Sweden) where debris interfered with large-scale dredging or access was difficult. Recent sediment dredging projects have incorporated pre-removal of boulders, wood timbers, and other debris using excavator equipment prior to initiating dredging (Grasse River, Massena, New York; GM Foundry/St. Lawrence River, New York). This requires a complete investigation (debris survey) to identify where debris is present.

Sediment Accessibility

Difficult to access areas (i.e., near pilings, floating docks/marinas, riprap slopes, and between pilings and bulkheads) may require use of specialized equipment to adequately remove contaminated sediments. Recent projects have included multiple removal techniques in the remedial design to address these difficulties. For example, the Port of Vancouver Copper Spill Project (Vancouver, Washington) used a hydraulic cutterhead dredge in open areas with 0.5 feet of overdredge and diver-assisted suction dredging in underpier areas. The Port of Portland T4 Pencil Pitch Site (Portland, Oregon) used a shrouded environmental clamshell bucket for open-water areas, while nearshore and underpier areas were excavated with an airlift pump. Yet another example includes the Wyckoff/West Eagle Harbor Superfund Site where environmental clamshell buckets were used for open-water areas and backhoes were used for underpier areas at low tide. Typically, the dredging of under-pier areas is inefficient and leaves significant dredge residuals. Capping is typically incorporated into the remedial design for these areas. The method carried forward in the FS will depend upon sediment removal volumes, site access, upland space capacity for dewatering, and disposal.

Staging Areas & Logistics

Shoreline access is also a factor. Adequate space is required to establish shoreline staging areas for equipment, water pumps, dewatering equipment, personnel, sand cap material, and offloading/onloading of barge and dredge equipment. Availability of land-based space for support operations may factor into the selection of dredge type. To protect migrating salmonids, the USFWS limits the period in which in-water construction can be performed to certain "fish windows." Dredging can also be limited by the ability to transport, dewater, and dispose of excavated material. A significant limiting constraint for dredging is the availability of on-land property for staging and support activities, as well as disposal options (i.e., ability to transport dredged sediments to the disposal site at a rate equivalent to that of the dredging production rate).

Resuspension Potential

A major consideration for dredge design is the capability for removing targeted sediments with a minimum amount of sediment resuspension and loss during dredging (Anchor 2003; Averett 1997; Averett et al. 1999; Havis 1988). Sediment resuspension is unavoidable to some extent, regardless of the type of dredge employed, but can be minimized with operational techniques (e.g., controlling the dredge speed or cycle time). Although several specialty dredges (Cable Arm™ Bucket, Bonacavor) have been developed to reduce sediment resuspension, proper operation by an experienced contractor is an important factor to minimizing contaminant loss. The degree of sediment resuspension is also dependent on site conditions and variables, including sediment properties and size fractions (ability to resuspend), river flow hydraulics and hydrodynamics (extent of offsite transport), and ambient water quality (chemical partitioning into the water column). Data recently compiled for Scenic Hudson (Cleland 2000) and the Los Angeles Contaminated Sediments Task Force (Anchor 2003) determined that hydraulic and pneumatic dredges generally resuspend less sediment than mechanical dredges at the point of dredging. However, this benefit is offset by the much higher water entrainment encountered in the dredged material, the difficulty in managing dissolved-phase contaminants in the dredged materials, and in many cases the greater residuals at the point of dredging.

Sediment Residuals

All in-water removal operations will leave behind some level of residual contamination after completion of dredging. Although resuspension, with subsequent resettling is one factor that can influence the residual concentrations of contaminants, other factors such as the type and size of dredging equipment, level of operator skill, positioning equipment used during dredging, and the substrate type and bottom topography all combine to influence the post-dredging residuals. Managing dredging residuals is difficult simply because the dredge operator cannot see and manage the removal operation. A commonly observed phenomenon in both hydraulic and mechanical dredging is the creation of furrows or ridges between passes of the dredge equipment. The substrate and topography can greatly influence residuals. Where bedrock or hard clay underlies contaminated sediments, complete removal to low residual concentrations is both difficult and costly. When dredging on a slope, material often slumps and flows after being undercut during a removal path, resulting in recontamination of the just-dredged area. Hydraulic dredges generate residuals when the cutterhead is placed too low in the sediment or if the rate of advancement is too fast; both causing sloughing of the side cuts.

In recent years, dredging contractors have become more experienced and sophisticated at minimizing residuals. Bid documents prepared for remedial dredging include both horizontal and vertical specifications to account for uncertainty in the dredging footprint, and often specify a minimal number of passes within the footprint to achieve complete removal. However, residuals have been observed at sites after multiple dredge passes. Overlap between dredging lanes is often required, as well as the use of computer-aided positioning equipment and software, such as WINOPS, to ensure accurate and complete coverage of the dredge footprint. Matching the appropriate equipment to the dredging conditions, coupled with water quality monitoring during removal, aids in minimizing resuspension and recontamination. Even with these controls, dredging operations can still leave behind contaminant concentrations indicative of residuals at the conclusion of operations. The design should consider procedures for residuals management as part of any dredging design, and the limitations of dredging to achieve a clean final surface should be considered as part of remedial alternatives evaluation and cleanup decision-making. In short, dredging is an imperfect technology and typically leaves some degree of residual contamination, even with the use of best practices to minimize that residual.

Application of Turbidity Barriers

Turbidity barriers are specialized equipment that can be used as an engineering control to minimize downstream transport and loss of suspended solids during dredging operations. Because of their inherent logistical difficulties, they are typically employed where experience has shown that other operational controls cannot adequately meet water quality criteria. Turbidity barriers can be placed into two categories: structural and non-structural. Structural barriers are semi-permanent or permanent features to control the movement of sediment. The most common type is the sheet pile wall, a series of interlocking steel sections driven into the sediment to the same depth below mudline. This technology is expensive but effective in rivers with strong currents and/or tidal action and very high contaminant levels. It is often used in nearshore areas for dewatering and dry excavation. Non-structural, flexible barriers include oil booms, silt curtains, and silt screens. They are less expensive, easy to set up, and more movable than the structural barriers. Oil booms are utilized where dredged material may release oil residues on the water surface. Silt curtains are impervious fabrics that block, deflect, or substantially minimize the flow of water and suspended sediments. Silt screens are semi-permeable fabrics that allow water to pass while impeding the flow of coarse- to medium-grained fractions of the suspended load. Silt screens and curtains are typically suspended by floatation devices at the water surface and secured vertically in-place by a ballast chain within the lower hem of the skirt and anchored to the river bottom. These barrier systems are relatively cheap and easy to re-locate, but are limited by water depth (less than 21 feet), strong river currents (less than 1.5 feet/sec), and tidal cycles. Tidal ranges within the Whatcom Waterway can be as much as 16 feet and limit the effectiveness of screens or curtains.

Sediment Debris

The amount and type of debris to be found in the dredge zone will influence the type of dredging equipment and affect the production rate. Examples of debris include sunken logs, large rocks, shopping carts, engine blocks, rope, chain, concrete chunks, sunken boats, propane tanks, pilings, dolphins, rip rap, and other materials. Debris may also clog hydraulic dredge cutter or suction heads and pipeline, causing an increase in resuspension and requiring a temporary shutdown to remove the obstruction, thereby slowing the production rate. Debris can also inhibit the full sealing of mechanical dredge buckets, which causes loss of sediment during the buckets vertical assent through the water column and increases the rate of resuspension. The loss of sediment and the extra time devoted to handling and disposing of debris reduces the production rate.

Equipment Availability

Availability of dredging equipment is an important consideration. A number of floating clamshell dredges and small hydraulic dredges are available in the Puget Sound region. Large construction backhoes and equipment barges are also available. However, many of the specialty dredges discussed herein are not available locally and/or would require transport to the area or fabrication of new dredging equipment and a period of time to acquire operating experience. Conditions within the Whatcom Waterway site are not expected to require specialty equipment.

Dredge Accuracy and Removal Rates

Dredging accuracy is of significant importance in environmental dredging projects to ensure removal of contaminated sediments, minimize the volume of uncontaminated sediments removed, and minimize the number of passes required. Recent advances in dredging technology have included high-precision GPS location control. Several differential GPS units are used in the dredging operation, and placed on the barge and the dredge bucket or hydraulic cutterhead itself to provide a three-dimensional, real-time orientation of the equipment. High-resolution measurements provide the operator with real-time, sub-meter location precision and accuracy. These data, coupled with computer location software, allow the operator to know: (1) exactly where the dredge is collecting sediment from, (2) the amount of overlap needed to remove a swath of sediment, and (3) the exact depth of each dredge cut. In the past, system inaccuracies required remedial designs to operate on the order of 4-foot dredge prisms. With precision equipment and navigational aids, dredge operators can consistently operate to depth prisms of 0.5 foot or less with reliable accuracy. Removal efficiency is the capability for removing the target contaminated sediment layer in a single (or minimum number of) pass(es) with the dredge equipment, while minimizing the quantity of over dredged material to be treated and disposed. The costs and schedule for environmental dredging are largely dependent on the amount of sediment to be removed and the rate of removal. The rate of removal is affected by several variables, including water depth, type of excavation (wet or dry), the number and sizes of dredges used, the dredge operational speed, and the capacity of transport barges for mechanical and/or sediment dewatering, and water treatment systems for hydraulic dredging. Uncontrollable factors also affect the removal rate, such as passing ships and navigation restrictions, adverse weather conditions, unexpected presence of debris or bedrock, noise level restrictions, seasonal “fish window” restrictions, and tribal fishing rights.

Management of Entrained Water

Another decision factor is water management, and the practicality of managing large volumes of water associated with dredged material that will require collection and treatment prior to discharge of return flow to the Bay. The water volumes range from small amounts of free water and drainage arising from mechanically-dredged sediment to significant continuous volumes associated with return flow from a hydraulic dredge.

Hydraulic dredging would create large quantities of dredge slurry and entrained water. That contaminated water would ultimately be discharged back to Bellingham Bay. Assuming typical operating parameters (i.e., a controlled 2,000 cubic yard per day dredge production rate, a 10:1 water to sediment ratio and either one or two dredge units operating simultaneously) the hydraulic dredging would result in discharge of between 4 million and 8 million gallons per day of produced dredge waters to the Bay. The ability to treat and dispose of this continuously-generated water in a cost-effective and environmentally sound manner is a pre-requisite for the successful application of hydraulic dredging for large project areas. In some cases, the conditions under which hydraulic dredging and water management are performed can result in biogeochemical mobilization of bound sediment contaminants, such as at the Lavaca Bay, Texas dredging project. Bloom and Lasorsa (1999) report that high concentrations of methylmercury were released during separation of dredged material and entrained water from a hydraulic dredging event. The amount of methylmercury released was greater than could be accounted for by sediment pore water or bound methylmercury, suggesting that methylation of mercury was promoted by the conditions associated with the dredging and phase separation activities.

Dredging programs must consider the quantity and quality of waters to be generated, and must provide for management of water quality impacts to maintain the effectiveness of the dredging activity. In some cases dredging is not effective because these secondary impacts cannot be reliably controlled.

Contractual Issues and Operator Experience

The need exists for appropriately structured cleanup contracts, skilled operators, and preparation time for the operators to become familiar with the site. Adequate site characterization from the RI/FS process is typically supplemented during remedial design, and in some cases during the project bidding process. The characterization data relevant to dredging contracts include (1) the vertical extent of contaminated sediment requiring removal, (2) ship traffic and current/tidal ranges, and (3) the expected range of sediment physical properties (i.e., density, grain size, plasticity). These factors affect contractor costs, equipment selection and dredging procedures. The contractual agreements between the project engineer and the general contractor/dredge contractor are equally important. The emphasis should be carefully placed on the quality of removal, environmental protection and cost-effectiveness of the whole cycle of dredging, transport and disposal, not solely on the speed/cost of removal. Otherwise, cost-cutting measures taken at the point of dredging can result in significant environmental problems and cost control issues with the downstream activities (i.e., dredge material disposal, residuals management). During the selection process, the experience and skill of equipment operators should be evaluated and included as part of a contractor pre-qualification process.

In addition to selecting skilled and experienced contractors to conduct a dredging operation, operator experience can be managed in part by performance-based contracts to help ensure compliance with environmental monitoring and criteria. These contracts should allow the contractor flexibility to select or modify dredge equipment in order to meet the project objectives, but require compliance with the overall project objectives, including water quality goals. In the case of Puget Sound area projects, such as the Sitcum Waterway and Wyckoff/West Eagle Harbor projects, the contractor was aware of the project objectives, given flexibility to meet these objectives, and held accountable through performance-based contracting. Coupled with performance-based contracting and skilled operators is the requirement for skilled and knowledgeable independent oversight, as well as an adequate water quality monitoring program. Project oversight and contract management provide independent verification of achievement of project goals and objectives. The water quality monitoring program provides immediate feedback on the overall performance to both the dredging and oversight contractors.

5.5 Sediment Disposal and Reuse Options

If sediments are to be removed by dredging and not contained on site, then they must be disposed off-site or beneficially reused. Potential disposal and reuse options are described below.

5.5.1 Subtitle D Landfill Disposal

Dredged sediments containing elevated constituent levels can be disposed at permitted upland landfills. The solid waste landfills that manage refuse from households and businesses are known as Subtitle D facilities, because they are regulated under Subtitle D of the federal solid waste regulations. These landfills require "daily cover" to be placed over solid wastes at the end of each day of filling. Contaminated soils and sediments like those of the Whatcom Waterway can be used as daily cover at these facilities. This type of disposal is described in this Feasibility Study as "Subtitle D Landfill Disposal."

A recent study by the US Army Corps of Engineers (USACE, 2003) identified upland disposal in a commercial landfill as the preferred alternative for management of contaminated sediment in Puget Sound. A typical process would include offloading sediments from the point of dredging to an upland staging area, loading sediments into transportation from an upland staging area, transportation of the sediments to the landfill, and disposal in the landfill. For low-solids sediments, it may be desirable to decrease the volume and mass of sediments disposed in the landfill through dewatering, provided that this can be accomplished cost-effectively and in an environmentally protective manner. The exact management and treatment train depends on the volume of sediments to be disposed, the sediment properties, the required production rate, and the dredging method.

The Disposal Siting Documentation Report identified the Roosevelt Regional Landfill as a potential upland disposal site. The landfill is located in Roosevelt, Washington approximately 220 miles by rail from Bellingham. For use of this disposal site, dredged sediments would be offloaded from barges and loaded into railcars for transport to Roosevelt. The offloading could take place in Bellingham at a facility constructed to accommodate the sediment offloading and shipment, or at an already constructed facility, such as those in Seattle and Tacoma.

The Columbia Ridge landfill located in eastern Oregon is also available for management of dredged materials, and like the Roosevelt landfill is capable of managing sediments containing free liquids. The current capacity of the Roosevelt Regional Landfill and the Columbia Ridge landfill are on the order of several million cubic yards of sediment.

Other Subtitle D disposal sites located in Western Washington are generally limited to the management of materials that pass paint-filter tests for free liquids. This results in additional requirements for dewatering and/or solidification of the dredged materials for shipment to these alternative facilities.

The Subtitle D disposal option was retained for further evaluation in the Feasibility Study. Remedial alternatives development and cost estimation were based on pricing for transportation and disposal of materials to landfills permitted to accept wet dredged sediment materials.

5.5.2 New Upland Disposal Sites

For development of remedial alternatives and cost estimates, only existing facilities permitted to accept impacted sediments were used. It is possible that a new upland disposal site may be developed by a third party and would be available for use for sediment disposal.

An example of a potential new upland disposal site is the analysis conducted during the Bellingham Bay Demonstration Pilot of the Whatcom-Skagit Phyllite Quarry. The Whatcom-Skagit Phyllite Quarry is a soon to be closed quarry located approximately 15 miles from the site. If used for disposal of dredged sediments, a Washington Solid Waste permit would likely be required to construct a disposal facility in the quarry. The quarry would be graded, and a liner and leachate collection system constructed. Dredged sediments would be offloaded from barges in Bellingham, potentially dewatered, and transported to the quarry. After all sediments had been placed in the quarry, the sediments would be graded, and a cover constructed over the sediments. A wetland similar to those surrounding the site may be constructed over the cover. In the long term, leachate from the sediments would be collected, treated if necessary, and discharged to the City of Burlington sewer system. The capacity of the Whatcom-Skagit Phyllite Quarry was assessed at approximately 200,000 to 240,000 cubic yards of sediment. The final unit costs for disposal at the Phyllite Quarry would likely be similar to or in excess of Subtitle D disposal options. The availability and public acceptability of the option are not certain.

Other disposal facilities not currently certified as Subtitle D landfills could alternatively be suitable for use at the time of project implementation. These could potentially include some disposal facilities in British Columbia that are not directly subject to U.S. regulations, but rather are regulated by Canadian and/or provincial regulations. Use of these types of alternative disposal facilities would need to be approved by the Department of Ecology. These types of facilities are not necessarily precluded from use during the project, but were not used for cost analysis or development of remedial alternatives in the Feasibility Study.

5.5.3 PSDDA Disposal and Beneficial Reuse

In Puget Sound, the open water disposal of aquatic sediments is managed under the Puget Sound Dredged Material Management Program (DMMP). This program is administered jointly by the US Army Corps of Engineers, the US Environmental Protection Agency, the Washington Department of Natural Resources, and the Washington Department of Ecology. Under the DMMP, six aquatic disposal sites (PSDDA sites) have been created in Puget Sound, and several more outside Puget Sound. The PSDDA site typically used for Bellingham Bay maintenance dredging projects is located in Rosario Straits. The PSDDA sites are monitored by Washington Department of Natural Resources to ensure that the sediments placed in these sites do not pose unacceptable impacts in the long term.

In order to dispose of sediments in one of the sites, the sediments are first characterized to ensure that they meet the criteria for disposal at the PSDDA site. For removed sediments that exceed PSDDA criteria, alternative containment, treatment and/or disposal options must be used. The appropriate permits are obtained for the dredging work, and an application made for disposal in the PSDDA site. Washington Department of Natural Resources reviews the application and determines if the sediments may be disposed in the PSDDA site. If approved for PSDDA disposal, a Site Use Authorization will be issued. The applicant can then dredge their project and dispose of the material in the PSDDA site. A fee is paid by the applicant for use of the disposal site.

The PSDDA program has also developed guidance for the beneficial reuse of clean dredged materials. Reuse options must be compatible with the chemical and physical properties of the materials, and with applicable regulatory requirements.

5.5.4 Regional Multi-User Disposal Sites

At some point in the future, a multi-user sediment disposal site may be developed within the greater Puget Sound area. Significant efforts have been expended both within Bellingham Bay, and within the greater Puget Sound region to evaluate the potential design, location, operating procedures and long-term care requirements associated with such a facility. These efforts were supported by multiple environmental and resource agencies, and included programmatic evaluations by the Army Corps of Engineers, WDNR and other agencies. A multi-user disposal site scenario was pursued as part of the 2000 RI/FS and EIS, and was identified as an element of the preferred remedial alternative identified in those studies. However, the multi-user disposal site proved infeasible due to implementability barriers and associated costs. To date, the development of multi-user disposal sites within Bellingham Bay or Puget Sound has been unsuccessful.

There is no active proposal for development of a specific multi-user site that is likely to produce a completed site within the next three to five years. Lacking a specific regional multi-user disposal site, the regional disposal site option was not carried forward in the Feasibility Study. The potential for development of a project-specific disposal site is addressed by the Cornwall CAD and ASB CND options evaluated in the Feasibility Study.

5.6 *Ex Situ* Treatment

Treatment is a preferable remedy for long-term effectiveness under MTCA. However, with the exception of certain technologies such as dewatering and solidification, the feasibility of most treatment technologies has not yet been demonstrated for application to contaminated sediments. The Cooperative Sediment Management Program (CSMP), a consortium of federal and state agencies formed in 1994 to oversee the management of Puget Sound sediments, recently initiated a study to assess the feasibility and practicability of developing a multi-user treatment program or facility to help manage contaminated sediments in Puget Sound.

As part of the CSMP, a recent study by Ecology on the viability of sediment treatment in Puget Sound concluded that a centralized sediment treatment facility was economically feasible, though a combination of public and private capital would be required to develop such a facility (SAIC, 2001). Also as part of the CSMP, the US Army Corps of Engineers conducted a feasibility study for siting of a contaminated sediment management facility in Puget Sound, which included both disposal sites and treatment. This study concluded that because of the availability and interest from several upland landfills, that disposal in an existing commercial upland landfill provided the best approach for management of contaminated sediments expected to be generated from cleanup projects in Puget Sound (USACE, 2003). These studies and the general lack of demonstrated effectiveness of treatment of sediment indicate that treatment is not likely to be a viable option for sediments from the Whatcom Waterway, unless a new technology or capital source for a new treatment facility is identified.

Nevertheless, the treatment technologies that have been evaluated are described below. For each technology, agency technology reviews by EPA (1994 and 1999) have been supplemented with additional technology reviews performed for this project.

5.6.1 Dewatering & Volume Reduction

Sediment dewatering can include mechanical and passive methods. Mechanical dewatering involves the use of equipment such as centrifuges, hydrocyclones, belt presses, and plate and frame filter presses to remove moisture from the sediments. Passive dewatering (also referred to as gravity dewatering) involves the gravity separation of water and solids in a sedimentation basin. Treatment of wastewater generated during sediment dewatering may be required to meet water quality requirements for either discharge to a municipal wastewater treatment system, or back to surface water. Dewatering can be considered active treatment to the extent that it reduces the volume or toxicity of an impacted material.

Mechanical Dewatering

Mechanical dewatering equipment physically forces water out of sediment, and are typically paired with hydraulic removal systems. Four techniques are typically considered for dewatering dredged sediments: centrifugation, diaphragm filter presses, belt presses, and hydrocyclones.

- **Centrifugation** uses centrifugal force to separate liquids from solids. Water and solids are separated based upon density differences. The use of a cloth filter or the addition of flocculent chemicals assists in the separation of fine particles.

- **Hydrocyclones** are continuously-operated devices that use centrifugal force to accelerate the settling rate and separation of sediment particles within water. Hydrocyclones are cone shaped. Slurries enter near the top and spin downward toward the point of the cone. The particles settle out through a drain in the bottom of the cone, while the effluent water exits through a pipe exiting the top of the cone.

- **Diaphragm filter presses** are filter presses with an inflatable diaphragm, which adds an additional force to the filter cake prior to removal of the dewatered sediments from the filter. Filter presses operate as a series of vertical filters that filter the sediments from the dredge slurry as the slurry is pumped past the filters. Once the filter's surface is covered by sediments, the flow of the slurry is stopped and the caked sediments are removed from the filter. Filter presses are very costly and labor intensive.

- **Belt presses** use porous belts to compress sediments. Slurries are sandwiched between the belts, resulting in high pressure compression and shear, which promotes the separation. Flocculents are often used to assist the removal of water from the sediments. The overall dewatering process usually involves gravity-draining free water, low pressure compression, and finally high pressure compression. Belt presses can be fixed based or transportable. They are commonly used in sludge management operations at municipal and industrial wastewater treatment plants.

Mechanical dewatering is considered potentially cost-effective for application to low-solids materials such as the ASB sludges, and has been retained for consideration in the Feasibility Study for these materials. Volume reduction in the ASB sludges could significantly reduce disposal volumes, tonnages and costs. Application of mechanical dewatering to other medium and high solids materials such as the sediments outside the ASB is unlikely to be cost-effective.

5.6.2 Acid Extraction

The acid extraction process selectively extracts targeted metals while non-regulated metals theoretically remain in the treated soil or sediment. Under optimal conditions, metals can be concentrated from the process and may be suitable for recycling.

The process is semi-continuous and consists of three key treatment steps: physical separation, chemical extraction, and liquids processing. In the physical separation step, the dredged sediments are segregated at a land-based facility into various size fractions (typically using a 1/16 to 1/4 inch screen), to exclude relatively clean coarse materials such as sands and gravels from further treatment. The chemical extraction step typically consists of a multistage solvent extraction which utilizes proprietary additives in an acidic solvent to preferentially remove target metals. A slurry consisting of sediment and the acidic solvent is vigorously agitated in closed-top tanks to ensure thorough contact between the sediment and solution. Mechanical mixing and/or air sparging accomplish the agitation. The rate at which the metal ions are solubilized and enter the liquid phase is determined by controlling the residence time, solid particle size, degree of agitation, and the extraction solution composition. The optimal solvent/additives formulation, the required number of stages, and the key operating parameters are site specific and are determined by performing bench-scale treatability studies.

In the liquids processing step, the metal-laden solvent may be treated by filtration and electro-chemical processes to selectively recover the metal contaminants in a concentrated form. The solvent is treated and recycled back to the chemical extraction portion of the process.

To date, slurry extraction technology has been used at upland soil sites containing very high concentrations of target metals and much lower volumes of contaminated materials. The presence of organic materials and naturally occurring metals (e.g., iron) that are typical of Whatcom Waterway sediments are of significant concern when applying this process, and can affect performance and increase costs.

A "ballpark" cost estimate per unit of sediments treated, including upland disposal of residues is approximately \$200 to \$500 per cubic yard of in situ sediment (EPA, 1999). This technology was not considered effective or implementable for application at the Whatcom Waterway site.

5.6.3 Phytoremediation

Phytoremediation includes a variety of processes that use natural or genetically altered terrestrial plant species to accomplish chemical transformation, accumulation in plant tissue, and/or volatilization to the atmosphere.

In previous experimentation and pilot-scale testing specific to soils with relatively high mercury concentrations, gene isolation and introduction methods have been used to genetically engineer various plant species to accomplish such transformations. For example, strains of "hyperaccumulator" species such as Yellow poplar and cattail have been developed that release enzymes into soils, geochemically converting (over several steps) the metal compounds which are then transpired through the plant tissue, and released into the atmosphere (Phytoworks, Inc., unpublished data, 1998). The potential health hazards associated with application of this technology would need to be addressed in any full-scale operation.

Use of phytoremediation technologies within the Whatcom Waterway Area would require transfer of sediments to an upland treatment/disposal facility, and spreading of the sediments in a relatively thin layer (e.g., up to several feet thick) that would be seeded with freshwater or brackish hyperaccumulator species. Currently, field-scale phytoremediation of mercury soils has only been performed in the southeast (characterized by relatively long growing seasons), though bench-scale testing is currently underway in other areas of the U.S. Similar to the acid extraction technology, these sites have contained much higher concentrations and much lower volumes of contaminated materials than those present in the Whatcom Waterway site.

Based on these previous applications, a range of plant tissue manipulations, bench-scale laboratory analysis, and pilot-scale testing would likely be necessary to determine the feasibility of this process for application to the Whatcom Waterway site. Finally, because low-level contaminant residues could continue to persist in the treated material, the final residue may still require containment or upland landfill disposal.

A ballpark cost estimate per unit of sediments treated, including upland disposal of residues, would likely exceed roughly $200 per cubic yard of in situ sediment and the technology would require very large areas for implementation. This technology is not considered effective or implementable for application at the Whatcom Waterway site.

5.6.4 Soil/Sediment Washing

Soil/sediment washing is a water-based, volumetric reduction process whereby chemicals such as mercury are extracted and concentrated into a smaller residual volume using physical and chemical methods. Similar to the acid extraction process summarized above, an initial physical separation step is used at a land-based facility to exclude relatively clean coarse materials such as sands and gravels from further treatment. Subsequently, chemical extraction agents are added to the water-based "washing" medium, and may include surfactants, chelating agents, coagulants, flocculants, and pH modifiers. Under optimal conditions, the washing process permits concentration of hazardous chemicals into a residual liquid (water-based) product representing 10 to 30 percent of the original sediment volume. However, these volumetric reductions can become more difficult to achieve for sediments such as those within the Whatcom Waterway Area, which typically contain more than 80 percent fines. The presence of woody materials, also characteristic of subsurface sediments in the Whatcom Waterway Area, may further reduce the effectiveness of soil/sediment washing. The residual liquid (water-based) product produced by the soil/sediment washing process requires further treatment and disposal. Chemical extraction is discussed above, while thermal treatment and stabilization are described below. In some cases, the wastewater may be discharged to an off-site treatment plant or may be treated and discharged to Bellingham Bay. A "ballpark" cost estimate per unit of sediments treated, including treatment of residues, may range from approximately $100 to $500 per cubic yard of in situ sediment, depending on site conditions (EPA, 1999). Like Phytoremediation, the residual sediments are likely to contain constituent levels that would restrict reuse options and would require disposal of the treated residuals. This technology is not considered implementable or cost-effective for application to the Whatcom Waterway site.

5.6.5 Thermal Desorption

Several vendors have developed and commercialized medium-temperature thermal desorption processes for removing mercury from soils and sediments However, none of these technologies are permitted for application in the Puget Sound region. The process can recover a range of inorganic forms of mercury, if mercury recovery is performed. Lower cost forms of the technology volatilize mercury into the atmosphere.

In the higher-cost version of the process, soils/sediments are blended with a proprietary additive, which promotes decomposition of stable mercury compounds, and the blended sediments are then loaded into a batch-operated furnace for processing. Thermal processing is divided into two stages: feed drying and mercury desorption. The furnace temperature is ramped to a temperature at which moisture in the feed can be removed with minimum volatilization of mercury. During this stage, the process off gas is routed through a gas filtration system. After the feed has been dried, the furnace temperature is raised to, and held at, a temperature at which the mercury is driven off as a dry vapor. In this stage, the process gas stream is routed through a heat exchanger to condense metallic mercury from mercury vapor before the gas is routed through a gas filtration system. The operating temperature for the process typically ranges from 300 to 1,400 degrees Fahrenheit, depending on the moisture content of the soil/sediment and other site characteristics. The furnace and air handling components are typically protected by secondary containment, which operates under an air treatment system separate from that of the process air.

The medium-temperature thermal desorption process has been used successfully to remediate a range of upland soil sites containing mercury and other metals. Typically, these sites have contained much higher concentrations (e.g., hazardous waste mercury sludges) and much lower volumes of mercury-containing materials than those present in the Whatcom Waterway site. Considering the relatively high moisture content of Whatcom Waterway sediments, relative to upland soils, a "ballpark" cost estimate per unit of sediments treated, including disposal of residues, is approximately $500 to $2,000 per cubic yard of in situ sediment (EPA, 1999). This technology is not considered cost-effective for application at the Whatcom Waterway site.

5.6.6 Light Weight Aggregate Production

Several commercial ventures have developed processes that use mostly or all contaminated sediments as the raw material to produce light weight aggregate (LWA) with 30 percent less weight than regular rock but with the same strength. Typical LWA is made by heating pellets of compacted sediment (supplemented with clay or shale as required) to about 1,100 ^{o}C in a kiln. The material tends to break along fracture lines and therefore has inherent weak points.

A typically process flow consists of the following steps: 1) screen or filter dredged sediments to separate out sands, gravels, and other coarse materials; 2) grind, mix (possibly with clay or shale), and dry the material; 3) process the material through an extruder to make homogenous pellets; 4) further dry the pellets (optional); 5) process the pellets through a kiln; and 6) cool the pellets prior to transport and use.

Some of the issues that would need to be addressed in a full-scale application of LWA production include: 1) energy required to run the plant and possible use of waste heat in the drying process at a fixed plant location; 2) transportation costs; 3) kiln temperatures of 1,100 ºC may not be sufficient to destroy all organic contaminants; 4) the limited regional "market" for contaminated sediment treatment that may result in increased costs; and 5) the atmospheric release of volatile mercury from the treatment process would likely result in an unacceptable health risk. Given these parameters, a "ballpark" cost estimate per unit of sediments treated could range from approximately $100 to $200 per cubic yard of in situ sediment, depending on operating parameters, air emissions control requirements, availability of a reuse market for LWA.

Production of LWA from dredge materials is not considered implementable or cost-effective for application at the Whatcom Waterway site.

5.6.7 Plasma Vitrification

Several companies are currently developing higher-temperature processes in which contaminated sediments may be converted to a useful glass product by direct injection into the plume of a high-power, non-transferred-arc plasma torch (McGlaughlin et al., 1999). The sediments are first pretreated by conventional sorting and washing processes to remove large particles and debris, and to reduce the salt content. The sediment is then partially dewatered to produce a slurry or paste with as low a moisture content as possible while still being pumpable. Fluxing agents such as lime and soda ash are then added to adjust the final properties of the glass to be produced (melting point, viscosity, thermal expansion, and leachability). The mixture is then melted in the plasma reactor at temperatures exceeding 2,000 ^{o}C. The resulting molten glass for many sediments is granulated, producing an aggregate product which typically has low leachability. The glass product may then be used as the feedstock for a variety of products, including sandblasting grit, fiberglass, insulation fiber, roofing granules, and road aggregate. However, residual constituent concentrations can limit reuse options, and the current excess of recycled glass materials negatively affects the down-stream economics of this process. Without potential revenue from the sale of tile, this treatment process is not cost-effective. For high production facilities, a "ballpark" cost estimate per unit of sediments treated is approximately $150 to 200 per cubic yard of in situ sediment (McGlaughlin et al., 1999). This technology is not considered implementable or cost-effective for application at the Whatcom Waterway site.

5.6.8 Stabilization/Solidification

Solidification involves mixing a chemical agent with dredged sediments to absorb moisture. Portland cement, pozzolan fly ash, fly ash/Portland cement mixtures, and lime kiln dust are common additives. The chemical agent and sediments may be mixed in a pug mill or in a contained area (e.g., a roll off box or pit) using an excavator, depending upon sediment production rates and work space areas. Solidification is commonly used for sediments that have been partially dewatered by another means. Mechanically-dredged sediments can sometimes be solidified directly. Solidification is not a practical method for dewatering hydraulically-dredged sediments in the absence of thickening the solids by some other means, because the amount of chemical agent required becomes cost prohibitive. Requirements for solidification vary depending on the requirements of the disposal site or subsequent treatment option, the properties of the dredged materials, and also on the extent of previous dewatering conducted.

A number of different companies have developed manufacturing technologies for producing construction-grade cements or lightweight aggregate materials from a wide variety of contaminated waste materials, including sediments. Using various proprietary additives and processes, metals and organic chemicals can be immobilized and sequestered within the stabilized sediment. The material can be transformed into construction-grade cement. However, stabilization is typically conducted as part of a disposal step (i.e., as pretreatment of highly-impacted materials prior to disposal) rather than as a true material reuse application.

While stabilization has been used successfully using relatively coarse soils and sediments, the fine-grained characteristics of Whatcom Waterway sediments (i.e., greater than 80 percent fines) would require the addition of sand and/or gravel material to achieve typical structural requirements. Further, the presence of woody debris and other organic materials that are typical of Whatcom Waterway sediments are of significant concern when applying this process, and can substantially affect performance and increase costs. Finally, since the stabilization process does not permanently destroy chemical contaminants, the permanence (e.g., long-term durability) of the stabilized matrix would need to be addressed in bench-scale testing.

A ballpark cost estimate per unit of sediments treated is approximately $100 per cubic yard of in situ sediment (EPA, 1999), and a large disposal area or reuse area for the solidified material would be required. Washington state regulations (MTCA requirements and State Solid Waste Management Regulations) could further limit the ability to reuse the materials as construction subgrade or controlled density fill, and would likely require the materials to be managed as a solid waste. This technology is not considered implementable or cost-effective for application at the Whatcom Waterway site.

5.7 *In Situ* Treatment

Multiple bench and pilot-scale studies have evaluated potential *in situ* treatment technologies for sediment. These have included nutrient enhanced biological degradation, chemical oxidation, and stabilization. None of these studies has proven effective to date. However, a detailed screening was conducted for each of two in situ technologies. The first is an *in situ* treatment technology specifically intended for removal of metals from impacted sediments and sludges. The second technology is a type of capping known as "reactive capping."

5.7.1 Electro-Chemical Reductive Technology

Electro-chemical reductive technology (ECRT) was originally developed in Europe. The technology is based on imposing a direct electrical current with a superimposed alternating energy current via in situ electrodes, to optimize and utilize the electrical capacitance properties of soil and sediment particles.

The technology purports to be capable of oxidizing organic chemicals *in situ*, and concurrently enhancing the mobility of metals such as mercury, resulting in metal precipitation onto the electrodes. To date, the technology has been applied at one sediment site in Europe containing elevated concentrations of mercury and other metals. However, the technology has not yet been applied on a full scale in the U.S.

A pilot test of ECRT was performed at the Log Pond area of the Whatcom Waterway site, as described in Section 7.3 of the RI Report. However, it was found to be ineffective at achieving mercury removal. This technology is not considered sufficiently effective for application at the Whatcom Waterway site.

5.7.2 Reactive Caps

Reactive capping is a developing technology that incorporates catalytic, sequestering, or blocking agents into the sediment cap design. This may be done by specification of a total organic carbon content in the applied cap, or through additions of materials that have been shown to be effective in dechlorination, sequestering of metals or recalcitrant hydrocarbons, or providing a seal against contaminant migration through a cap.

In recent Puget Sound projects, organic carbon additions have included application of granulated anthracite to the Pacific Sound Resources RA1 cap, addition of peat mixed with the sand cap in the Head of the Thea Foss Waterway project (DOF 2004), and the addition of granular activated carbon to the cap at the Olympic View Restoration Area. At the Olympic View Restoration area, high TOC materials mixed with sand was placed as part of the lower layer of an isolation cap to protect against PCBs and dioxins. This "high TOC/sand" layer was 6 inches thick. The material was not thought of as a reactive cap, but was placed as a precautionary barrier (K. Keeley, EPA, personal communication). The cap design followed the standard USACE guidance calculations for caps. According to the design document, the GAC used was a "common commercial-grade product" mixed at 4 percent by volume (1.5 percent by weight) (Hart Crowser 2002).

A major demonstration of several of the more active-addition reactive cap designs is now underway on the Anacostia River in Washington, DC (HSRC 2004). The objective of the Anacostia River demonstration project, which began field trials in spring 2004, is to provide information on the design, construction, placement and effectiveness of these augmented caps. The cap methods selected for use in the pilot demonstration included multiple augmentation materials. AquaBlok™, a commercial product designed to enhance chemical sequestering (e.g., through TOC amendments to the cap) and to reduce permeability at the sediment-water interface. AquaBlok™ is not recommended for application in saline environments. Apatite is a material added to encourage precipitation and sorption of metals. Coal and/or coke breeze materials were added because they can strongly adsorb hydrophobic organic contaminants such as PCBs.

Based on the success of the Log Pond cap at preventing migration of sediment contaminants upward through the cap, there does not appear to be a need to apply reactive cap technology at the Whatcom Waterway site. Reactive cap technology was not retained for application at the site.

5.8 Summary of Retained Technologies

As described in Sections 5.2 through 5.7 above and as indicated in Table 5-1, the following remedial technologies were considered sufficiently effective, implementable, and cost-effective for use in the development of remedial alternatives:

- **Monitored Natural Recovery:** The effectiveness of natural recovery at reducing surface concentrations of mercury within the site has been demonstrated. The use of Monitored Natural Recovery as part of a remedial strategy for the site is considered effective and implementable. This technology is retained for use in the development of remedial alternatives.

- **Containment by Capping:** Capping is effective, implementable and cost-effective, and is retained for use in the development of remedial alternatives. Land use, navigation patterns and physical factors will be considered in the discussion of capping feasibility for specific site areas.

- **On-Site Containment:** Section 5.3 addresses potential on-site containment options for contaminated sediments that maybe generated during site remediation. These include the development of a CAD site adjacent to the Cornwall Avenue Landfill and the development of a CND within the ASB. These containment options are retained for use in the development of remedial alternatives.

- **Removal by Mechanical Dredging:** Mechanical dredging using appropriate equipment is retained for use in the development of remedial alternatives. Mechanical dredging is the most commonly used form of dredging for implementation of site cleanup projects, and appropriate equipment and skilled operators are available from within the region.

- **Removal by Hydraulic Dredging:** Hydraulic dredging was retained for use in the development of remedial alternatives, particularly for potential removal of ASB sludges, or for localized work within the Whatcom Waterway. Any application of hydraulic dredging would need to provide for management of sediment debris, minimization of dredging residuals, and methods for managing produced dredge slurry and separated waters in a cost-effective and environmentally protective manner.

- **Removal by Excavation:** Excavation of sediments without overlying water is retained for use in the development of remedial alternatives for specific portions of the site such as the ASB that could potentially be dewatered. Wet excavation using an articulated dredge is also retained for consideration. This method could be used in both confined and exposed portions of the site.

- **Treatment for Volume Reduction:** For low-solids sediments such as the ASB sludges, treatment for volume reduction using centrifuges, hydrocyclones or other mechanical dewatering equipment is retained for use in the development of remedial alternatives. Treatment for volume reduction is not retained for medium to high solids sediments such as those from areas outside of the ASB.

- **Subtitle D Landfill Disposal:** Contaminated sediments may be disposed at a permitted off-site subtitle D disposal facility. This disposal option is retained by use in the development of remedial alternatives.

- **PSDDA Disposal and/or Beneficial Reuse:** In specific areas of the site, sediments may be suitable for PSDDA disposal or beneficial reuse. These disposal and reuse options are retained for use in the development of remedial alternatives.

- **Institutional Controls:** Institutional controls are effective, implementable and cost-effective and are carried forward for use in the development of remedial alternatives.

Table 5-1. Screening of Remedial Technologies

General Response Actions	Remedial Technology	Technology Retained ?	Summary of Technology Screening Decision and Factors to be Considered in Development of Alternatives
1. Institutional Controls			
	Institutional Controls and Monitoring	**Yes**	No remedial technologies are considered likely to remove 100% of the impacted sediments from the site. Prior to dredging or in-water construction projects, environmental reviews are conducted by the Corps of Engineers, the Department of Ecology, and other resource agencies. These reviews address some of the issues related to long-term institutional controls for the remedies. Additional monitoring and institutional controls are appropriate to maintain the effectiveness of the remedy. Appropriate institutional controls will be developed to ensure maintenance of remedy protections in the future, potentially including updates to waterway designations, harbor area designations and/or use authorizations. Information documenting site remedial actions may be recorded in County property records, or in records maintained by the State for state-owned aquatic lands.
2. Natural Recovery			
	Monitored Natural Recovery	**Yes**	The data documented in the site Remedial Investigation indicate that natural recovery has been effective in reducing surface sediment concentrations in many areas of the site. MNR has been successfully applied at other Puget Sound area sites and may be appropriate for application at the Whatcom Waterway site in areas where land use and navigation conditions do not conflict with its use, and where monitoring and modeling demonstrate its effectiveness.
	Enhanced Natural Recovery	No	Enhanced natural recovery could be used at the site to enhance the restoration time-frame of areas where monitored natural recovery is occurring but has not yet achieved remedial objectives. However, the Feasibility Study will use MNR and Capping for alternatives development, in order to consolidate the number of remedial alternatives evaluated.For purposes of the FS, the use of ENR will be considered a potential enhancement of MNR.
3. Sediment Containment			
	Capping In Place	**Yes**	Capping has been used successfully within the Log Pond portion of the site to address imapacted sediments there, and has been successfully implemented at other sites within Puget Sound. The costs of capping are typically lower than those for sediment removal and treatment, disposal, or containment in newly constructed on-site facilities. Capping may be applied either for 1) in-situ capping, 2) capping after partial removal actions, or 3) management of dredge residuals. Capping decision factors are discussed in Section 4.
	Confined Nearshore Disposal	**Yes**	Confined nearshore disposal options have been successfully implemented at other sites within the Puget Sound region. The use a CND facility for sediment management was also previously evaluated for application at the Whatcom Waterway site. Georgia Pacific proposed the construction of a CND facility within the ASB as part of the 2002 Supplemental Feasibility Study. This technology has been carried forward for the development of remedial alternatives. Other CND facilities that were screened out during previous Bellingham Bay Pilot evaluations are not carried forward in this Feasibility Study.
	Confined Aquatic Disposal	**Yes**	Confined Aquatic Disposal options have been successfully implemented at other sites within the Puget Sound Region. The use a CAD facility for sediment management was also previously evaluated for application at the Whatcom Waterway site. The development of a CAD facility adjacent to the Cornwall Avenue Landfill was identified as the preferred alternative in the 2000 EIS. This technology has been carried forward for the development of remedial alternatives. Other CAD facilities that were screened-out during previous Bellingham Bay Pilot evaluations are not carried forward in this Feasibility Study.

Table 5-1. Screening of Remedial Technologies

General Response Actions	Remedial Technology	Technology Retained ?	Summary of Technology Screening Decision and Factors to be Considered in Development of Alternatives
4. Sediment Removal Methods			
	Mechanical Dredging	**Yes**	Mechanical dredging is the most widely used technology for removing sediments during navigational and cleanup dredging in the Puget Sound region. Mechanical dredging expertise and equipment are available locally. Dredging decision factors are discussed in Section 4.
	Hydraulic Dredging	**Yes**	Hydraulic dredging may be suitable for application in specific areas of the site, or with specific disposal options. If applied for general remediation of the site, hydraulic dredging may produce between 4 and 8 million gallons per day of impacted water that must be treated and discharged to the sanitary sewer and/or Bellingham Bay. The application of hydraulic dredging is considered most implementable for the ASB sludges, where the removal could be constructed using a closed-loop water management system prior to final water treatment and disposal. Hydraulic dredging may also be suitable for use in localized site areas where overall water generation can be minimized. Finally, hydraulic dredging could be used with the ASB CND option, provided that design evaluations confirm the ability to manage debris, dredge residuals and generated waters. Other dredging decision factors are discussed in Section 4.
	Excavation	**Yes**	Excavation without overlying water can not realistically be used for remediation of the majority of the site. However, the enclosed nature of the ASB area may allow for excavation of the ASB sludges, or for excvation of dredge residuals remaining after mass sludge removal. Any application of excavation removal would need to address dewatering methods for the area to be excavated. The use of excavator dredges for in-water dredging is also considered feasible, but these dredge methods are considered as a subset of the mechanical dredging options discussed above.
5. Disposal and Reuse Options (Section 4.3)			
	Subtitle D Disposal Sites	**Yes**	The use of Subtitle D disposal has been successfully applied to navigation dredging and remediation dredging at multiple sites within the Puget Sound Region. At least two regional landfills are available that can accept wet materials typically generated at dredging projects, and both of these landfills have sufficient capacity for use during the project. Other Subtitle D landfills are available within the region that may accept dewatered or solidified dredge materials.
	New Upland Disposal Sites	No	The development of a new upland disposal site is not carried forward for development of remedial alternatives. The costs of developing a new upland disposal site are likely to be similar to or greater than upland disposal in an existing Subtitle D facility. If a suitable facility is developed by a third party prior to project implementation, then it can be consdered at the time of project remedial design, permitting and/or contracting. However, no suitable disposal sites were identified at the time of RI/FS preparation as being under development with anticipated permit flexibility and disposal capacity appropriate for management of Whatcom Waterway dredge materials.
	PSDDA Disposal and/or Beneficial Reuse	**Yes**	Procedures for management of sediments under the PSDDA program are well developed, and are retained for consideration for those materials that meet or are likely to meet PSDDA program requirements. Beneficial reuse of certain materials may also be appropriate, especially clean sand and stone materials from the ASB berms. Such materials could be reused as part of cleanup and/or habitat enhancement actions within Bellingham Bay. PSDDA disposal and/or beneficial reuse are retained for use in the development of remedial alternatives.
	Regional Multi-User Disposal Sites	No	To date, no regional multi-user disposal sites have been developed, and no sites are proposed at this time that are considered likely to be available at the time of project implementation.

Table 5-1. Screening of Remedial Technologies

General Response Actions	Remedial Technology	Technology Retained ?	Summary of Technology Screening Decision and Factors to be Considered in Development of Alternatives
6. Ex-Situ Sediment Treatment			
	Dewatering & Volume Reduction	**Yes**	Commercially-viable technologies are available for dewatering and volume reduction of low-solids materials such as the ASB sludges. For low-solids materials, these technologies may be cost-effective and may substantially reduce overall disposal requirements. These technologies are not considered necessary or cost-effective for pre-treatment of medium- and high-solids sediments that are to be disposed in subtitle D facilities capable of accepting wet materials. The use of other subtitle D facilities that can accept only dry materials would require application of dewatering or solidification methods prior to transportation and disposal.
	Acid Extraction	No	This technology is costly and has not been successfully applied at large sediment sites. The treatment would not address organic contaminants, and would not remove the need for sediment disposal following treatment. This technology is least effective for fine-grained sediments such as those at the Whatcom Waterway site.
	Phytoremediation	No	Phytoremediation has not been successfully implemented on a large scale for management of dredged marine sediments containing both organic and inorganic contaminants. The technology would require a large land area for treatment, and the residuals would likely require subsequent disposal, along with plant matter produced during the phytoremediation process, increasing overall disposal requirements.
	Soil/Sediment Washing	No	Soil washing is least effective on fine-grained sediments such as those present at the Whatcom Waterway. This technology has not been successfully applied at similar sediment sites. The process would generate large volumes of contaminanted water requiring subsequent treatment and disposal to Bellingham Bay. Treated residuals would likely require disposal, limiting the overall benefit of this technology. Costs of the technology are higher than those for Subtitle D disposal.
	Thermal Desorption	No	There are no permitted mobile or fixed facilities in the Puget Sound region that are currently capable of conducting thermal desorption of Whatcom Waterway sediments. To avoid potentially harmful air emissions of mercury, thermal desorption would require the use of expensive air emissions controls. The projected costs for thermal treatment including appropriate emissions controls are substantially greater than those for Subtitle D disposal.
	Light-Weight Aggregate Production	No	There are no commercially viable facilities for the production of light-weight aggregate from dredged materials. Any new facility would require air emission controls to prevent potentially harmful emissions of mercury. There is no existing market for light-weight aggregate produced from dredged materials. The estimated costs for light-weight aggregate production are estimated to substantially exceed those of subtitle D disposal.
	Plasma Vitrification	No	Plasma vitrification could be used to convert dredged sediments to a glass matrix. The treated residuals could then be managed similar to recycled glass. However, residual contaminants will remain in the vitirified matrix, limiting potential reuse options. Currently there is no market for vitrified sediment residuals in the Puget Sound area. The costs of vitrification are substantially greater than those of Subtitle D disposal.
	Stabilization/Solidification	No	Stabilization/solidification as a pre-treatment for Subtitle D disposal is not carried forward, due to the availability of disposal sites permitted to accept wet dredge materials. It could be appropriate to use the technology if alternative disposal sites are used that cannot accept wet sediments. Due to residual contamination and the presence of biodegradable woody materials in the Whatcom Waterway sediments, reuse of the stabilized materials as soil amendments or construction subgrade is not considered practicable. Washington State Solid Waste Handling regulations may require stabilized materials to be managed as a solid waste. Therefore, stabilization/solidification as a stand-alone technology is not carried forward for development of remedial alternatives.

Table 5-1. Screening of Remedial Technologies

General Response Actions	Remedial Technology	Technology Retained ?	Summary of Technology Screening Decision and Factors to be Considered in Development of Alternatives
7. In-Situ Treatment			
	Electro-Chemical Reduction Technology (ECRT)	No	ECRT was pilot-tested in the Log Pond and was found to be ineffective. The technology has not been successfully implemented for treatment of metals-impacted sediments on a scale similar to that at the Whatcom Waterway site. The technology does not address organic contaminants.
	Reactive Caps	No	Reactive capping technology remains under development, and has not been applied for on a full scale for metals-impacted sediments in marine environments. Reactive caps have been applied mainly for reducing the mobility of organic contaminants. Previous capping of the Log Pond demonstrated that standard thick capping methods can prevent upward migration of both inorganic and organic constituents. The incremental costs associated with the use of reactive cap designs are not considered appropriate given the preliminary nature of the technology for metal-impacted marine sediments and the success of standard thick-capping methods.

6 Description of Remedial Alternatives

This section includes a description of the eight remedial alternatives. The alternatives were developed using the technologies selected during the technology screening (Section 5). Table 6-1 provides a concise summary of the remedial alternatives and the technologies applied from Section 5. The information in this section provides for each of the alternatives:

- a detailed description of the cleanup actions performed in each portion of the Site;
- a discussion of the management options used for dredged materials generated by the cleanup action;
- a summary of the costs and schedule of the cleanup alternative;
- a discussion of potentially significant changes to existing habitat conditions associated with implementation of the cleanup action; and
- land use and navigation considerations relevant to the cleanup action.

Table 6-1 Concise Summary of Remedial Alternatives & Technologies Applied

Alternative Number	Probable Cost ($million)	Institutional Controls	Monitored Natural Recovery	Containment	Removal & Disposal	Treatment	Reuse & Recycling
Alt. 1	$8	Yes	Yes	Yes	—	—	—
Alt. 2	$34	Yes	Yes	Yes	—	—	—
Alt. 3	$34	Yes	Yes	Yes	—	—	—
Alt. 4	$21	Yes	Yes	Yes	Yes	—	—
Alt. 5	$42	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 6	$44	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 7	$74	Yes	Yes	Yes	Yes	Yes	Yes
Alt. 8	$146	Yes	Yes	Yes	Yes	Yes	Yes

Table 6-2 provides a detailed description of each of the eight remedial alternatives described in this section. Figures 6-1 through 6-9 illustrate the design concept of each of the alternatives. Detailed cost and engineering assumptions are provided in Appendices A and B.

6.1 Alternative 1

Alternative 1 uses containment, monitored natural recovery and institutional controls to comply with SMS cleanup levels and MTCA cleanup requirements. Alternative 1 is illustrated in Figure 6-1. Alternative 1 makes the least use of active remedial technologies of all of the evaluated alternatives.

6.1.1 Actions by Site Unit

Cleanup actions under Alternative 1 are described below by site area. The application of active cleanup measures and institutional controls is detailed in Table 6-2 for each Site Unit:

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 1, no dredging or capping will be performed in the outer portion of Whatcom Waterway. Surface sediments in this area currently comply with SMS criteria. Subsurface impacted sediments would remain in place beneath the clean surface sediments. Some reduction in waterway depth would result under this alternative. Future channel maintenance would likely be restricted beneath elevations of approximately 26 feet below MLLW in order to avoid resuspension of impacted subsurface sediments. This depth restriction would need to be addressed in Waterway planning and site institutional controls.

- **Inner Whatcom Waterway (Units 2 & 3):** As with the Outer Whatcom Waterway, no dredging or capping would be performed in the Inner Whatcom Waterway under Alternative 1. The majority of this area has naturally recovered, with some surface contamination remaining in nearshore berth areas along the Colony Wharf portion of the Central Waterfront site. Additional recovery time will be required to achieve full restoration of this area. Reductions in waterway depths will accompany the use of natural recovery in the Inner Whatcom Waterway areas. The effective waterway depth will vary as shown in Figure 6-1. Additional recovery modeling would be required as part of Cleanup Action Plan development and/or remedial design to verify the applicability of natural recovery for this area.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** The sludges within the ASB will be remediated using a thick sub-aqueous cap. Prior to cap placement, the treatment equipment (aerators, weirs, etc.) would be removed from the ASB. The conceptual design for the cap includes a nominal 3-foot layer of sandy capping material, with coarse materials placed in nearshore areas where wind-driven wave action may be significant. If the ASB is to be used for future stormwater/cooling water treatment, then the ASB would need to either remain connected to the current GP-owned outfall, or be provided with an alternate, appropriate-sized discharge outfall. Other modifications may be required depending on planned future uses.

6.1.2 Sediment Disposal

No sediment dredging is included in Alternative 1. All impacted sediments are managed in-place using containment technologies (capping) and monitored natural recovery. No sediment disposal sites are required under this alternative.

6.1.3 Costs & Schedule

Alternative 1 is the lowest cost of the eight evaluated alternatives. The total probable cost of Alternative 1 is $8 million. Most of this cost is associated with the capping of the ASB sludges and the two impacted harbor areas. Additional costs are included to provide for long-term monitoring of capping and natural recovery areas (Appendices A and B).

The construction activities in Alternative 1 can likely be completed within a single construction phase. The capping activities in the two impacted harbor areas would be completed during appropriate times of the year when the potential for impacts to juvenile salmonids is minimized. These construction “fish windows” are typically specified as part of project permitting requirements. Because the ASB area is not connected to Bellingham Bay, the capping activities within the ASB will not necessarily be time-limited by the “fish windows”.

Monitoring of capped and natural recovery areas will occur under Alternative 1. Previous recovery analyses performed as part of the Remedial Investigation suggest that 5 and 10 years may be required for the sediment areas near the Colony Wharf portion of the Central Waterfront site. Site-specific recovery modeling would be required as part of Cleanup Action Plan development or remedial design to verify the effectiveness of this alternative. Appendix A includes unit cost and volume assumptions for Alternative 1.

6.1.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 1 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 1 does not change habitat conditions in the Outer Whatcom Waterway.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 1, no dredging is conducted within the Inner Whatcom Waterway areas, and additional shoaling would occur as part of monitored natural recovery. These processes result in preservation and enhancement of the quantity of shallow-water aquatic habitat.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 1 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 1 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 1 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 1 does not change the existing habitat conditions for the ASB. The ASB sludges will be capped, and this area will remain isolated from Bellingham Bay.

6.1.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 1 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 1 conflicts with existing and planned navigation uses in the Outer Whatcom Waterway. The presence of residual impacted sediments will impact the effective water depth of the terminal area. Current depths range from about 30 feet to over 35 feet below MLLW, but dredging will be required in the future to maintain navigation depth. Such dredging would resuspend impacted sediments unless the dredging were precluded below the current mudline. This would effectively limit the usable and maintainable water depth in this area to a minimum of approximately 25 feet below MLLW.

- **Inner Whatcom Waterway (Units 2 & 3):** The Inner Whatcom Waterway area has highly variable mud-line elevations. Shoaling is present particularly at the head of the waterway (near the Roeder Avenue bridge) and along the berth areas of the Central Waterfront shoreline. Effective water depths (the usable water depth along the current pierhead line) in this area vary from about -7 feet MLLW to areas that are exposed at low tide. The use of natural recovery as the remedial strategy for these areas under Alternative 1 would limit usable water depths to current conditions, with an additional measure of shoaling required to permit continuance of natural recovery and protect against resuspension of underlying contaminated sediments. Future docks or floats could be constructed in deeper waterway areas, however; the portion of the Waterway useable for navigation would be significantly less than under other project alternatives, resulting in conflicts in some areas with planned navigation and land use improvements (section 4.1.2). Further, Alternative 1 does not stabilize Inner Whatcom Waterway shorelines, resulting in potential additional use limitations in unstable shoreline areas.

- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.

- **Areas Offshore of ASB (Unit 5)::** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) will reduce navigation depths in this area by approximately 3 feet (final cap thickness to be determined in final design and permitting). This change will not preclude navigation uses in this area, but will need to be incorporated into future navigation and infrastructure planning for the area.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 1 are consistent with current and anticipated navigation and land uses at Starr Rock.

- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 1 conflicts with this planned use.

6.2 Alternative 2

Alternative 2 uses monitored natural recovery, institutional controls and containment technologies to comply with SMS cleanup levels and MTCA cleanup requirements. However, unlike Alternative 1, dredging of sediments from within the Whatcom Waterway channel is conducted. These sediments are managed in a new Confined Aquatic Disposal (CAD) facility that would be developed offshore of the Cornwall Avenue Landfill. The Cornwall CAD site location was selected during the 2000 EIS after evaluation of potential alternative locations. The design concept for alternative 2 is shown in Figure 6-2.

6.2.1 Actions by Site Unit

Alternative 2 represents a modification of the preferred alternative from the 2000 RI/FS and EIS process. These analyses were based on continued industrial uses of the Central Waterfront and New Whatcom areas. These analyses also assumed that future land uses would comply with the restrictions applicable to continued maintenance of the 1960s federal navigation channel. Current zoning and land use planning have changed, necessitating re-evaluation of the site remedial alternatives.

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 2, the outer portion of the waterway would be dredged to a minimum depth of 35 feet below MLLW. Where technically feasible, the dredging depths would be increased to allow dredging to the base of the impacted sediments in the channel areas. Anticipated dredge depths vary from 35 feet below MLLW to about 41 feet below MLLW. The sediments removed during this dredging would be barged to the Cornwall CAD site location, and placed within the containment facility. The sediments from Units 1A and 1B would be used in upper portions of the CAD site, and the facility would be completed as described below. Some capping may be required in areas that are not technically feasible to dredge (to be determined during remedial design and permitting). Dredging methods used for the Outer Whatcom Waterway would likely be mechanical, reducing the entrained water management concerns applicable to hydraulic dredging, and producing dredge materials with physical properties appropriate for CAD site management. Detailed dredging and construction procedures and alternatives would be evaluated in project design and permitting.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 2, sediment dredging would be performed as necessary to provide for future use and maintenance of the 1960s federal navigation channel to the head of the waterway. The 1960s federal channel boundaries specify a water depth of 30 feet below MLLW from the Port terminal area to Maple Street. A depth of 18 feet is specified from Maple Street to the head of the waterway. In the Outer Whatcom Waterway, the dredging cut would be established at an elevation at least 35 feet below MLLW. This would remove sediments where technically feasible, and would provide sufficient overdepth to allow residual sediments to be capped without impeding future maintenance of the federal channel. The design concept assumes a cap thickness of 3 feet over dredged areas with residual subsurface sediment impacts. Due to historical encroachment of shoreline fills on the federal channel boundaries, many of the Inner Whatcom Waterway shoreline areas have fill and bulkheads located near or at the pierhead line. Most of these bulkheads would require replacement and/or substantial upgrades in order to maintain shoreline stability in these areas during and after dredging. Most docks and bulkheads along the Central Waterfront shoreline were constructed historically when the channel depth was shallower (18 feet below MLLW) and these docks and bulkheads would need to be either removed or replaced in order to accommodate federal channel dredging and future use. After dredging, the effective water depth (water depth at the pierhead line) will vary with location along the shoreline. The effective water depth will be controlled mostly by the type of shoreline infrastructure (i.e., nearshore fill, docks and bulkheads) that is established there. Without substantial infrastructure investments in shoreline modifications, bulkheading and dock reconstruction, the effective water depth for the head of the waterway will be significantly less in most areas than the federal channel project depth. This alternative is inconsistent with planned use of the Inner Whatcom Waterway, as described in Section 4.2.1. Planned use of the Inner Whatcom Waterway includes providing waterfront uses that combine public access, habitat enhancement and navigation uses in a manner consistent with the current-mixed use waterfront zoning. The remedial costs of this alternative address only sediment removal. The costs of the shoreline infrastructure required to improve the effective waterway depth would be borne by area redevelopment actions.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** The ASB will will be remediated using a thick sub-aqueous cap. Prior to cap placement, the treatment equipment (aerators, weirs, etc.) would be removed from the ASB. The conceptual design for the cap includes a nominal 3-foot layer of sandy capping material, with coarse materials placed in nearshore areas where wind-driven wave action may be significant. If the ASB is to be used for future stormwater/cooling water treatment, then the ASB would need to either remain connected to the current GP-owned outfall, or be provided with an alternate, appropriate-sized discharge outfall. Other modifications may be required depending on planned future uses.

6.2.2 Sediment Disposal

Unlike Alternative 1, Alternative 2 involves substantial sediment dredging. The sediments dredged from the Waterway areas will be managed by containment in a new Confined Aquatic Disposal (CAD) area adjacent to the Cornwall Avenue landfill. The design concept estimates disposal of approximately 472,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas, and an additional 113,000 cubic yards of sediments dredged from Units 1A and 1B.

The Cornwall CAD site location was identified through the Bellingham Bay Pilot process, after evaluation of balancing criteria including costs, navigation, land use and habitat factors. The CAD location was incorporated into the range of remedial alternatives discussed in the 2000 RI/FS. The principal benefit of the Cornwall location as identified under the Pilot was the ability to create nearshore aquatic habitat using the CAD design approach. The geography of the area requires initial construction of an armored containment berm, prior to placement of the dredged materials within the site. Armoring of the outer edges of the berm is required to ensure long-term stability of the completed structure under anticipated wave energy and erosion conditions.

During filling of the CAD site, the containment berms would be constructed above tidal elevations. Sediments would be loaded into the facility and allowed to consolidate. The design and permitting for the CAD site would optimize sediment handling and offloading procedures to ensure compliance with water quality criteria near the CAD site location.

After the facility has been filled to design capacity, a capping layer of clean sediments would be placed to provide the final cap surface. The capping sediments will need to be appropriately sized and the cap edges will need to be appropriately constructed to resist wave-induced erosion.

Long-term monitoring and maintenance and institutional controls for the CAD facility would be required as part of the remedy. The construction of the CAD facility would also require coordination with the Cornwall Avenue Landfill and RG Haley cleanup sites, located adjacent to the CAD site location.

6.2.3 Costs & Schedule

The probable costs of Alternative 2 are $34 million. In order of decreasing cost, this estimate addresses dredging and CAD site disposal of Waterway sediments, capping costs for the ASB and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring. Long-term monitoring costs are higher than under Alternative 1, because of the additional monitoring and periodic maintenance required for the completed CAD facility (Appendices A and B).

As described above, the costs for Alternative 2 do not include the costs for upgrading shoreline infrastructure in the Inner Whatcom Waterway as necessary to stabilize shoreline conditions and support the navigation use of the Waterway berth areas. Because the 1960s channel dimensions were never fully implemented and because of encroachment along the pierhead lines, substantial infrastructure investments would be required in shoreline areas to achieve target navigation depths and complete implementation of this alternative consistent with the requirements of an industrial channel (see Figure 4-2). These costs are associated with shoreline modifications, bulkhead replacements and dock replacements, and would need to be provided as part of shoreline redevelopment actions in order to complete the cleanup in a coordinated manner. The funding and design of these shoreline actions would need to be completed in parallel with the Whatcom Waterway cleanup in order to provide for CAD-site disposal of sediments from Waterway berth areas. Otherwise, the dredging in the Waterway would be limited by side-slope stability and construction setbacks, and would generally avoid dredging activities in berth areas. Residual sediments in the berth areas would be capped pending any future redevelopment of the shoreline area. Future shoreline modifications that involved sediment generation would likely be required to manage that sediment by upland landfill disposal. Such future costs are not included in Alternative 2.

The construction activities in Alternative 2 can likely be completed within four construction seasons. With the exception of the ASB area, work activities would be confined to appropriate “fish windows.” Because the ASB area is not connected to Bellingham Bay, the capping activities within the ASB will not necessarily be time-limited by the “fish windows.”

Monitoring of capped and natural recovery areas will occur under Alternative 2. Monitoring will also be performed at the CAD site to ensure long-term effectiveness of the sediment containment.

6.2.4 Changes to Existing Habitat Conditions

The significant changes to existing habitat conditions that will occur as a result of implementing Alternative 2 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 2 includes dredging of the Outer Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 2, dredging of the Inner Whatcom Waterway is conducted consistent with the boundaries of the 1960s federal channel. This requires the removal of emergent shallow-water habitat at the head and along the sides of the channel. Further, to achieve target dredge depths and navigation conditions, the shorelines must be hardened with bulkheads and other infrastructure similar to that shown in Figure 4-2. The application of this shoreline infrastructure would further reduce the existing quality of nearshore aquatic habitat within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB(Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 2 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 2 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 2 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 2 does not change the existing habitat conditions for the ASB. The ASB sludges will be capped, and this area will remain isolated from Bellingham Bay.

- **Cornwall CAD Area:** Alternative 2 involves the creation of a confined aquatic disposal facility near the Cornwall Avenue Landfill. Such a facility will involve the conversion of a significant area of deep-water habitat to shallow-water habitat. The final area, elevation and quality of this shallow-water habitat will vary depending on the final design of the facility.

6.2.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 2 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 2 is consistent with current and planned land and navigation uses. The alternative allows for continued maintenance of the federal shipping channel in this area. Some infrastructure maintenance and/or upgrades would likely be required at the shipping terminal to support dredging there.

- **Inner Whatcom Waterway (Units 2 & 3):** Community land use planning efforts have emphasized the need to provide for multiple waterfront uses in the Inner Whatcom Waterway area. These uses include shoreline public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use waterfront zoning. This alternative conflicts with these planned land and navigation uses. In order to support deep dredging of the 1960s industrial channel, substantial shoreline infrastructure upgrades are required. These upgrades are inconsistent with habitat enhancement actions in these same areas. Secondly, the land uses necessary to justify Corps participation in future channel maintenance likely conflict with mixed-use redevelopment and shoreline public access objectives. Some navigation uses such as transient moorage may be precluded, or may be significantly restricted in the Inner Whatcom Waterway areas. This contrasts with other FS Alternatives (i.e., Alternatives 4, 5 and 6) that assume the application of a mixed-use channel within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.

- **Areas Offshore of ASB (Unit 5)::** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) will reduce navigation depths in this area by approximately 3 feet (to be determined in final design and permitting). This change will not preclude navigation uses in this area, but will need to be incorporated into future navigation and infrastructure planning for the area.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 2 are consistent with current and anticipated navigation and land uses at Starr Rock.

- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 2 conflicts with this planned use.

6.3 Alternative 3

Alternative 3 uses a combination of institutional controls, monitored natural recovery and containment to achieve compliance with SMS cleanup levels.

Alternative 3 uses dredging to remove sediments from the Whatcom Waterway as necessary to allow use and maintenance of the 1960s federal navigation channel. These sediments are managed by creating a nearshore fill within the majority of the ASB. The portion of the ASB not required for the fill would be retained for stormwater or cooling water treatment uses. Alternative 3 is shown in Figure 6-3

6.3.1 Actions by Site Unit

Cleanup Alternative 3 represents a modification of the cleanup Alternative "J" evaluated in a previous Supplemental Feasibility Study (Anchor, 2002) after closure of the Pulp Mill and Chlor-Alkali Plant. The original evaluation of this remedial alternative was based on continued industrial uses of the ASB and upland properties adjacent to the Whatcom Waterway site. These land uses are no longer applicable (Section 4). A description of Alternative 3 by site unit follows:

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 3, the outer portion of the waterway would be dredged to a minimum depth of 35 feet below MLLW. Where technically feasible, the dredging depths would be increased to allow dredging to the base of the impacted sediments in the channel areas. Anticipated dredge depths vary from 35 feet below MLLW to about 41 feet below MLLW. Under this alternative, dredging from the Outer Whatcom Waterway areas could potentially be conducted using either hydraulic or mechanical dredging. Hydraulic dredging could provide the most cost-effective initial placement of the sediments within the ASB, and may potentially reduce turbidity levels at the point of dredging. However, hydraulic dredging is not well suited for areas containing woody debris, as expected in the Waterway. Further, hydraulic dredging with a cutter-head dredge can leave significant dredging residuals, up to a foot in thickness. Finally, hydraulic dredging would create large quantities of dredge slurry and entrained water. That contaminated water would ultimately be discharged back to Bellingham Bay. Assuming typical operating parameters (i.e., a controlled 2,000 cubic yard per day dredge production rate, a 10:1 water to sediment ratio and either one or two dredge units operating simultaneously) the hydraulic dredging would result in discharge of between 4 million and 8 million gallons per day of produced dredge waters to the Bay. Mechanical dredging and hydraulic dredging would need to be evaluated during remedial design to optimize project design and ensure protection of water quality during the dredging, both at the point of dredging and at the point of disposal for any generated waters. Sediments dredged from the waterway would be contained within the ASB fill as described below.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 3, sediment dredging would be performed within the Inner Whatcom Waterway as necessary to provide for future use and maintenance of the federal navigation channel to the head of the waterway. The 1960s federal channel boundaries specify a water depth of 30 feet below MLLW from the BST area to Maple Street. A depth of 18 feet is specified from Maple Street to the head of the waterway. In the deeper portion of the waterway, the dredging cut would be established at depths at least 35 feet below MLLW. This would remove sediments where technically feasible, and would provide sufficient over-depth to allow residual sediments to be capped without impeding future maintenance of the federal channel. The design concept assumes a cap thickness of 3 feet over dredged areas with residual subsurface sediment impacts. Due to historical encroachment of the shoreline on the federal channel boundaries, many of the Inner Whatcom Waterway shoreline areas have fill and bulkheads up to or near to the pierhead line. Most of these bulkheads would require replacement and/or substantial upgrades in order to maintain shoreline stability in these areas during and after dredging. Docks may also have to be upgraded or replaced as described in Alternative 2 in order to accommodate federal channel dredging and future use. After dredging, the effective water depth (water depth at the pierhead line) will vary with location along the shoreline. The effective water depth will be controlled mostly by the type of shoreline infrastructure (i.e., nearshore fill, docks and bulkheads) that is established there. Without substantial infrastructure investments, the effective water depth for the Inner Whatcom Waterway will be significantly less in most areas than the federal channel project depth. The remedial costs of this alternative address only sediment removal. The costs of the shoreline infrastructure required to improve the effective waterway depth would be borne by area redevelopment actions.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** Under Alternative 3, the ASB sludges would be contained within the existing ASB. Most sludges would simply be buried beneath the nearshore fill. However, the Alternative assumes that the sludges located in the outer portion of the ASB (the area not required for a nearshore fill) would be dredged and consolidated within the fill area. Construction sequencing would involve initial lowering of the water level of the ASB, followed by the removal of the wastewater treatment equipment (aerators, weirs, etc.). Dredging of sludges from the future edge of the nearshore fill would then be conducted. A berm would be constructed along this alignment. Finally, the remaining sludges would be dredged from the area outside of the berm, for consolidation within the new fill area. Because construction within the ASB would disrupt the bentonite sealant present along the bottom and sides of the ASB, some additional measures (in addition to lowering of the water level of the ASB during construction) may be required to prevent significant water leakage through the berm during and after construction. These actions may include driving of sheet-piling, placement of new bentonite sealant, or other measures. Some residual sludges would likely remain in the dredged area of the ASB, and these would be managed by sediment capping. If the ASB is to be used for future stormwater/cooling water treatment, then the ASB would need to either remain connected to the current GP-owned outfall, or provided with an alternate, appropriately-sized outfall. Other modifications may be required depending on planned future uses.

6.3.2 Sediment Disposal

Under Alternative 3, the sediments dredged from the Waterway areas will be managed by containment in a new sediment disposal site. Alternative 3 uses a nearshore fill design. The design concept estimates disposal of approximately 472,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas, and an additional 113,000 cubic yards of sediments dredged from Units 1A and 1B. Approximately 71,000 cubic yards of ASB sludges in the outer portion of the ASB would be consolidated in the fill area, along with the dredged sediments. Additional materials would be used to construct the containment berm within the ASB, and to cap the facility after placement of dredged sediments.

The principal remedial benefit associated with the ASB fill site is that the main ASB berm already exists, and does not need to be constructed. Secondly, the use of the ASB provides for consolidation of the ASB sludges as well as the dredged sediments from the Waterway.

Whether the Waterway dredging is conducted using hydraulic or mechanical dredging, the existing berms of the ASB facility would be maintained largely in their current configuration. A new berm would be constructed within the interior of the facility as described above.

Previous leachability studies conducted as part of the 2000 RI/FS and the PRDE investigation report (Anchor 2003) included evaluation of contaminant mobility under various conditions. Mobility of mercury was lowest in those tests under anoxic conditions. The design of the fill would place the dredged materials and ASB sludges below the elevation at which groundwater levels are anticipated to stabilize after facility construction. The elevated TOC content of the sediments and ASB sludges, combined with long-term groundwater saturation would tend to retain anoxic conditions within the impacted portion of the fill. Sediments from Unit 1A and 1B would be placed in upper portions of the fill, and clean sediments and/or soils would be placed on top of the final fill as a capping layer. The design and construction of the facility would provide for sediment and sludge consolidation.

The land created by the fill would be subject to further consolidation over time, due to decomposition of high-organic materials in the ASB sludges and the decomposition of woody materials in waterway sediments. This process would be similar to the long-term settlement that occurs in solid waste landfills. Any future use of the property would need to allow for such settlement to occur. Pile-supported foundations would likely be required for most buildings, involving penetration of the pilings through the fill materials and into underlying sandy soils. Water quality evaluations conducted during design and permitting would need to address water quality issues within the fill, to ensure long-term protection of surface waters. If maintenance of the bentonite sealing layer within the fill is required for long-term surface water protection, then penetration of this layer with foundation pilings could be subject to significant limitations or could be prohibited altogether. Future development of enclosed structures within the fill area would also be subject to requirements for under-building methane-control systems, similar to those used for buildings constructed on peat deposits or for buildings on or adjacent to municipal landfills.

Long-term monitoring and maintenance and institutional controls for the nearshore fill would be required as part of the remedy.

The construction of the nearshore fill would need to be coordinated with the activities at the adjacent Central Waterfront site. This would mainly involve ensuring that construction and any future reuse of the fill area does not adversely impact groundwater conditions within the Central Waterfront site.

6.3.3 Costs & Schedule

The probable costs of Alternative 3 are approximately $34 million (Appendix A). In order of decreasing cost, this estimate address dredging and ASB site disposal of Waterway sediments, preparation and completion of the ASB facility, capping costs for harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring. Long-term monitoring costs include provisions for groundwater and vapor monitoring associated with the fill area.

The costs for Alternative 3 do not include the costs for upgrading shoreline infrastructure in the Inner Whatcom Waterway as necessary to stabilize shoreline conditions and support the navigation use of the water depth provided by the 1960s federal channel dimensions. Because the 1960s channel dimensions were never fully implemented, and because of encroachment along the pierhead lines, substantial investments would be required in shoreline areas. These costs are associated with shoreline modifications, bulkhead replacements and dock replacements, and would need to be provided as part of shoreline redevelopment actions in order to complete the project. As discussed in the companion EIS document, the funding and design of these shoreline actions would need to be completed in parallel with the Whatcom Waterway cleanup in order to provide for ASB disposal of sediments from waterway berth areas. Otherwise, the dredging in the Waterway would be limited by side-slope stability and construction setbacks, and would generally avoid dredging activities in berth areas. Residual sediments in the berth areas would be capped pending any future redevelopment of the shoreline area. Future shoreline modifications that involved sediment generation would likely be required to manage that sediment by upland landfill disposal. Such costs are not included in Alternative 3.

The construction activities in Alternative 3 can likely be completed within three construction seasons. The range of construction time requirements is 2 to 4 years, depending on dredging rates and construction sequencing. Higher dredging rates reduce the restoration time, but are logistically more difficult to maintain. For hydraulic dredging, use of high production rates significantly increases the rates of water generation requiring treatment and discharge to Bellingham Bay. With the exception of the initial and final work within ASB area, work activities would be confined to appropriate “fish windows”. Because the ASB area is not connected to Bellingham Bay, some of the initial ASB preparation and the final capping activities within the ASB will not necessarily be time-limited by the “fish windows.”

6.3.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 3 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 3 includes dredging of the Outer Whatcom Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 3, dredging of the Inner Whatcom Waterway is conducted consistent with the boundaries of the 1960s federal channel. This requires the removal of emergent shallow-water habitat at the head and along the sides of the channel. Further, to achieve target dredge depths and navigation conditions, the shorelines must be hardened with bulkheads and other infrastructure similar to that shown in Figure 4-2. The application of this shoreline infrastructure would further reduce the existing quality of nearshore aquatic habitat within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5)::** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 3 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 3 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 3 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 3 involves construction of a nearshore fill within the ASB. The construction of the nearshore fill would permanently convert the majority of the ASB area from its current condition (wastewater treatment facility) to upland characteristics.

6.3.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 3 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 3 is consistent with current and planned land and navigation uses. The alternative allows for continued maintenance of the federal shipping channel in this area. Some infrastructure maintenance and/or upgrades would likely be required at the shipping terminal to support dredging there.

- **Inner Whatcom Waterway (Units 2 & 3):** Community land use planning efforts have emphasized the need to provide for multiple waterfront uses in the Inner Whatcom Waterway area. These uses include shoreline public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use waterfront zoning. This alternative conflicts with these planned land and navigation uses. In order to support deep dredging of the 1960s industrial channel, substantial shoreline infrastructure upgrades are required. These upgrades are inconsistent with habitat enhancement actions in these same areas. Secondly, the land uses necessary to justify Corps participation in future channel maintenance likely conflict with mixed-use redevelopment and shoreline public access objectives. Some navigation uses such as transient moorage may be precluded, or may be significantly restricted in the Inner Whatcom Waterway areas. This contrasts with other FS Alternatives (i.e., Alternatives 4, 5 and 6) that assume the application of a mixed-use channel within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.

- **Shoulder of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy with identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** As in Alternatives 1 and 2, the cap in the barge dock area (Unit 6-B & C) will reduce navigation depths in this area by approximately 3 feet (to be determined in final design and permitting). This change will not preclude navigation uses in this area, but will need to be incorporated into future navigation and infrastructure planning for the area.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 3 are consistent with current and anticipated navigation and land uses at Starr Rock.

- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 3 conflicts with this planned use. Alternative 3 permanently precludes such uses by designating the ASB area for a nearshore fill site. Future upland uses of the fill site may be subject to limitations, depending on final environmental and geotechnical analyses performed during remedial design and permitting.

6.4 Alternative 4

Cleanup Alternative 4 uses removal and upland disposal technology, in addition to institutional controls, monitored natural recovery and containment to comply with SMS cleanup levels. The alternative uses capping in-place for management of the ASB sludges. Alternative 4 is shown in Figure 6-4.

6.4.1 Actions by Site Unit

Cleanup actions are described below by site unit. Dredging activities within the Whatcom Waterway are targeted on appropriate areas to support a multi-purpose Waterway concept, including a mix of deep-draft navigation, public access, transient moorage and habitat enhancement uses. Sediments dredged from the Waterway are managed by upland disposal at appropriately-permitted off-site facilities.

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 4, the outer portion of the waterway would be dredged to a depth of approximately 35 feet below MLLW. The sediments removed during this dredging would be barged to an offload facility within Port-owned property. The sediments would be transferred to lined railcars for transportation to an appropriately-permitted offsite disposal facility. The cost estimates are based on the use of Subtitle D permitted landfills that can accept wet sediments for reuse as daily cover. Other disposal facilities that have appropriate environmental permits may be used, subject to applicable regulations and logistical considerations. The costs for sediment transportation and disposal under this alternative were based on pricing for eastern Washington and eastern Oregon landfills. This does not preclude potential use of alternate locations subject to final remedy design, permitting and contractor discretion. After removal of sediments to -35 feet MLLW, a thick sediment cap would be placed over residual impacted sediments. The cap would be designed to resist erosive forces of prop wash, and to minimize the potential for aquatic wildlife exposures. Based on previous sediment testing, the sediments from Units 1A and 1B appear to be suitable for beneficial reuse or PSDDA disposal, subject to final testing and suitability determinations. These sediments could potentially be reused as part of the project for capping subgrade within the Inner Whatcom Waterway. However, the fine particle size distribution within the Unit 1A/1B sediments makes this use subject to logistical and long-term stability considerations. The Alternative 4 cost estimate assumes that Unit 1A and 1B sediments that are dredged are managed by open water disposal consistent with PSDDA program requirements. Mechanical dredging methods would likely be used for the Outer Whatcom Waterway area, as hydraulic dredging is impracticable without a large area for management of produced dredge waters and for separating entrained waters from dredge materials. Detailed dredging and construction procedures would be determined in project design and permitting.

- **Inner Whatcom Waterway (Units 2 & 3):** The design concept included in Alternative 4 assumes that the majority of the Inner Whatcom Waterway is to be managed for effective water depths of between 18 feet and 22 feet. This water depth range provides for navigation opportunities consistent with the mixed-use zoning of the waterfront properties, described in Section 4.2.1. The central portion of the waterway is dredged to depths at least 5 feet below the planned effective water depth. A sediment cap is then applied over any residual sediments, with the cap grading from a minimum thickness of 3 feet, to a maximum thickness of 6 feet near the Log Pond. Shoreline slopes would be stabilized using appropriately designed side-slopes and materials that maximize nearshore habitat quality and quantity, while maintaining stability and providing for appropriate navigation needs within the Waterway. Under Alternative 4, the emergent tideflats at the head of the waterway are preserved, and shallow-water habitat areas along the sides of the waterway are preserved and enhanced.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals.

No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** As with Alternatives 1 and 2, the ASB will be remediated using a thick sub-aqueous cap.

6.4.2 Sediment Disposal

Sediments removed from Waterway areas under this Alternative will be managed by disposal at a Subtitle D upland disposal facility. Subtitle D facilities are commercially available, and are designed and permitted for management of solid waste. The design of Subtitle D facilities includes a liner, a cap, a monitoring network, and institutional controls and financial assurance provisions under state and federal solid waste regulations.

The design concept for Alternative 4 estimates disposal of approximately 68,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas at upland disposal sites. An additional 113,000 cubic yards of sediments dredged from Units 1A and 1B would be managed by beneficial reuse or PSDDA disposal.

Options for transportation of dredged materials to upland disposal sites include barge, truck and rail. Barge transportation can utilize alternate offloading locations located away from the site. Such offloading facilities exist in Seattle, Vancouver B.C. and elsewhere. The sediments are generally then transferred to truck or rail for final shipment to the disposal facility. Truck transportation is commonly used for small sediment volumes. Multiple intermodal yards exist around the region where truck containers can be transloaded for final rail shipment to the disposal site. However, for large sediment volumes, truck transportation results in additional traffic burdens and is less fuel efficient than rail transportation. The design concept and cost estimate assumes the placement of temporary rail improvements at the former GP mill site, and shipment of sediments directly from the site to the upland disposal site by rail. Stormwater management and "surge" stockpile areas are included in the project cost assumptions.

6.4.3 Costs & Schedule

The probable costs of Alternative 4 are approximately $21 million. The costs of Alternative 4 are the second lowest of all of the evaluated alternatives. In order of decreasing cost, this estimate addresses dredging and upland disposal of Whatcom Waterway sediments, capping costs for the ASB and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring (Appendices A and B).

The in-water construction activities in Alternative 4 can likely be completed within a single construction season. With the exception of the ASB area, and initial preparation and final demobilization of the upland sediment offload area, work activities would be confined to appropriate "fish windows". Because the ASB area is not connected to Bellingham Bay, the capping activities within the ASB will not necessarily be time-limited by the "fish windows".

Monitoring of capped and natural recovery areas will occur under Alternative 4. Because natural recovery is only applied in areas that have already achieved compliance with cleanup standards, additional restoration time would not be required.

6.4.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 4 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 4 includes dredging of the Outer Whatcom Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas in the Outer Whatcom Waterway.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 4, dredging is conducted to support planned navigation and land uses along the Inner Whatcom Waterway. This results in some conversion of shallow-water habitat to deep-water habitat. However, the proposed configuration of the multi-purpose channel implemented under Alternative 4 retains existing emergent shallow-water habitat areas at the head and along the sides of the waterway. Under this alternative, waterway shorelines are stabilized with slopes, rather than through the use of bulkheads and hardened shoreline infrastructure. This approach will increase the area and quality of nearshore aquatic habitat. In addition to the habitat effects achieved as a result of Whatcom Waterway cleanup, additional dock and bulkhead removals and shoreline stabilization work is contemplated as part of coordinated cleanup actions at the Central Waterfront site, and as part of mixed-use redevelopment of the properties along the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to likewise enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of “habitat benches” along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 4 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 4 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 4 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 4 does not change the existing habitat conditions for the ASB. The ASB sludges will be capped, and this area will remain isolated from Bellingham Bay.

6.4.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 4 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 4 preserves the flexibility for deep draft waterway uses and/or institutional uses at the Bellingham Shipping Terminal. The alternative allows for continued maintenance of the federal channel in this area. Some infrastructure maintenance and/or upgrades would likely be required at the shipping terminal to support dredging there.

- **Inner Whatcom Waterway (Units 2 & 3):** As defined in previous and ongoing community land use planning efforts, the priorities for the Inner Whatcom Waterway area are to provide for waterfront uses that combine public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use waterfront vision. Alternative 4 integrates cleanup actions with that waterfront vision. Infrastructure costs are reduced while simultaneously maximizing land use flexibility and improving both habitat conditions and navigation opportunities. There will be some depth limitation in the Inner Whatcom Waterway (18 to 22 feet vessel draft), but deeper draft vessels can be accommodated in the Outer Whatcom Waterway near the Bellingham Shipping Terminal. The navigation uses for the Inner Whatcom Waterway would accommodate transitional uses by tug boats and barges, though tractor tugs and ocean-going barges would be precluded (except for the Outer Whatcom Waterway areas). Compatible navigation uses consistent with the long-term redevelopment of the waterfront include access by recreational vessels, whale watching boats, intermediate-draft institutional vessels (i.e., research boats), sailing ships (i.e., most "Tall Ships Festival" vessels) and most passenger-only ferries. Under Alternative 4, the design of the Inner Whatcom Waterway would be integrated with local land-use planning efforts. Alternative 4 assumes that the 1960s federal channel will be updated at the head of the waterway to provide for integrated public access, habitat enhancement and navigation uses. By transitioning from a federal channel with its requisite use restrictions, to a locally-managed multi-purpose waterway, additional land use flexibility can be accommodated both within the channel area and also along the adjacent shorelines. Specifically, construction of navigation improvements beyond the pierhead line could be allowed, with appropriate land use planning and permitting. This enables navigation uses to be developed along-side habitat enhancements. For example, rather than constructing bulkheaded shorelines and over-water wharfs to the pierhead line and dredging for maximum usable depth in waterway berth areas, navigation structures such as floats can be located offshore of nearshore habitat benches and softened shorelines

- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to likewise enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area near the barge dock area (Unit 6-B & C) will be capped as described in Alternatives 1 through 3, with a slight reduction in water depth within the capped area.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 4 are consistent with current and anticipated navigation and land uses at Starr Rock.

- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 4 conflicts with this planned use.

6.5 Alternative 5

Alternative 5 uses multiple technologies to comply with SMS cleanup levels. Institutional controls, monitored natural recovery and containment are used in various portions of the site. Removal and upland disposal are used for ASB sludges and impacted sediments from outside of the ASB. The ASB sludges are treated to achieve volume reduction. Alternative 5 is shown in Figure 6-5

6.5.1 Actions by Site Unit

Under Alternative 5 dredging activities within the Whatcom Waterway are targeted on appropriate areas to support a multi-purpose Waterway concept, including a mix of deep-draft navigation, public access, transient moorage and habitat enhancement uses. Sediments dredged from the Waterway and the sludges removed from the ASB are managed by upland disposal at appropriately-permitted off-site Subtitle D facilities. Specific actions within each site unit are described below:

- **Outer Whatcom Waterway (Unit 1):** Under Alternative 5, the outer portion of the waterway would be dredged to a depth approximately 35 feet below MLLW, as with Alternative 4. The residual sediments in this area would be capped with a thick sediment cap. The cap would provide a sufficient thickness of cap material to allow for future waterway maintenance dredging, and would provide resistance against potential erosion by prop wash. Sediments removed during this dredging would be barged to an offload facility within Port-owned property, and would be transferred to for transportation to an appropriately-permitted offsite disposal facility. The sediments from waterway Units 1A and 1B are managed by PSDDA disposal, as in Alternative 4. Mechanical dredging methods would likely be used in the Outer Whatcom Waterway area.

- **Inner Whatcom Waterway (Units 2 & 3):** The cleanup of the Inner Whatcom Waterway will be performed using the same approach as with Alternative 4. The alternative assumes that the 1960s federal channel will be updated at the head of the waterway to provide for integrated public access, habitat enhancement and navigation uses. The design concept included in Alternative 5 assumes that the majority of the Inner Whatcom Waterway is managed for effective water depths of between 18 feet and 22 feet. This water depth range provides for navigation opportunities consistent with the mixed-use zoning of the waterfront properties. Under Alternative 5, the emergent tideflats at the head of the waterway are preserved, and shallow-water habitat areas along the sides of the waterway are preserved and enhanced. At the same time, the central portion of the waterway is dredged to depths 5 feet below the planned effective water depth. A sediment cap is then applied over any residual sediments, with the cap grading from a minimum thickness of 3 feet, to a maximum thickness of 6 feet in areas near the Log Pond and Bellingham Shipping Terminal. Shoreline slopes would be stabilized using appropriate side-slopes and materials.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas Offshore of ASB (Unit 5):** Exceedances of site-specific cleanup goals within Unit 5-B will be remediated using sub-aqueous capping. Appendix C describes the design concept for this area, including methods to maintain cap stability in a manner compatible with anticipated permitting requirements. The remaining areas of Unit 5 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas at this time. Additional evaluations of sediment stability will be conducted as part of engineering design. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels. Additional measures will be taken in this area only if engineering design evaluations indicate that such measures are required.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The area south of the barge docks at the Bellingham Shipping (Units 6-B and 6-C) contains exceedances of SMS cleanup levels. This area will be remediated using a deep-water sub-aqueous cap. Final water depths in this area will be greater than -18 feet MLLW in most areas, consistent with shoreline infrastructure and navigation uses historically conducted there. The cap will be constructed of coarse granular materials and will be designed to resist potential prop-wash erosion effects. The remaining portions of Unit 6 comply with site-specific cleanup goals. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **Starr Rock (Unit 7):** Sediments in the Starr Rock area currently comply with site-specific cleanup levels. No sediment capping or dredging is proposed for these areas. These areas will be monitored to document the continued effectiveness of natural recovery at complying with cleanup levels.

- **ASB (Unit 8):** Under Alternative 5, the ASB sludges would be removed from the waterfront. The design concept is based on a five-step process. First, the water level in the ASB will be lowered and the connection between the ASB and the outfall plugged. Second, the water treatment equipment (aerators, weirs, etc.) will be removed, and the tops of the berms removed. These berm materials consist of clean sand and stone materials used to construct the ASB and can be reused within other portions of the project area. The exterior of the berm will be reduced in elevation to approximately 16 feet above MLLW. The interior of the berm will be removed to elevations approximately 10 feet above MLLW. Sheet piling will be driven along the berm to prevent migration of impacted water through the berm during dredging. Third, the majority of the ASB sludges will be removed by hydraulic dredging. The hydraulic dredge slurry will be treated in centrifuges or hydrocyclones to separate sludge solids form the entrained waters. Solids separated from the dredge slurry will be shipped by rail for upland disposal. Water from the hydraulic dredging will be returned to the ASB in a closed-loop system, to minimize the overall generation of contaminated waters. The use of hydraulic dredging and maintenance of a water layer overlying the sludges during removal will also minimize odors and potential wildlife exposures during sludge removal. During the fourth step, the impacted waters from the ASB will be pumped out, treated to remove suspended and dissolved contaminants, and will be discharged to the sanitary sewer. If sewer capacity is limited, the treated waters will be managed using a permitted temporary surface water discharge. Finally, the residual solids within the dewatered ASB will be removed by land-based excavation equipment. By conducting this final phase of removal without overlying water, the result will maximize sludge removal and minimize residual contamination. Alternatively, dredge residuals within the ASB could be managed through capping. This would remove the need for dewatering of the ASB, but would limit future depths of ASB reuse. Following cleanout of the sludges, the sheet-piling may be removed from the ASB, the ASB filled to appropriate elevations with surface water, and the berm opened. Some additional impacted sediments will be generated for upland disposal at the time the new access channel to the ASB (Unit 2-B) is created.

6.5.2 Sediment Disposal

Alternative 5 does not involve the creation of new disposal sites within Bellingham Bay. Sediments removed from Waterway under this Alternative will be managed by disposal in appropriately-permitted upland disposal sites. The design concept for Alternative 5 estimates disposal of approximately

76,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas and the disposal of approximately 412,000 cubic yards of sludges removed from the ASB. An additional 113,000 cubic yards of sediments dredged from Units 1A and 1B would be managed by beneficial reuse or PSDDA disposal.

The design concept for Alternative 5 assumes that dredged sediments and ASB sludges are shipped by rail to the upland disposal site. Rail shipment is more fuel efficient and provides fewer traffic conflicts than truck transportation. As with Alternative 4, the Alternative 5 design concept and cost estimate assumes the placement of temporary rail improvements at the former GP mill site. Stormwater management and "surge" stockpile areas are included in the project cost assumptions.

6.5.3 Costs & Schedule

The probable costs of Alternative 5 are approximately $42 million (Appendix A). In order of decreasing cost, this estimate addresses removal and disposal of the ASB sludges, dredging and upland disposal of Whatcom Waterway sediments, capping costs for the Waterway and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring. Under Alternative 5, clean sediments and stone from the ASB berms are reused within the project as part of capping, shoreline stabilization and habitat enhancement actions.

Because of the work within the ASB, the construction activities are more complex than those in alternative 4, resulting in a longer construction period. The construction of alternative 5 will likely require a three-phase construction cycle, taking place over a 3 to 4 year period. The initial ASB preparation and waterway dredging activities will take place during the first construction phase. The second construction phase will involve ASB sludge removal, dewatering and final ASB cleanout. The final construction phase will involve opening of the ASB berm, completion of final dredging and capping activities within the waterway areas. The first and third phases of construction will be restricted to appropriate "fish windows." The second construction phase will not involve activities in areas connected to surface water, and will not necessarily be subject to "fish window" limitations.

Monitoring of capped and natural recovery areas will occur under Alternative 5. Because natural recovery is only applied in areas that have already achieved compliance with cleanup standards, additional restoration time would not be required.

6.5.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 5 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 5 includes dredging of the Outer Whatcom Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas in the Outer Whatcom Waterway.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 5, dredging is conducted to support navigation and land uses. This results in some conversion of shallow-water habitat to deep-water habitat. However, the proposed configuration of the multi-purpose channel implemented under Alternative 5 retains existing emergent shallow-water habitat areas at the head and along the sides of the waterway. Under this alternative, waterway shorelines are stabilized with slopes, rather than through the use of bulkheads and hardened shoreline infrastructure. This approach will increase the area and quality of nearshore aquatic habitat. In addition to the habitat effects achieved as a result of Whatcom Waterway cleanup, additional dock and bulkhead removals and shoreline stabilization work is contemplated as part of coordinated cleanup actions at the Central Waterfront site, and as part of mixed-use redevelopment of the properties along the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to likewise enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 5 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 5 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 5 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 5 includes removal of the ASB sludges and opening of the ASB berm in the Site Unit 2-B. These actions restore the connection of the ASB with Bellingham Bay. This will permit utilization of the interior portions of the ASB by juvenile salmonids and other aquatic organisms. The estimated increase in aquatic area is 28 acres. The estimated length of shoreline migration corridor that would become available for use by juvenile salmonids is just under 4,500 linear feet.

6.5.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 5 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 5 preserves the flexibility for deep draft waterway uses and/or institutional uses at the Bellingham Shipping terminal. The alternative allows for continued maintenance of the federal shipping channel in this area. Some infrastructure maintenance and/or upgrades would likely be required at the shipping terminal to support dredging there.

- **Inner Whatcom Waterway (Units 2 & 3):** As with Alternative 4, Alternative 5 provides for multi-purpose use within the Inner Whatcom Waterway. This multi-purpose use includes public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use zoning. Alternative 5 integrates cleanup actions with that waterfront vision, as in Alternative 4. Infrastructure costs are reduced while simultaneously maximizing land use flexibility and improving both habitat conditions and navigation opportunities.

- **Log Pond (Unit 4):** Consistent with property restrictive covenants, the uses of the Log Pond have been restricted to uses that do not expose capped sediments. This remains unchanged under this alternative and is consistent with planned land uses in nearby areas. Public access (i.e., shoreline promenade) along the Log Pond shoreline is anticipated as part of future area-wide redevelopment activities.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the

Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to likewise enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. The construction of a cap in this area using the proposed design concept does not conflict with current or planned uses of the ASB, or with navigation uses in surrounding areas. Appropriate navigation aids would likely be required in perimeter areas of the cap and habitat bench to prevent inadvertent groundings of small recreational vessels. The water depths in this area are already shallow enough that larger vessels are precluded from this area.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The barge dock area (Unit 6-B & C) will be capped, with a slight reduction in water depth within the capped area.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 5 are consistent with current and anticipated navigation and land uses at Starr Rock.

- **ASB (Unit 8):** The ASB has been identified in previous land use studies as the preferred location for development of a future environmentally sustainable marina with integrated public access and habitat enhancement features (Figure 4-4). Alternative 5 is consistent with such uses.

6.6 Alternative 6

Cleanup Alternative 6 is in most respects the same as Alternative 5. The difference between the alternatives, is that under Alternative 6 additional dredging is conducted adjacent to the Bellingham Shipping Terminal. Other features of the Alternative, including the cleanout of the ASB and the remedial approach to the Inner Whatcom Waterway and Harbor areas are the same as in Alternative 5. Alternative 6 is shown in Figure 6-6.

6.6.1 Actions by Site Unit

A detailed description of Alternative 6 follows. Because many aspects of this alternative are the same as with Alternative 5, the alternative description focuses only on areas of difference between the two cleanup alternatives. Both conduct remediation of the ASB using removal, treatment and upland disposal technologies. They both remediate the Inner Whatcom Waterway with dredging and capping, consistent with the vision of a locally-managed multi-purpose channel. Remediation activities outside of the waterway are also similar, including development of a cap and habitat bench along the ASB shoulder (Unit 5-B) and capping in the barge dock area (Unit 6B and 6C). The principal difference between the two alternatives is the extent of dredging near the Bellingham Shipping Terminal (Unit 1-C).

Under Alternative 5, the extent of dredging provides for maintenance of the 30-ft federal channel. This requires dredging to depths of at least 35 feet below MLLW. Residual sediments are capped with a thick layer of sediment. In contrast, Alternative 6 conducts sediment removal in the Unit 1-C area to the extent technically practicable. Under this alternative, the depth of dredge cuts would be increased, in most areas extending dredging to the interface with clean native sediments. The depth of dredging under Alternative 6 would range from 35 feet to 41 feet below MLLW in Unit 1-C. The dredging would need to address geotechnical and structural integrity limitations associated with existing piers and structures in the terminal area. However, it is expected that most portions of Unit 1C could be remediated, without requiring subsequent application of a thick cap.

6.6.2 Sediment Disposal

As with Alternative 5, all impacted sediments dredged from the Waterway and all of the sludges removed from the ASB would be managed by upland disposal at appropriately permitted facilities. Alternative 6 does not involve the creation of new disposal sites within Bellingham Bay.

The design concept for Alternative 6 estimates disposal of approximately 118,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas and the disposal of approximately 412,000 cubic yards of sludges removed from the ASB. An additional 113,000 cubic yards of sediments dredged from Units 1A and 1B would be managed by beneficial reuse or PSDDA disposal.

Transportation of sediments for upland disposal would be conducted by rail to minimize fuel use and avoid potential traffic impacts. The design concept and cost estimate assumes the placement of supplemental temporary rail improvements at the former GP mill site. Stormwater management and “surge” stockpile areas are included in the project cost assumptions.

6.6.3 Costs & Schedule

The probable costs of Alternative 6 are approximately $44 million. In order of decreasing cost, this estimate addresses removal and disposal of the ASB sludges, dredging and upland disposal of Whatcom Waterway sediments, capping costs for the portions of the Waterway and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring (Appendices A and B). Under Alternative 6, clean sediments and stone from the ASB berms are reused within the project as part of capping, shoreline stabilization and habitat enhancement actions.

The schedule and phasing of construction activities under Alternative 6 are similar to those under Alternative 5. The work will likely require a three-phase construction cycle, taking place over a 3 to 4 year period. The initial ASB preparation and waterway dredging activities will take place during the first construction phase. The second construction phase will involve ASB sludge removal, dewatering and final cleanout. The final construction phase will involve opening of the ASB berm, completion of final dredging and capping activities within the waterway areas. The first and third phases of construction will be restricted to appropriate “fish windows.” The second construction phase will not involve activities in areas connected to surface water, and will not necessarily be subject to “fish window” limitations.

Monitoring of capped and natural recovery areas will occur under Alternative 6. Because natural recovery is only applied in areas that have already achieved compliance with cleanup standards, additional restoration time would not be required.

6.6.4 Changes to Existing Habitat Conditions

Table 6-2 summarizes the changes to existing habitat conditions that are associated with the implementation of Alternative 6. Most habitat changes associated with Alternative 6 are the same as those for Alternative 5.

Alternative 6 involves additional dredging within Unit 1C. However, this dredging takes place in deep water, with no significant changes to shallow-water habitat areas. The dredging would not significantly affect (positively or negatively) aquatic habitat functions or values in this area.

6.6.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 6 are summarized in Table 6-2. These land use and navigation issues are virtually identical to those of alternative 5.

The only difference in land use benefits between Alternative 5 and Alternative 6 is the flexibility provided by Alternative 6 for future depth changes in the deep draft portions of the Whatcom Waterway (Unit 1-C). By removing sediments to the limits of technical and economic practicability, Alternative 6 provides for additional navigation flexibility at the Bellingham Shipping Terminal. Potentially the navigation depth of the federal channel near the terminal could be increased at a future date, should such an increase be warranted. This additional flexibility is obtained at an incremental cost of approximately $3 million, in comparison to Alternative 5.

6.7 Alternative 7

Alternative 7 uses the same technologies as Alternatives 5 and 6 to comply with SMS cleanup levels. These include institutional controls, monitored natural recovery, containment, removal & disposal, treatment and reuse & recycling. Alternative 7 is shown in Figure 6-7.

The elements of Alternative 7 and the differences between it and alternatives 5 and 6 are described below by site Unit.

6.7.1 Actions by Site Unit

Like Alternative 5 and 6, Alternative 7 uses hybrid technologies to accomplish the remediation of the Whatcom Waterway site. The ASB is remediated using removal, treatment and upland disposal technologies, consistent with alternatives 5 and 6. The Outer Whatcom Waterway areas are similarly remediated by dredging and upland disposal, as in Alternative 6. Unlike the preceding Alternatives, Alternative 7 removes sediment from the Inner Whatcom Waterway to allow use and maintenance of the 1960's federal channel.

Under Alternative 7 dredging is conducted consistent with the dredge prisms used in Alternative 2 and Alternative 3. Impacted sediments that are more than 5 feet below the 1960s channel project depth are capped in place, using a thick sediment cap. Capping may also be used in nearshore berth areas where full sediment removal is technically impracticable, or where the shoreline infrastructure does not allow sediments to be removed without compromising side-slope stability or the integrity of existing structures.

Other aspects of Alternative 7 remain the same as in alternative 6. These include the capping of the ASB shoulder and barge dock area, the enhancements to the Log Pond shoreline, and the use of monitored natural recovery for other bottom areas that currently comply with site cleanup levels.

6.7.2 Sediment Disposal

Alternative 7 does not involve the creation of new disposal sites within Bellingham Bay. Sediments removed from the Waterway under this Alternative will be managed by disposal in appropriately-permitted upland disposal sites. The design concept for Alternative 7 estimates disposal of approximately 479,000 cubic yards of sediments dredged from the Outer and Inner Whatcom Waterway areas and the disposal of approximately 412,000 cubic yards of sludges removed from the ASB. This represents an increase of 113,000 cubic yards of sediment disposal over that provided in Alternative 6. This additional volume substantially increases project remedial costs, without a corresponding increase in remedy protectiveness.

As with Alternative 6, the design concept for Alternative 7 assumes that dredged sediments and ASB sludges are shipped by rail to the upland disposal site. Rail shipment is more fuel efficient and provides fewer traffic conflicts than truck transportation.

6.7.3 Costs & Schedule

The probable costs of Alternative 7 are $74 million (Appendix A). In order of decreasing cost, this estimate addresses dredging and upland disposal of the 1960s federal channel sediments, removal and disposal of the ASB sludges, capping costs for the portions of the Waterway and harbor areas, enhancements to the Log Pond shoreline, and provisions for long-term monitoring. This cost is nearly double that of Alternative 6, while providing only a slight increase in overall remedy protectiveness. The remedy provides a lower habitat benefit than in Alternative 6, and is not consistent with community land use objectives as described below.

Like Alternatives 2 and 3, implementation of Alternative 7 must be integrated with shoreline infrastructure upgrades along the Inner Whatcom Waterway shoreline. This will increase the time required for project design and permitting relative to Alternative 6. The additional dredging involved in Alternative 7 also increases the duration and complexity of project construction activities. Alternative 7 is likely to require an additional year of construction over that required in Alternative 6.

Monitoring of capped and natural recovery areas will occur under Alternative 7. Because natural recovery is only applied in areas that have already achieved compliance with cleanup standards, additional restoration time would not be required for natural recovery to occur.

6.7.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 7 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 7 includes dredging of the Outer Whatcom Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 7, dredging of the Inner Whatcom Waterway is conducted consistent with the boundaries of the 1960s federal channel. This requires the removal of emergent shallow-water habitat at the head and along the sides of the channel. Further, to achieve target dredge depths and navigation conditions, the shorelines must be hardened with bulkheads and other infrastructure similar to that shown in Figure 4-2. The application of this shoreline infrastructure would further reduce the existing quality of nearshore aquatic habitat within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas Offshore of ASB (Unit 5):** The design concept for the sediment cap at the shoulder of the ASB (Unit 5-B; design concept included in Appendix C) results in an increase in sediment elevation from between -6 to -10 feet MLLW to elevations between -3 to -6 feet MLLW. The measures applied in the Appendix C design concept to reduce wave energy and stabilize the cap surface are expected to likewise enhance habitat quality by facilitating the growth of aquatic vegetation. These changes are consistent with previous the Bellingham Bay Comprehensive Strategy which identifies the development of "habitat benches" along this portion of the shoreline to enhance habitat quality for migrating juvenile salmonids. Alternative 7 does not result in any changes to habitat conditions in Units 5A and 5C.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** The cap in the barge dock area (Unit 6-B & C) is to be constructed in deep water and is not expected to significantly modify existing habitat quality. Alternative 7 does not involve any changes to habitat conditions in Unit 6A.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 7 do not modify existing habitat conditions at Starr Rock.

- **ASB (Unit 8):** Alternative 7 includes removal of the ASB sludges and opening of the ASB berm in the Site Unit 2-B. These actions restore the connection of the ASB with Bellingham Bay. This will permit utilization of the interior portions of the ASB by juvenile salmonids and other aquatic organisms. The estimated increase in aquatic area is 28 acres. The estimated length of shoreline migration corridor that would become available for use by juvenile salmonids is just under 4,500 linear feet.

6.7.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 7 are summarized in Table 6-2. For the ASB, Outer Whatcom Waterway and most other site areas, the land use benefits and impacts of Alternative 7 are identical to those of Alternatives 5 and 6. The principal difference for Alternative 7 is the treatment of the Inner Whatcom Waterway.

As with Alternatives 2 and 3, Alternative 7 conducts dredging of the Inner Whatcom Waterway based on the obsolete 1960s federal channel dimensions.

That channel was established for an industrial land use pattern that is inconsistent with current zoning and redevelopment planning. Further, the infrastructure required to fully implement the 1960s federal channel was never fully developed, resulting in shorelines in most of the Inner Whatcom Waterway area that are incapable of achieving an effective water depth consistent with the 1960s channel dimensions. These shorelines were constructed earlier based on the historical 18-foot waterway depth. If Alternative 7 is implemented, then it will trigger extensive infrastructure requirements along much of the Inner Whatcom Waterway.

Community land use planning efforts have emphasized the need to provide for multiple waterfront uses in the Inner Whatcom Waterway area. These uses include shoreline public access, habitat enhancement and navigation uses in a manner consistent with the mixed-use waterfront zoning. Alternative 7 conflicts with planned land and navigation uses in the Inner Whatcom Waterway. In order to support deep draft dredging in this area, substantial shoreline infrastructure upgrades are required. These upgrades are inconsistent with habitat enhancement actions in these same areas. Secondly, the land uses necessary to justify Corps participation in future channel maintenance likely conflict with mixed-use redevelopment and shoreline public access objectives. Some navigation uses such as transient moorage may be precluded, or may be significantly restricted in the Inner Whatcom Waterway areas. This contrasts with other FS Alternatives (i.e., Alternatives 4, 5 and 6) that assume the application of a mixed-use channel within the Inner Whatcom Waterway.

The alternative approach to implementing Alternative 7 would be to dredge only the federal channel areas that can be dredged while leaving geotechnically stable side-slopes. This would avoid direct triggering of additional infrastructure requirements, but would limit waterway navigation uses unless the waterway was reauthorized consistent with Alternatives 4, 5 and 6.

In summary, Alternative 7 does not provide incremental benefits to area land uses. Rather, the alternative is based on an obsolete industrial waterway vision that was never fully implemented and that never received the requisite investments in shoreline infrastructure upgrades. The alternative does not enhance navigation opportunities within the Whatcom Waterway, since a full range of intermediate to deep draft uses is already provided under Alternatives 5 and 6. Implementation of Alternative 7 would adversely impact area land use and redevelopment potential by creating additional cost burdens on property owners and local governments (i.e., requirements to upgrade shoreline infrastructure), and by restricting shoreline land use flexibility as necessary to maintain a federal interest in navigation channel maintenance. These issues are significant in the comparative evaluation of alternatives conducted in Section 6.

6.8 Alternative 8

Alternative 8 is the last of the alternatives evaluated in the Feasibility Study. The Alternative uses the same range of technologies evaluated for Alternatives 5, 6 and 7 to comply with SMS cleanup levels. However, the extent of dredging and upland disposal is expanded under Alternative 8 relative to the preceding alternatives. Alternative 8 is shown in Figure 6-8

6.8.1 Actions by Site Unit

Alternative 8 manages most site cleanup areas through sediment removal and upland disposal. Like preceding alternatives, Alternative 8 conducts removal and upland disposal for the sludges within the ASB and for sediments within the Waterway navigation areas. However, Alternative 8 also removes sediments in outlying portions of the site, including areas addressed by capping and monitored natural recovery under other alternatives.

- **Outer Whatcom Waterway (Unit 1):** Dredging of the Outer Whatcom Waterway is conducted the same as for Alternatives 6 and 7. Dredging is conducted to native bottom sediments except where this is not technically feasible. Sediments are managed by upland disposal, except for those sediments of Unit 1A and 1B that may be suitable for beneficial reuse or PSDDA disposal.

- **Inner Whatcom Waterway (Units 2 & 3):** Like Alternatives 2, 3 and 7, this alternative conducts dredging within the Inner Whatcom Waterway as necessary to provide for future use and maintenance of the federal navigation channel to the head of the waterway. The 1960s federal channel boundaries specify a water depth of 30 feet below MLLW from the BST area to Maple Street. A depth of 18 feet is specified from Maple Street to the head of the waterway. In the deeper portion of the waterway, the dredging cut would be established at depths at least 35 feet below MLLW. This would remove sediments where technically feasible, and would provide sufficient over-depth to allow residual sediments to be capped without impeding future maintenance of the federal channel. The design concept assumes a cap thickness of 3 feet over dredged areas with residual subsurface sediment impacts. Due to historical encroachment of the shoreline on the federal channel boundaries, many of the Inner Whatcom Waterway shoreline areas have fill and bulkheads up to or near to the pierhead line. Most of these bulkheads would require replacement and/or substantial upgrades in order to maintain shoreline stability in these areas during and after dredging. Docks may also have to be upgraded or replaced as described in Alternative 2 in order to accommodate federal channel dredging and future use. Containment by capping with appropriate institutional controls will be required for areas where removal is not technically feasible.

- **Log Pond (Unit 4):** The Log Pond area was previously remediated as part of an Interim Action implemented in 2000. Subsequent monitoring has demonstrated the protectiveness of the subaqueous cap, and the effectiveness of habitat enhancement actions completed as part of that project. Actions in this area will be limited to enhancements to the shoreline edges of the cap, to ensure long-term stability of the cap edges. These enhancements are described in Appendix D of this report.

- **Areas offshore of ASB, Areas Near Bellingham Shipping Terminal, Starr Rock (Units 5, 6 & 7):** Under Alternative 8 dredging with upland disposal will be implemented in Unit 5 (ASB shoulder area), Unit 6 (Areas Near Bellingham Shipping Terminals) and Unit 7 (Starr Rock area). Sediments that currently exceed cleanup standards, as well as those that currently comply with cleanup standards would be removed. As with portions of the Inner Whatcom Waterway, some residual sediments would remain in areas where removal was not technically feasible. Some institutional controls, monitoring and/or containment would likely be required in portions of the harbor and bottom areas.

- **ASB (Unit 8):** As with Alternatives 5, 6 and 7, the ASB sludges are removed, treated to reduce volume and are disposed at a permitted upland disposal facility. Removal methods are the same as in the preceding alternatives.

6.8.2 Sediment Disposal

Alternative 8 does not involve the creation of new disposal sites within Bellingham Bay. Sediments removed from Waterway under this Alternative will be managed by disposal in appropriately-permitted upland disposal sites. The design concept for Alternative 8 estimates disposal of approximately 1.26 million cubic yards of dredged sediments and the disposal of approximately 412,000 cubic yards of sludges removed from the ASB. This is a dramatic increase in the disposal volumes over the preceding alternatives.

6.8.3 Costs & Schedule

The probable costs of Alternative 8 are approximately $146 million (Appendices A and B). This cost is nearly double that of Alternative 7, and is over three times higher than the cost of Alternatives 5 and 6.

The implementation of Alternative 8 will require extensive design and permitting prior to initiation of construction. In areas of the Inner Whatcom Waterway, project planning must be coordinated with future shoreline infrastructure improvements. A design and permitting period of 3 to 6 years is estimated.

The additional dredging involved in Alternative 8 will result in a substantial increase to the duration of project construction. All of the additional dredging will involve work in restricted "fish windows." The project is expected to require between 5 and 7 construction seasons, with in-water work activities during each of those seasons. Including project design and permitting, the restoration time for Alternative 8 is estimated at 8 to 13 years.

Monitoring will likely be required in some areas where removal of sediments is not technically feasible and the application of capping and/or natural recovery is required. As with preceding alternatives, capping is assumed for these areas, resulting in no additional restoration time to achieve compliance with cleanup levels in these areas.

6.8.4 Changes to Existing Habitat Conditions

Significant changes to existing habitat conditions that will occur as a result of implementing Alternative 8 are summarized in Table 6-2 and include the following:

- **Outer Whatcom Waterway (Unit 1):** Alternative 8 includes dredging of the Outer Whatcom Waterway areas. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.

- **Inner Whatcom Waterway (Units 2 & 3):** Under Alternative 8, dredging of the Inner Whatcom Waterway is conducted consistent with the boundaries of the 1960s federal channel. This requires the removal of emergent shallow-water habitat at the head and along the sides of the channel. Further, to achieve target dredge depths and navigation conditions, the shorelines must be hardened with bulkheads and other infrastructure similar to that shown in Figure 4-2. The application of this shoreline infrastructure would further reduce the existing quality of nearshore aquatic habitat within the Inner Whatcom Waterway.

- **Log Pond (Unit 4):** Construction of shoreline enhancements consistent with the design concept in Appendix D will result in changes to substrate type and elevations in shoreline edges of the cap.

- **Areas offshore of ASB, Areas Near Bellingham Shipping Terminal, Starr Rock (Units 5, 6, & 7):** The dredging of the harbor areas would not produce the habitat bench near the shoulder of the ASB provided under the other alternatives. Rather, the dredging would reduce mud-line elevations in this area and result in a net reduction in habitat quality in this area. This type of habitat conversion is inconsistent with habitat preservation and enhancement goals of the Bellingham Bay Comprehensive Strategy.

- **Areas Offshore of ASB (Unit 5):** Under Alternative 8, remediation of Unit 5 sediments is conducted by dredging. Portions of Unit 5 are located in shallow-water areas. Dredging in these areas will result in conversions from shallow-water to deeper-water habitat. These conversions would reduce the quality of this area for use by juvenile salmonids.

- **Areas Near Bellingham Shipping Terminal (Unit 6):** Under Alternative 8, remediation of Unit 6 sediments is conducted by dredging. However, Unit 6 consists primarily of deep-water areas. Therefore, dredging of Unit 6 is not expected to result in changes to existing habitat that might adversely impact use by juvenile salmonids.

- **Starr Rock (Unit 7):** Cleanup activities under Alternative 8 will include dredging at Starr Rock. However, this dredging occurs in deep water and does not significantly affect shallow-water habitat areas.

- **ASB (Unit 8):** Alternative 8 includes removal of the ASB sludges and opening of the ASB berm in the Site Unit 2-B. These actions restore the connection of the ASB with Bellingham Bay. This will permit utilization of the interior portions of the ASB by juvenile salmonids and other aquatic organisms. The estimated increase in aquatic area is 28 acres. The estimated length of shoreline migration corridor that would become available for use by juvenile salmonids is just under 4,500 linear feet.

6.8.5 Land Use & Navigation Considerations

Significant land use and navigation considerations associated with the implementation of Alternative 8 are summarized in Table 6-2. These land use and navigation issues are generally the same as for Alternative 7. The additional dredging in the harbor and bottom areas of the Bay provides no incremental benefit to area navigation. As with Alternative 7, the dredging approach to the Inner Whatcom Waterway under Alternative 8 is inconsistent with current area zoning, and planned mixed-use redevelopment of the Inner Whatcom Waterway areas.

Some temporary disruption to area land uses will be encountered during implementation of the cleanup action, due to the extended duration of project construction activities.

Table 6-2. Detailed Description of Site Remediation Alternatives

Alternative Name & Description		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Design Concept Figure		Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Probable Cost ($ million)		$8 million	$34 million	$34 million	$21 million	$42 million	$44 million	$74 million	$146 million
Est. Time for Design/Construction (yrs)		6 to 12 yrs	6 to 9 yrs	5 to 8 yrs	3 to 4 yrs	5 to 6 yrs	5 to 6 yrs	7 to 9 yrs	8 to 13 yrs
ASB Area Summary [1]		Capping of ASB Sludges	Capping of ASB Sludges	Containment of ASB Sludges within Nearshore Fill	Capping of ASB Sludges	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]
Waterway Area Summary [1]		Capping and Monitored Natural Recovery with Restricted Channel Depths [2]	Dredging of 1960s Federal Channel with Disposal at Cornwall Confined Aquatic Disposal (CAD)	Dredging of 1960s Federal Channel with Disposal in ASB Nearshore Fill	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Expanded Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel & Additional Areas with Upland Disposal in Subtitle D Facility [5]
1. Cleanup Actions by Site Unit									
Outer Whatcom Waterway	Site Unit								
Outer Channel	Units 1A/1B	Monitored Natural Recovery & Institutional Controls	Dredging with Placement in Cornwall-Area CAD Site	Dredging with Placement in ASB Nearshore Fill	Dredging with Beneficial Reuse or PSDDA Disposal	Dredging with Beneficial Reuse or PSDDA Disposal	Dredging with Beneficial Reuse or PSDDA Disposal	Dredging with Beneficial Reuse or PSDDA Disposal	Dredging with Beneficial Reuse or PSDDA Disposal
Port Terminal Area	Unit 1C	Monitored Natural Recovery & Institutional Controls	Expanded Dredging[8] with Placement in Cornwall-Area CAD	Expanded Dredging[8] with Placement in ASB Nearshore Fill	Dredging for 30-ft Deep Draft Uses with Subtitle D Disposal, Followed by Capping & Institutional Controls	Dredging for 30-ft Deep Draft Uses with Subtitle D Disposal, Followed by Capping & Institutional Controls	Expanded Dredging[8] with Subtitle D Sediment Disposal	Expanded Dredging[8] with Subtitle D Sediment Disposal	Expanded Dredging[8] with Subtitle D Sediment Disposal
Inner Whatcom Waterway									
Inner Waterway	Unit 2A, 2C & 3B	Monitored Natural Recovery & Institutional Controls	Dredging of 1960s Federal Channel with Placement in Cornwall-Area CAD Site, Followed by Capping & Institutional Controls	Dredging of 1960s Federal Channel with Placement in ASB Nearshore Fill, Followed by Capping & Institutional Controls	Dredging for Multi-Purpose Channel with Subtitle D Disposal, Followed by Capping & Institutional Controls	Dredging for Multi-Purpose Channel with Subtitle D Disposal, Followed by Capping & Institutional Controls	Dredging for Multi-Purpose Channel with Subtitle D Disposal, Followed by Capping & Institutional Controls	Dredging of 1960s Federal Channel with Subtitle D Disposal, Followed by Capping & Institutional Controls	Dredging of 1960s Federal Channel with Subtitle D Disposal, Followed by Capping & Institutional Controls
ASB Access Channel	Unit 2B	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging for 18-ft Access Channel with Subtitle D Disposal	Dredging for 18-ft Access Channel with Subtitle D Disposal	Dredging for 18-ft Access Channel with Subtitle D Disposal	Dredging & Subtitle D Disposal
Emergent Tideflat	Units 3A	Monitored Natural Recovery & Institutional Controls	Dredging of 1960s Industrial Channel with Disposal in Cornwall-Area CAD Site	Dredging of 1960s Industrial Channel with Disposal in ASB Nearshore Fill	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging of 1960s Federal Channel with Subtitle D Disposal	Dredging of 1960s Federal Channel with Subtitle D Disposal
Log Pond	Unit 4	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]	Enhancements to Shoreline Cap Edges [6]
Areas Offshore of ASB									
Offshore of ASB	Unit 5A	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging & Subtitle D Disposal
Shoulder of ASB	Unit 5B	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Sediment Capping[7] & Institutional Controls	Dredging & Subtitle D Disposal
Waterway Side of ASB	Unit 5C	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging & Subtitle D Disposal
Areas Near Bellingham Shipping Terminal									
Recovered Harbor Areas	Unit 6A	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging & Subtitle D Disposal
Barge Dock Area	Unit 6B, 6C	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Sediment Capping & Insitutional Controls	Dredging & Subtitle D Disposal
Starr Rock	Unit 7	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Monitored Natural Recovery & Institutional Controls	Dredging & Subtitle D Disposal
ASB	Unit 8	Capping of ASB Sludges	Capping of ASB Sludges	Containment of ASB Sludges within Nearshore Fill	Capping of ASB Sludges	Removal of ASB sludges with Dewatering & Subtitle D Disposal	Removal of ASB sludges with Dewatering & Subtitle D Disposal	Removal of ASB sludges with Dewatering & Subtitle D Disposal	Removal of ASB sludges with Dewatering & Subtitle D Disposal
2. Sediment Disposal									
ASB Sludges	Unit 8	-- NA[3] --	-- NA[3] --	-- NA[3] --	-- NA[3] --	Removal, Dewatering & Subtitle D Disposal of 412,000 cyd ASB Sludges and Overdredge	Removal, Dewatering & Subtitle D Disposal of 412,000 cyd ASB Sludges and Overdredge	Removal, Dewatering & Subtitle D Disposal of 412,000 cyd ASB Sludges and Overdredge	Removal, Dewatering & Subtitle D Disposal of 412,000 cyd ASB Sludges and Overdredge
Aquatic Sediments	All Other Areas	-- NA[4] --	Containment of 585,000 cyd sediments in Cornwall CAD	Containment of 585,000 cyd sediments in ASB Nearshore Fill	Dredging & Subtitle D Disposal of 68,000 cyd Sediments	Dredging & Subtitle D Disposal of 76,000 cyd Sediments	Dredging & Subtitle D Disposal of 118,000 cyd Sediments	Dredging & Subtitle D Disposal of 479,000 cyd Sediments	Dredging & Subtitle D Disposal of 1.26 million cyd Sediments
					Beneficial Use or PSDDA Disposal of 113,000 cyd Unit 1A/1B Sediment	Beneficial Use or PSDDA Disposal of 113,000 cyd Unit 1A/1B Sediment	Beneficial Use or PSDDA Disposal of 113,000 cyd Unit 1A/1B Sediment	Beneficial Use or PSDDA Disposal of 113,000 cyd Unit 1A/1B Sediment	Beneficial Use or PSDDA Disposal of 113,000 cyd Unit 1A/1B Sediment

Notes:

1: All remedial alternatives involve the use of institutional controls, containment and monitoring to varying degrees. Refer to Sections 1 through 4 of this table for a specific description of remedial alternatives by Sediment Site Unit.
2: Channel depths will be restricted to depths shallower than current bathymetry under Alternative 1, as no dredging would be conducted either in the Inner Waterway or Outer Waterway areas.
3. Not applicable. Under this alternative, no removal of the ASB sludges will be conducted.
4. Not applicable. Under this alternative, no waterway sediment dredging will be conducted.
5. A Subtitle D Facility is a landfill that is designed and permitted for management of solid waste, and includes a liner, a cap, a monitoring network, and institutional controls and financial assurance provisions under state and federal solid waste regulations.
6. The design concept for stabilizing the shoreline cap edges is illustrated in Appendix D. The Log Pond area is subject to institutional controls recorded as part of the Log Pond Interim Remedial Action.
7. The design concept for the cap in the Unit 5B area is illustrated in Appendix C.
8. Dredging in this area will be conducted to the base of the contaminated sediments, and requirements for capping of the dredged area are not anticipated.

Table 6-2. Detailed Description of Site Remediation Alternatives

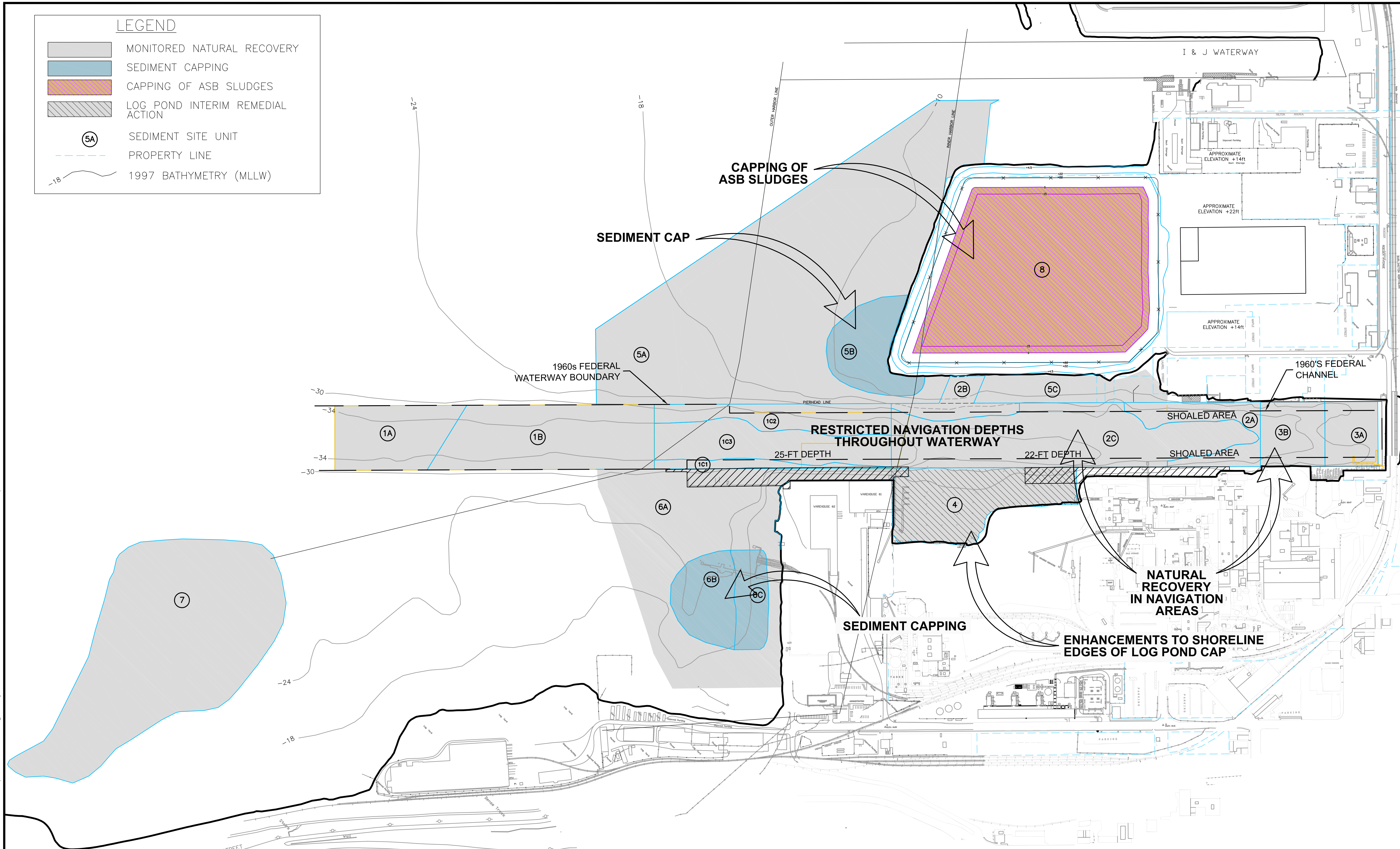
Alternative Name & Description		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Design Concept Figure		Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Probable Cost ($ million)		$8 million	$34 million	$34 million	$21 million	$42 million	$44 million	$74 million	$146 million
Est. Time for Design/Construction (yrs)		6 to 12 yrs	6 to 9 yrs	5 to 8 yrs	3 to 4 yrs	5 to 6 yrs	5 to 6 yrs	7 to 9 yrs	8 to 13 yrs
ASB Area Summary [1]		Capping of ASB Sludges	Capping of ASB Sludges	Containment of ASB Sludges within Nearshore Fill	Capping of ASB Sludges	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]
Waterway Area Summary [1]		Capping and Monitored Natural Recovery with Restricted Channel Depths [2]	Dredging of 1960s Federal Channel with Disposal at Cornwall Confined Aquatic Disposal (CAD)	Dredging of 1960s Federal Channel with Disposal in ASB Nearshore Fill	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Expanded Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel & Additional Areas with Upland Disposal in Subtitle D Facility [5]
3. Changes to Existing Habitat Conditions									
Outer Whatcom Waterway	Units 1A, 1B & 1C	No Change	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas	No Significant Changes -- Dredging Occurs in Deep-Water Areas
Inner Whatcom Waterway									
Inner Waterway	Unit 2A, 2C & 3B	Absence of Deep Dredging Retains Shallow-Water Habitat in Nearshore Shoaled Areas	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat and Requires Continued Use of Hardened Shorelines and Bulkheads to Achieve Target Dredge Depths	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat and Requires Continued Use of Hardened Shorelines and Bulkheads to Achieve Target Dredge Depths	Use of Sloping Shoreline Stabilization Methods Consistent with Multi-Purpose Channel Dimensions Preserves and Enhances Shallow-Water Habitat Along Salmonid Migration Corridors	Use of Sloping Shoreline Stabilization Methods Consistent with Multi-Purpose Channel Dimensions Preserves and Enhances Shallow-Water Habitat Along Salmonid Migration Corridors	Use of Sloping Shoreline Stabilization Methods Consistent with Multi-Purpose Channel Dimensions Preserves and Enhances Shallow-Water Habitat Along Salmonid Migration Corridors	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat and Requires Continued Use of Hardened Shorelines and Bulkheads to Achieve Target Dredge Depths	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat and Requires Continued Use of Hardened Shorelines and Bulkheads to Achieve Target Dredge Depths
ASB Access Channel	Unit 2B	No Change to Existing Shallow-Water Area	No Change to Existing Shallow-Water Area	No Change to Existing Shallow-Water Area	No Change to Existing Shallow-Water Area	Dredging of Channel Converts 0.7 Acres of Shallow-Water Habitat to Deep-Water Bottom Areas	Dredging of Channel Converts 0.7 Acres of Shallow-Water Habitat to Deep-Water Bottom Areas	Dredging of Channel Converts 0.7 Acres of Shallow-Water Habitat to Deep-Water Bottom Areas	Dredging of Channel Converts 0.7 Acres of Shallow-Water Habitat to Deep-Water Bottom Areas
Emergent Tideflat	Units 3A	No Change -- Emergent Shallow-Water Habitat is Preserved	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat	No Change -- Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat	No Change -- Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat	No Change -- Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat	Dredging of 1960s Industrial Channel Removes Emergent Shallow-Water Habitat
Log Pond	Unit 4	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond	Substrate Modifications Required to Stabilize Shoreline Edges of Log Pond
Areas Offshore of ASB									
Shoulder of ASB	Unit 5B	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Capping Design Concept Creates 4 to 6 Acres of Premium Nearshore Habitat	Dredging Converts 4 to 6 Acres of Shallow-Water Area to Deep-Water Area
Other Unit 5 Areas	Units 5A & 5C	No Change	No Change	No Change	No Change	No Change	No Change	No Change	Dredging Results in Deepening of Existing Shallow-Water Habitat Areas Along ASB Berm
Areas Near Bellingham Shipping Terminal									
Barge Dock Area	Unit 6B, 6C	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Capping Limited to Deep-Water Areas	No Change -- Dredging Limited to Deep-Water Areas
Other Unit 6 Areas	Unit 6A	No Change	No Change	No Change	No Change	No Change	No Change	No Change	Dredging will Result in Deepening of Shallow-Water Nearshore Habitat Areas
Starr Rock	Unit 7	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change -- Dredging Limited to Deep-Water Areas
ASB	Unit 8	No Change -- ASB Sludges are Capped and Area Remains Isolated from Bellingham Bay	No Change -- ASB Sludges are Capped and Area Remains Isolated from Bellingham Bay	Nearshore Fill is Constructed within ASB, Converting Area Permanently to Upland Characteristics	No Change -- ASB Sludges are Capped and Area Remains Isolated from Bellingham Bay	ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay

Table 6-2. Detailed Description of Site Remediation Alternatives

Alternative Name & Description		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Design Concept Figure		Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Probable Cost ($ million)		$8 million	$34 million	$34 million	$21 million	$42 million	$44 million	$74 million	$146 million
Est. Time for Design/Construction (yrs)		6 to 12 yrs	6 to 9 yrs	5 to 8 yrs	3 to 4 yrs	5 to 6 yrs	5 to 6 yrs	7 to 9 yrs	8 to 13 yrs
ASB Area Summary [1]		Capping of ASB Sludges	Capping of ASB Sludges	Containment of ASB Sludges within Nearshore Fill	Capping of ASB Sludges	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]	Removal, Treatment & Disposal of ASB Sludge in Subtitle D Facility [5]
Waterway Area Summary [1]		Capping and Monitored Natural Recovery with Restricted Channel Depths [2]	Dredging of 1960s Federal Channel with Disposal at Cornwall Confined Aquatic Disposal (CAD)	Dredging of 1960s Federal Channel with Disposal in ASB Nearshore Fill	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Expanded Dredging of Multi-Purpose Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel with Upland Disposal in Subtitle D Facility [5]	Dredging of 1960s Federal Channel & Additional Areas with Upland Disposal in Subtitle D Facility [5]
4. Land Use & Navigation Considerations									
Outer Whatcom Waterway	Units 1A, 1B & 1C	Restricted Water Depths will Limit Future Deep-Draft Uses of Terminal Area, Conflicting with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses	Dredging in Outer Waterway Preserves Deep Draft Uses of Terminal Area, Consistent with Current and Planned Uses
Inner Whatcom Waterway									
Inner Waterway	Unit 2A, 2C & 3B	Restricted Water Depths and Lack of Stabilized Shorelines will Limit Future Inner Waterway Navigation & Land Uses.	Industrial Shoreline Infrastructure Requirements and Land Use Restrictions Associated with Federal Channel Conflict with Planned Mixed-Use Redevelopment & Habitat Enhancements.	Industrial Shoreline Infrastructure Requirements and Land Use Restrictions Associated with Federal Channel Conflict with Planned Mixed-Use Redevelopment & Habitat Enhancements.	Locally-Managed Multi-Purpose Waterway is Consistent with Planned Mixed-Use Redevelopment, Including Infrastructure and Navigation Planning	Locally-Managed Multi-Purpose Waterway is Consistent with Planned Mixed-Use Redevelopment, Including Infrastructure and Navigation Planning	Locally-Managed Multi-Purpose Waterway is Consistent with Planned Mixed-Use Redevelopment, Including Infrastructure and Navigation Planning	Industrial Shoreline Infrastructure Requirements and Land Use Restrictions Associated with Federal Channel Conflict with Planned Mixed-Use Redevelopment & Habitat Enhancements.	Industrial Shoreline Infrastructure Requirements and Land Use Restrictions Associated with Federal Channel Conflict with Planned Mixed-Use Redevelopment & Habitat Enhancements.
ASB Access Channel	Unit 2B	No Use Changes. Area Not Dredged for Marina Access Channel.	No Use Changes. Area Not Dredged for Marina Access Channel.	No Use Changes. Area Not Dredged for Marina Access Channel.	No Use Changes. Area Not Dredged for Marina Access Channel.	Area Dredged Consistent with Plans for Multi-Purpose ASB Marina	Area Dredged Consistent with Plans for Multi-Purpose ASB Marina	Area Dredged Consistent with Plans for Multi-Purpose ASB Marina [9]	Area Dredged Consistent with Plans for Multi-Purpose ASB Marina [9]
Emergent Tideflat	Units 3A	Emergent Shallow-Water Habitat is Preserved, Consistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Dredging of 1960s Industrial Channel Requires Removal of Emergent Shallow-Water Habitat, Inconsistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Dredging of 1960s Industrial Channel Requires Removal of Emergent Shallow-Water Habitat, Inconsistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat, Consistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat, Consistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Multi-Purpose Channel Preserves Emergent Shallow-Water Habitat, Consistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Dredging of 1960s Industrial Channel Requires Removal of Emergent Shallow-Water Habitat, Inconsistent with Bellingham Bay Comprehensive Strategy Habitat Goals.	Dredging of 1960s Industrial Channel Requires Removal of Emergent Shallow-Water Habitat, Inconsistent with Bellingham Bay Comprehensive Strategy Habitat Goals.
Log Pond	Unit 4	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.	No Change -- Log Pond Cap & Habitat Enhancements Are Preserved. Some Modifications Required to Stabilize Shoreline Edges of Log Pond.
Areas Offshore of ASB									
Shoulder of ASB	Unit 5B	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Creation of Nearshore Habitat in this Area is Consistent with Bellingham Bay Comprehensive Strategy	Conversion of Shallow-Water Area to Deep-Water Area by Dredging is Inconsistent with Bellingham Bay Comprehensive Strategy
Other Unit 5 Areas	Units 5A & 5C	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	No Change. Preservation of Shallow-Water Habitat Areas Along Salmonid Migration Corridors is Consistent with Bellingham Bay Comprehensive Strategy.	Conversion of Shallow-Water Areas Along ASB Berm to Deep-Water Area by Dredging is Inconsistent with Bellingham Bay Comprehensive Strategy Concepts for Salmonid Migration Corridor Enhancements in these Areas
Areas Near Bellingham Shipping Terminal									
Barge Dock Area	Unit 6B, 6C	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Capping Design Not Expected to Impact Planned Navigation Uses.	No Change -- Dredging Has No Impact on Planned Navigation Uses.
Other Unit 6 Areas	Unit 6A	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change -- Dredging Has No Impact on Planned Navigation Uses in this Area.
Starr Rock	Unit 7	No Change	No Change	No Change	No Change	No Change	No Change	No Change	No Change -- Dredging Limited to Deep-Water Areas
ASB	Unit 8	Capping of ASB Sludges Conflicts with Planned Reuse of ASB for Marina with Integrated Public Access and Habitat Enhancements	Capping of ASB Sludges Conflicts with Planned Reuse of ASB for Marina with Integrated Public Access and Habitat Enhancements	Construction of Nearshore Fill Conflicts with Planned Reuse of ASB for Marina with Integrated Public Access and Habitat Enhancements	Capping of ASB Sludges Conflicts with Planned Reuse of ASB for Marina with Integrated Public Access and Habitat Enhancements	ASB Sludge Removal and Berm Opening is Consistent with Planned Reuse of ASB as Marina with Integrated Public Access and Habitat Enhancements	ASB Sludge Removal and Berm Opening is Consistent with Planned Reuse of ASB as Marina with Integrated Public Access and Habitat Enhancements	ASB Sludge Removal and Berm Opening is Consistent with Planned Reuse of ASB as Marina with Integrated Public Access and Habitat Enhancements	ASB Sludge Removal and Berm Opening is Consistent with Planned Reuse of ASB as Marina with Integrated Public Access and Habitat Enhancements

Notes:

9. Under Alternatives 7 & 8, the marina access channel may have to be relocated to the area offshore of the ASB in order to avoid navigation conflicts between the marina entrance and large-vessel navigation patterns in the Whatcom Waterway.



WHATCOM WATERWAY FEASIBILITY STUDY

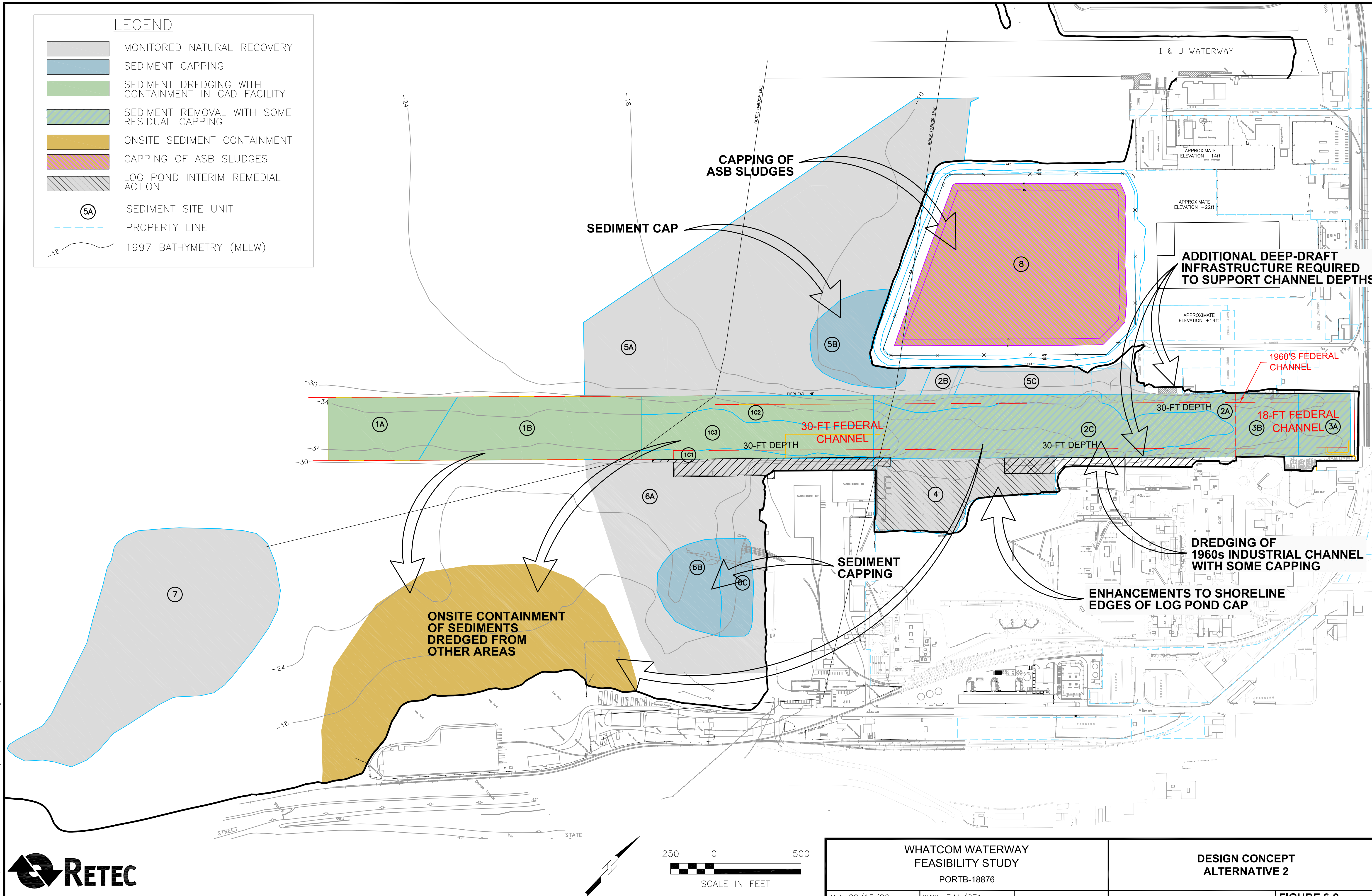
PORTB-18876

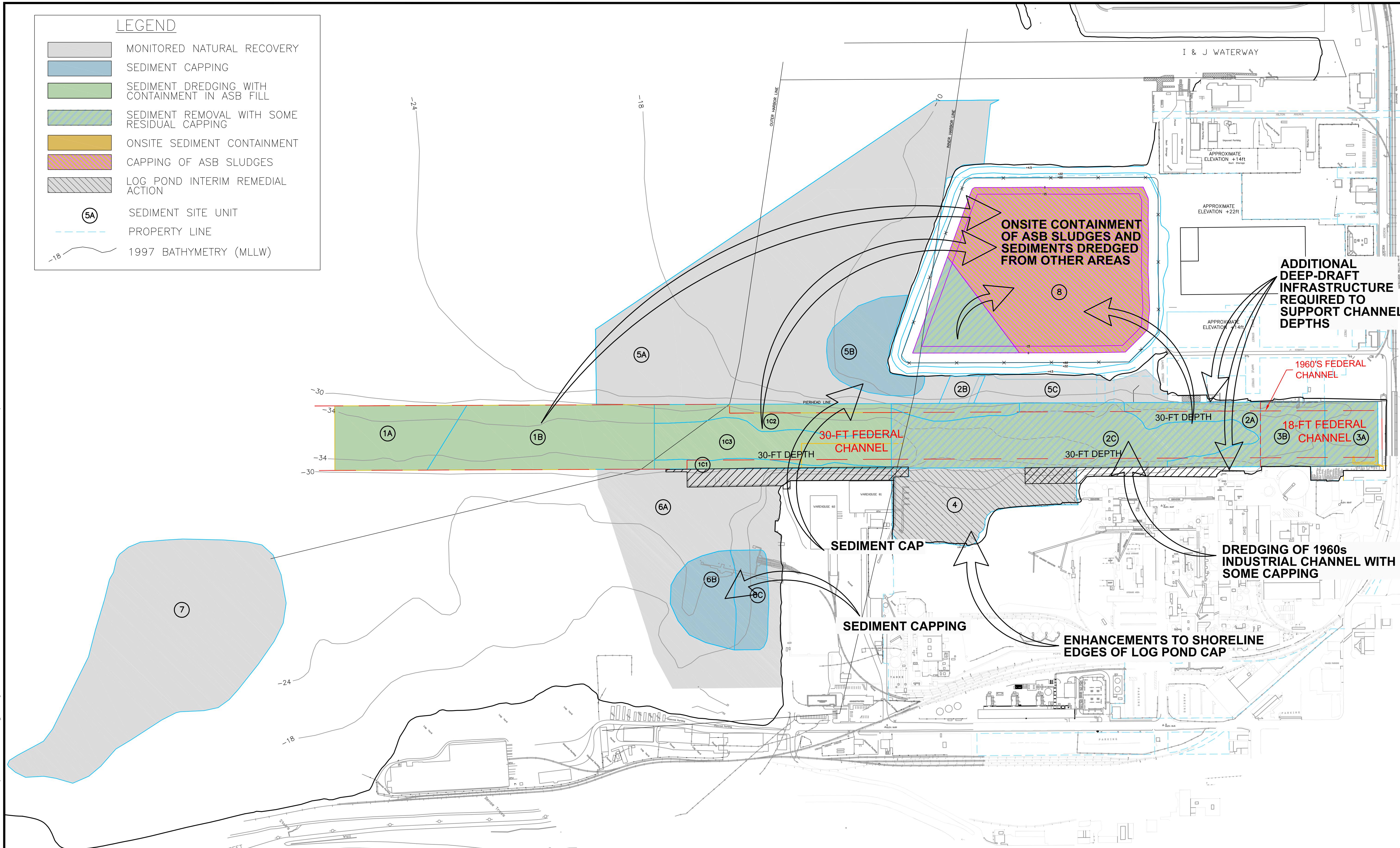
DESIGN CONCEPT ALTERNATIVE 1

DATE: 09/15/06 DRWN: E.M./SEA

FIGURE 6-1

File: H:\18876\FEASIBILITY STUDY\18876S209.dwg Layout: FIGURE 6-1 User: emarshall Plotted: Sep 28, 2006 - 8:36am Xref's:

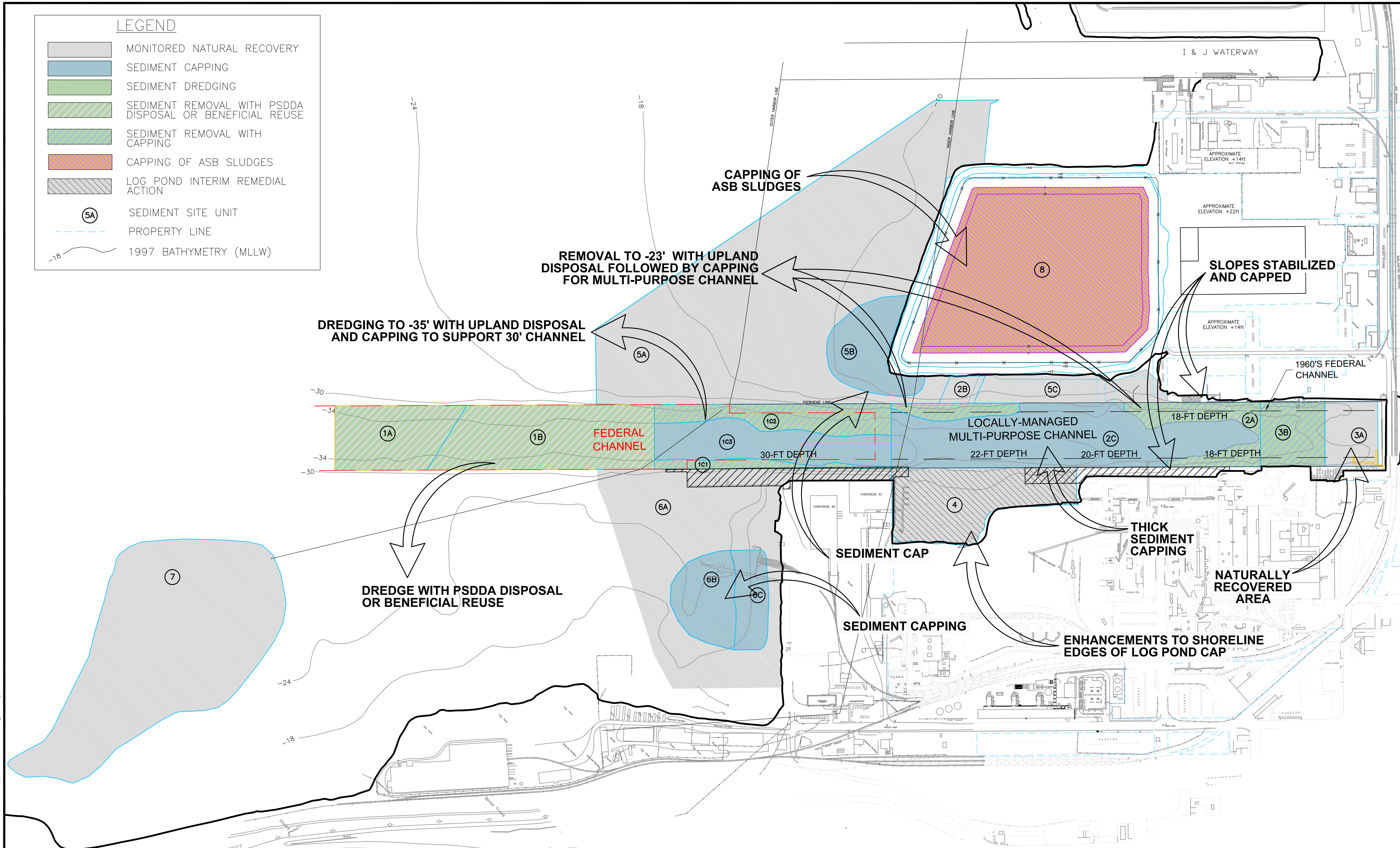

LEGEND
MONITORED NATURAL RECOVERY
SEDIMENT CAPPING
SEDIMENT DREDGING WITH CONTAINMENT IN CAD FACILITY
SEDIMENT REMOVAL WITH SOME RESIDUAL CAPPING
ONSITE SEDIMENT CONTAINMENT
CAPPING OF ASB SLUDGES
LOG POND INTERIM REMEDIAL ACTION
5A SEDIMENT SITE UNIT
PROPERTY LINE
-18 1997 BATHYMETRY (MLLW)
I & J WATERWAY
CAPPING OF ASB SLUDGES
SEDIMENT CAP
ADDITIONAL DEEP-DRAFT INFRASTRUCTURE REQUIRED TO SUPPORT CHANNEL DEPTHS
1960'S FEDERAL CHANNEL
30-FT DEPTH
30-FT FEDERAL CHANNEL
18-FT FEDERAL CHANNEL
30-FT DEPTH
30-FT DEPTH
DREDGING OF 1960s INDUSTRIAL CHANNEL WITH SOME CAPPING
SEDIMENT CAPPING
ENHANCEMENTS TO SHORELINE EDGES OF LOG POND CAP
ONSITE CONTAINMENT OF SEDIMENTS DREDGED FROM OTHER AREAS
APPROXIMATE ELEVATION +14ft
APPROXIMATE ELEVATION +22ft
APPROXIMATE ELEVATION +14ft
PIERHEAD LINE
OUTER HARBOR LINE
INNER HARBOR LINE
1A 1B 1C1 1C2 1C3 2A 2B 2C 3A 3B 4 5A 5B 5C 6A 6B 6C 7 8
250 0 500
SCALE IN FEET
RETEC
WHATCOM WATERWAY FEASIBILITY STUDY
PORTB-18876
DATE: 09/15/06
DRWN: E.M./SEA
DESIGN CONCEPT ALTERNATIVE 2
FIGURE 6-2
File: H:\18876\FEASIBILITY STUDY\18876S210.dwg Layout: FIGURE 6-2 User: emarshall Plotted: Oct 02, 2006 - 3:25pm Xref's:



File: H:\18876\FEASIBILITY STUDY\18876S211.dwg Layout: FIGURE 6-3 User: emarshall Plotted: Oct 02, 2006 - 3:23pm Xref's:

RETEC

WHATCOM WATERWAY FEASIBILITY STUDY PORTB-18876	DESIGN CONCEPT ALTERNATIVE 3
DATE: 09/15/06 DRWN: E.M./SEA	FIGURE 6-3



WHATCOM WATERWAY FEASIBILITY STUDY

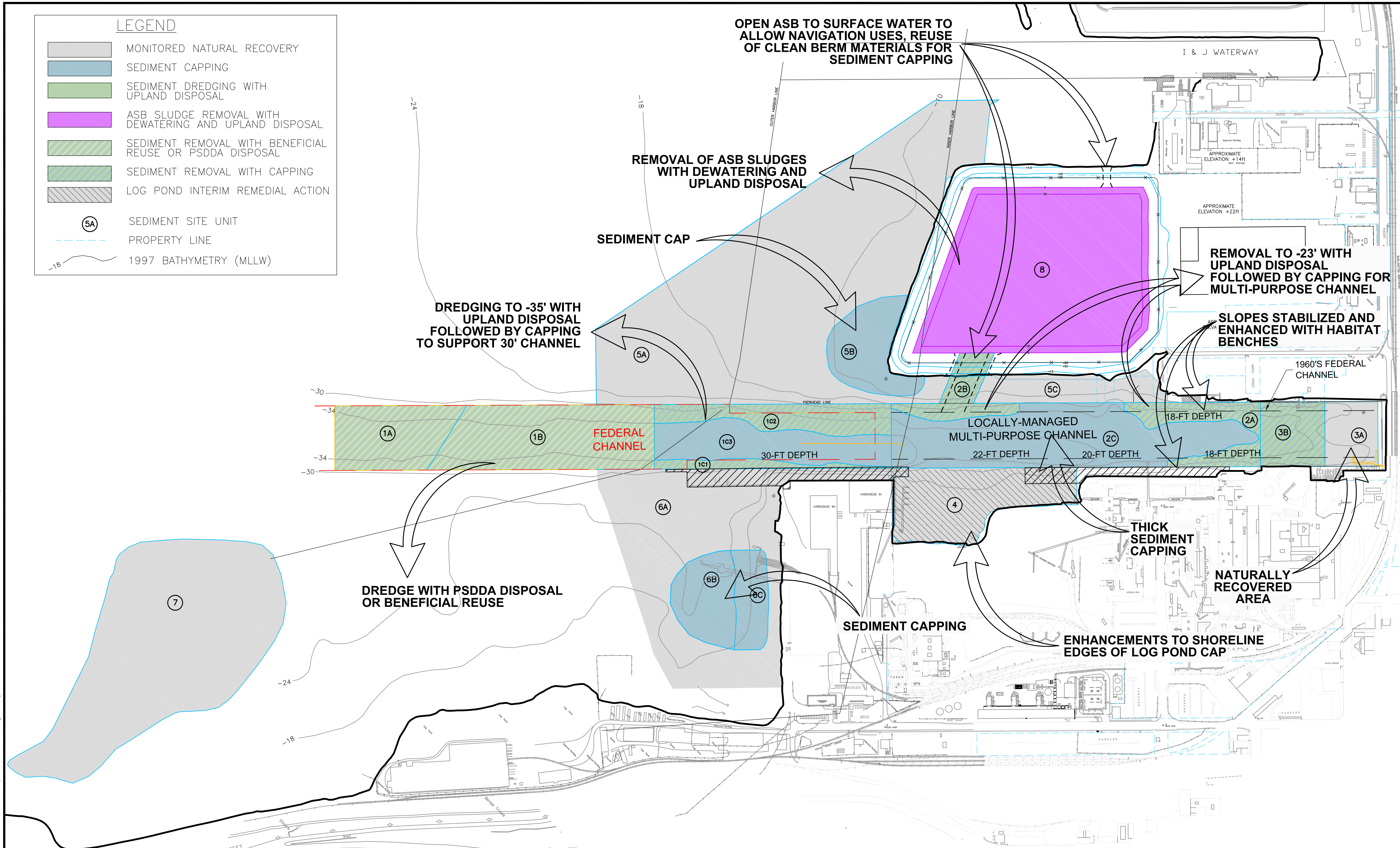
PORTB-18876

DATE: 09/15/06 DRWN: E.M./SEA

DESIGN CONCEPT ALTERNATIVE 4

FIGURE 6-4

File: H:\18876\FEASIBILITY STUDY\18876S212.dwg Layout: FIGURE 6-4 User: emarshall Plotted: Sep 28, 2006 - 8:38am Xref's:



RETEC

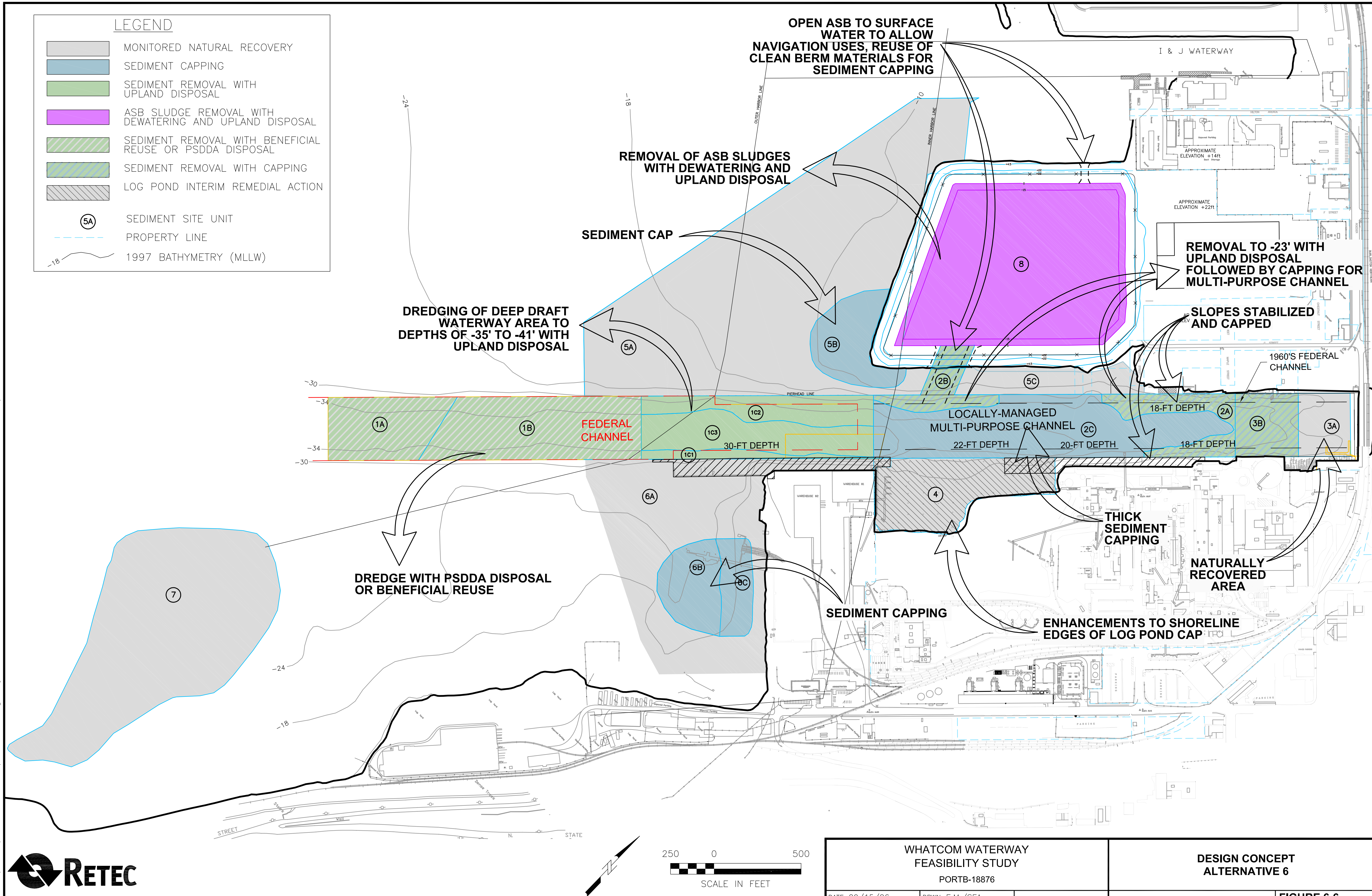
WHATCOM WATERWAY FEASIBILITY STUDY
PORTB-18876

DATE: 09/15/06 DRWN: E.M./SEA

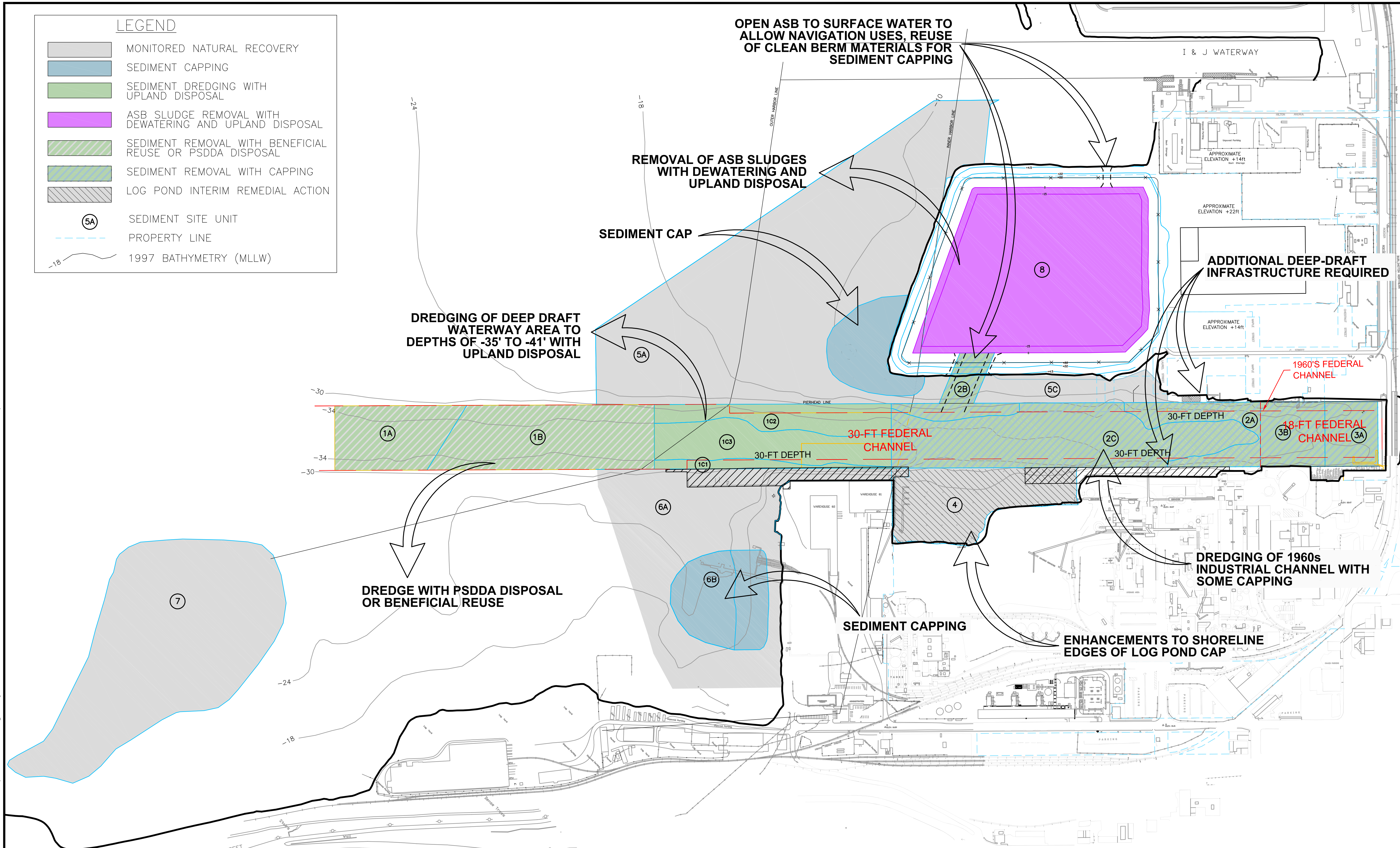
DESIGN CONCEPT ALTERNATIVE 5

FIGURE 6-5

File: H:\18876\FEASIBILITY STUDY\18876S213.dwg Layout: FIGURE 6-5 User: emarshall Plotted: Sep 28, 2006 - 8:39am Xref's:



LEGEND
MONITORED NATURAL RECOVERY
SEDIMENT CAPPING
SEDIMENT REMOVAL WITH UPLAND DISPOSAL
ASB SLUDGE REMOVAL WITH DEWATERING AND UPLAND DISPOSAL
SEDIMENT REMOVAL WITH BENEFICIAL REUSE OR PSDDA DISPOSAL
SEDIMENT REMOVAL WITH CAPPING
LOG POND INTERIM REMEDIAL ACTION
5A SEDIMENT SITE UNIT
PROPERTY LINE
1997 BATHYMETRY (MLLW)
OPEN ASB TO SURFACE WATER TO ALLOW NAVIGATION USES, REUSE OF CLEAN BERM MATERIALS FOR SEDIMENT CAPPING
I & J WATERWAY
REMOVAL OF ASB SLUDGES WITH DEWATERING AND UPLAND DISPOSAL
SEDIMENT CAP
APPROXIMATE ELEVATION +14ft
APPROXIMATE ELEVATION +22ft
REMOVAL TO -23' WITH UPLAND DISPOSAL FOLLOWED BY CAPPING FOR MULTI-PURPOSE CHANNEL
SLOPES STABILIZED AND CAPPED
1960'S FEDERAL CHANNEL
DREDGING OF DEEP DRAFT WATERWAY AREA TO DEPTHS OF -35' TO -41' WITH UPLAND DISPOSAL
OUTER HARBOR LINE
INNER HARBOR LINE
PIERHEAD LINE
FEDERAL CHANNEL
LOCALLY-MANAGED MULTI-PURPOSE CHANNEL
30-FT DEPTH
22-FT DEPTH
20-FT DEPTH
18-FT DEPTH
18-FT DEPTH
1A
1B
1C1
1C2
1C3
2A
2B
2C
3A
3B
4
5A
5B
5C
6A
6B
6C
7
8
-24
-18
-10
-30
-34
-34
-30
-24
-18
THICK SEDIMENT CAPPING
NATURALLY RECOVERED AREA
DREDGE WITH PSDDA DISPOSAL OR BENEFICIAL REUSE
SEDIMENT CAPPING
ENHANCEMENTS TO SHORELINE EDGES OF LOG POND CAP
STREET
STATE
RETEC
N
250 0 500
SCALE IN FEET
WHATCOM WATERWAY FEASIBILITY STUDY
PORTB-18876
DATE: 09/15/06
DRWN: E.M./SEA
DESIGN CONCEPT ALTERNATIVE 6
FIGURE 6-6



RETEC

WHATCOM WATERWAY FEASIBILITY STUDY

PORTB-18876

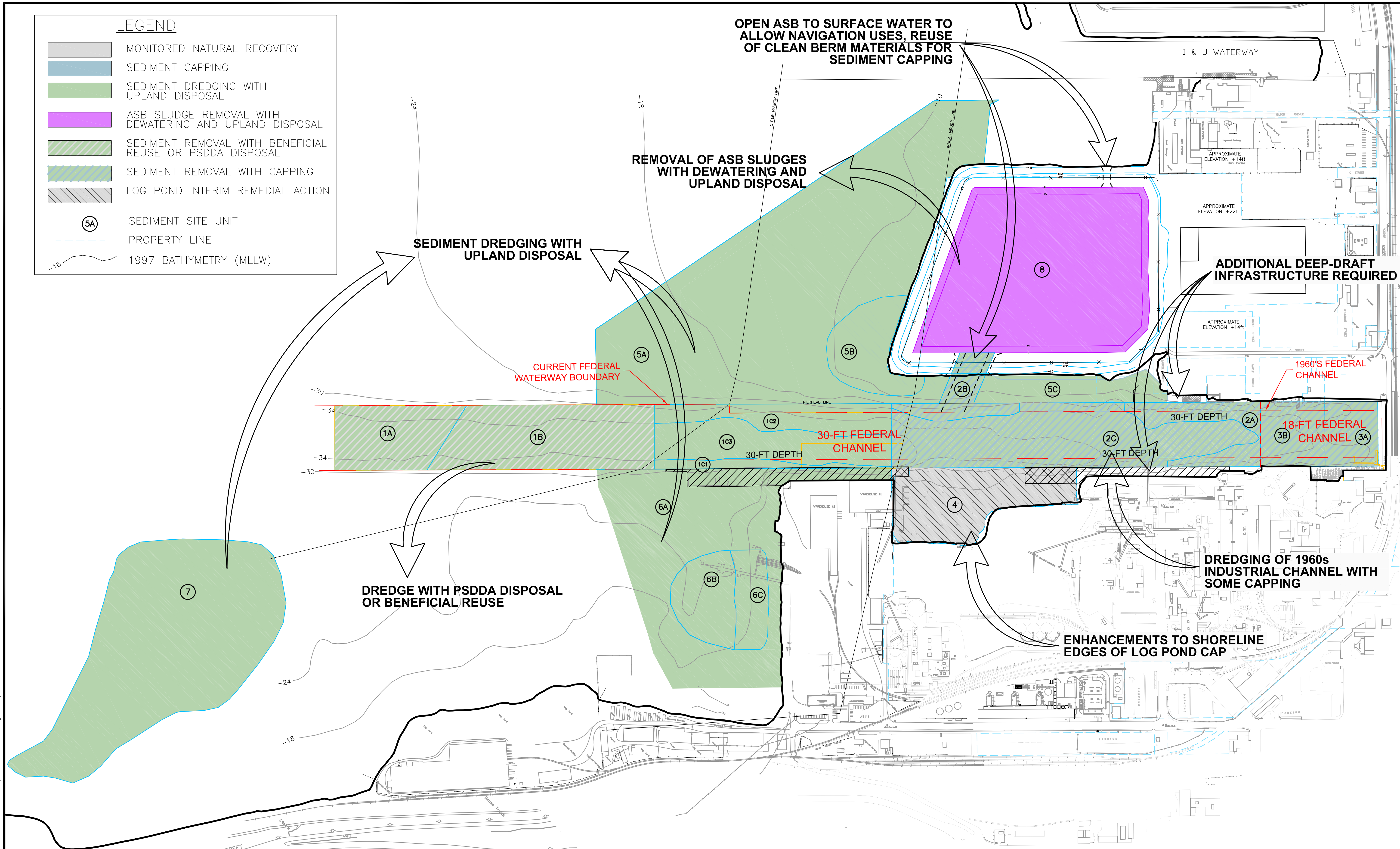
DATE: 09/15/06

DRWN: E.M./SEA

DESIGN CONCEPT ALTERNATIVE 7

FIGURE 6-7

File: H:\18876\FEASIBILITY STUDY\18876S215.dwg Layout: FIGURE 6-7 User: emarshall Plotted: Oct 02, 2006 - 3:26pm Xref's:



WHATCOM WATERWAY FEASIBILITY STUDY

PORTB-18876

DATE: 09/15/06 DRWN: E.M./SEA

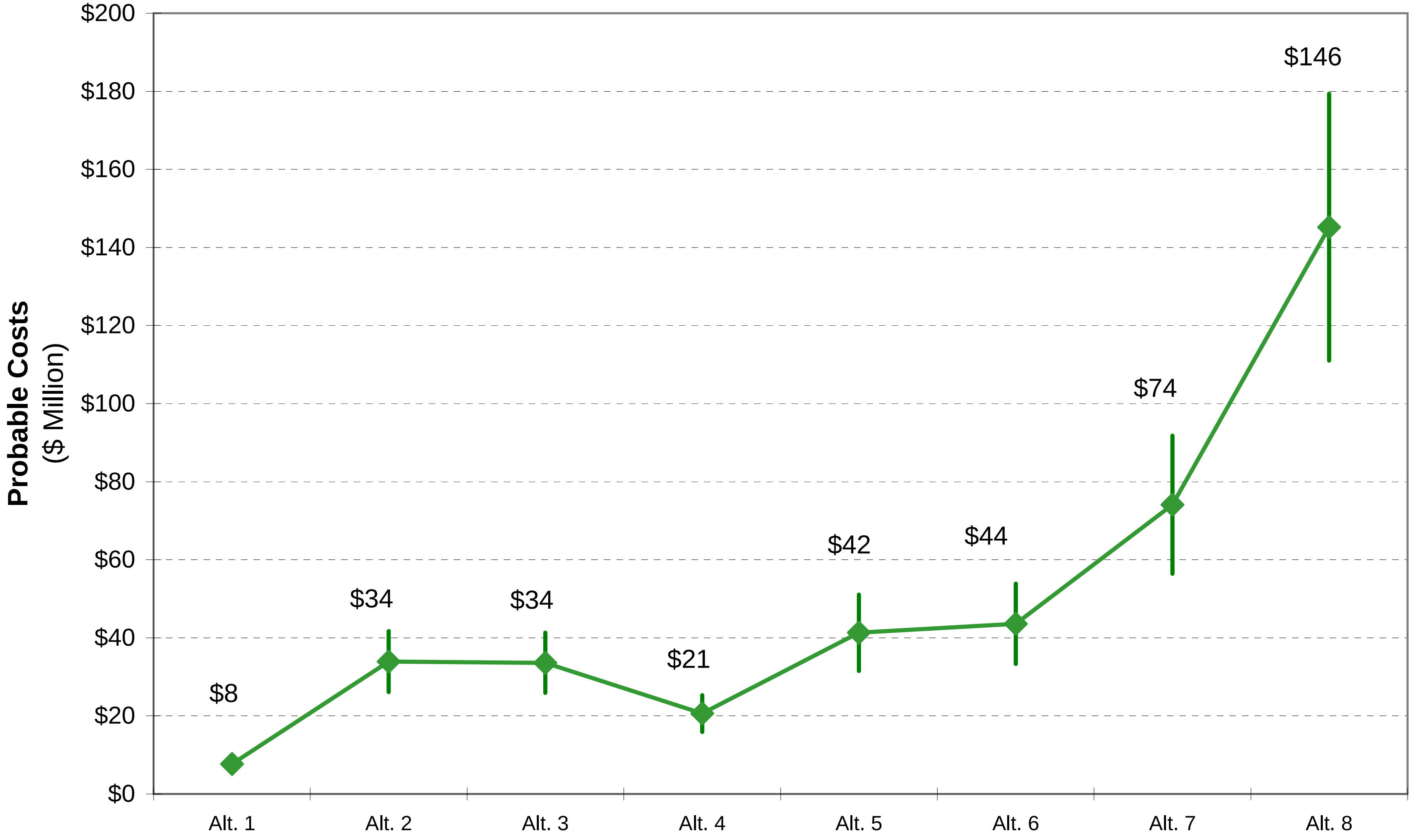
DESIGN CONCEPT ALTERNATIVE 8

FIGURE 6-8

RETEC

File: H:\18876\FEASIBILITY STUDY\18876S216.dwg Layout: FIGURE 6-8 User: emarshall Plotted: Oct 02, 2006 - 3:39pm Xref's:

Figure 6-9
Estimated Costs of Evaluated Alternatives



Note:

Costs shown are probable costs. Error bars illustrate cost uncertainties using a +/- 30% construction contingency.

All costs are presented as 2005 $U.S. currency, without correction for future inflation prior to project implementation dates.

7 Detailed Evaluation of Alternatives

This section provides an evaluation of each of the eight remedial alternatives described in Section 6. The detailed alternatives evaluation is conducted using MTCA and SMS criteria. These criteria govern the evaluation of remedial alternatives and the identification of preferred alternatives. This section is divided into three parts:

- Description of the MTCA and SMS evaluation criteria and remedy selection process (Section 7.1).

- Presentation of each alternative and how it addresses each of the MTCA and SMS criteria (Section 7.2)

- MTCA disproportionate cost analysis, used to identify preferred alternative(s) that are permanent to the maximum extent practicable (Section 7.3)

7.1 MTCA & SMS Evaluation Criteria

The MTCA and SMS regulations contain explicit criteria for the evaluation and selection of cleanup alternatives. This section provides an overview of these regulatory criteria. The consistency of each alternative with these criteria is then discussed in the subsequent sections.

7.1.1 MTCA Threshold Requirements

Cleanup actions selected under MTCA must comply with several basic requirements. Alternatives that do not comply with these criteria cannot be considered valid cleanup actions under MTCA. WAC 173-340-360(2)(a) lists four threshold requirements for cleanup actions. All cleanup actions must:

- Protect human health and the environment

- Comply with cleanup standards

- Comply with applicable laws

- Provide for compliance monitoring

All of the eight project alternatives contained in this Feasibility Study are designed to meet these threshold requirements.

7.1.2 Other MTCA Requirements

Under MTCA, when selecting from alternatives that meet the threshold requirements, the selected action must also address the following three criteria:

- **Provide a reasonable restoration time-frame** (WAC 173-340-360(2)(b)). MTCA places a preference on those alternatives that, while equivalent in other respects, can be implemented in a shorter period of time. MTCA includes a summary of factors that can be considered in evaluating whether a cleanup action provides for a reasonable restoration time-frame (WAC 173-340-360(4)). As described in Section 7.1.4, SMS regulations place a specific preference on remedies that can be completed within a 10-year restoration time-frame.

- **Use permanent solutions to the maximum extent practicable:** MTCA specifies that when selecting a cleanup action, preference shall be given to actions that are "permanent solutions to the maximum extent practicable." The regulations specify the manner in which this analysis of permanence is to be conducted. Specifically, the regulations require that the costs and benefits of each of the project alternatives be balanced using a "disproportionate cost analysis" (WAC 173-340-360(3)(e)). The criteria for conducting this analysis are described in Section 7.1.3 below.

- **Consider Public Concerns:** Ecology considers public comment raised during the RI/FS and EIS process in making its preliminary selection of a cleanup alternative for the Site. Ecology's preliminary decision is then articulated for public review in a draft Cleanup Action Plan.

7.1.3 MTCA Disproportionate Cost Analysis

The MTCA analysis of disproportionate costs is used to evaluate whether cleanup alternatives are permanent to the maximum extent practicable. This analysis compares the relative benefits and costs of cleanup alternatives. Seven criteria are used in the disproportionate cost analysis as specified in WAC 173-340-360(3)(f):

- Protectiveness
- Permanence
- Costs
- Long-Term Effectiveness
- Short-Term Risk Management
- Implementability
- Considerations of Public Concerns

The analysis compares the relative environmental benefits of each alternative against those provided by the most permanent alternative. These benefits can be qualitative as well as quantitative. Costs are disproportionate to benefits if the incremental costs of the more permanent alternative exceed the incremental degree of benefits achieved by the other lower-cost alternative (WAC 173-340-360(e)(i)). Where the quantitative and qualitative benefits of two alternatives are equivalent, the department shall select the less costly alternative (WAC 173-340-360(e)(ii)(c)).

Additional description of each of the seven MTCA criteria used in the disproportionate cost analysis are described below consistent with WAC 173-340-360(f).

Protectiveness

Overall protectiveness is a parameter that considers many factors. First, it considers the extent to which human health and the environment are protected and the degree to which overall risks at a site are reduced. Both on-site and off-site risks resulting from implementing the alternative are considered. The parameter also expresses the degree to which the cleanup action may perform to a higher level than specific standards in MTCA. Finally, it measures the improvement of the overall environmental quality at the site.

Permanence

The permanence of remedies under MTCA is measured by the relative reduction in toxicity, mobility or volume of hazardous substances, including both the original contaminated media, and the residuals generated by the cleanup action.

Remedy Costs

The analysis of costs under MTCA includes all costs associated with implementing the alternative, including design, construction, long-term monitoring and institutional controls. Costs are intended to be comparable among different project alternatives to assist in the overall analysis of relative costs and benefits of different alternatives. Costs are evaluated against remedy benefits in order to assess cost-effectiveness and remedy practicability.

Long-Term Effectiveness

Long-term effectiveness is a parameter that expresses the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards over the long-term performance of the remedy. The MTCA regulations contain a specific preference ranking for different types of technologies that is considered as part of the comparative analysis. The preference ranking places the highest preference on technologies such as reuse/recycling, treatment, immobilization/solidification, and disposal in an engineered, lined, and monitored facility. Lower preference rankings are applied for technologies such as on-site isolation/containment with attendant engineering controls, and institutional controls and monitoring. The regulations recognize that in most cases the cleanup alternatives will combine multiple technologies to accomplish remedial objectives. The preference ranking must be considered along with other site-specific factors in the ranking of long-term effectiveness. Table 6-1 illustrates the range of technologies used with each of the alternatives, in order of the long-term effectiveness rankings under MTCA.

Short-Term Risk Management

Short-term risk management is a parameter that measures the relative magnitude and complexity of actions required to maintain protection of human health and the environment during implementation of the cleanup action. Cleanup actions carry short-term risks such as potential mobilization of contaminants during construction, or safety risks typical to large construction projects. In-water dredging activities carry a relatively high risk of problems with water quality and potential sediment recontamination. Some short-term risks can be managed through the use of best practices during project design and construction, and other risks are inherent to project alternatives and can offset long-term benefits of an alternative.

Implementability

Implementability is an overall measurement expressing the relative difficulty and uncertainty of implementing the project. It includes technical factors such as the availability of mature technologies and experienced contractors to accomplish the cleanup work. It also includes administrative factors associated with permitting and completing the cleanup.

Consideration of Public Concerns

The public involvement process under MTCA is used to identify public concerns regarding alternatives, and the extent to which an alternative addresses those concerns is considered as part of the remedy selection process. This includes concerns raised by individuals, community groups, local governments, tribes, federal and state agencies, and other organizations that may have an interest in or knowledge of the site.

7.1.4 SMS Evaluation Criteria

Remedy evaluation criteria under SMS regulations are generally the same as under the MTCA. The SMS alternatives evaluation criteria are specified in WAC 173-204-560(4)(f)-(k). Most of these SMS evaluation criteria overlap with those of MTCA. The SMS evaluation criteria include the following:

- Overall protection of human health and the environment
- Attainment of cleanup standards
- Compliance with applicable state, federal and local laws
- Short-term effectiveness

- Long-term effectiveness
- Ability to be implemented
- Cost
- The degree to which community concerns are addressed
- The degree to which recycling, reuse and waste minimization are employed
- Analysis of environmental impacts consistent with SEPA requirements

Requirements under SMS for cleanup decisions are specified in WAC 173-204-580(2)-(4). This portion of the regulation specifies factors that are to be considered by Ecology in making its cleanup decision. Most of these requirements also overlap with those of MTCA. SMS cleanup decision requirements including the following:

- Achieve protection of human health and the environment
- Comply with applicable state, federal and local laws
- Comply with site cleanup standards
- Achieve compliance with sediment source control requirements
- Provide for landowner review of the cleanup study and consider public concerns raised during review of the draft cleanup report
- Provide adequate monitoring to ensure the effectiveness of the cleanup action
- Provide a reasonable restoration time-frame
- Consider the net environmental effects of the alternatives
- Consider the relative cost-effectiveness of the alternatives in achieving the approved site cleanup standards
- Consider the technical effectiveness and reliability of the alternatives

Like MTCA, the SMS regulations include a requirement for a reasonable restoration time-frame. However, SMS includes an explicit preference for restoration time-frames that are less than 10 years (WAC 173-204-580(3)). Longer restoration time-frames may be authorized, but only where it is not practicable to accomplish the remedy within a ten-year period.

Of the SMS evaluation criteria listed above, all but two are accomplished as part of the MTCA evaluation of alternatives. The two exceptions are 1) the completion of a SEPA analysis of environmental impacts, and 2) the analysis of net environmental effects of the alternatives. These two criteria are addressed as part of the companion Draft Supplemental EIS document. That document assesses environmental impacts of the remedial alternatives. Net environmental effects as defined under SMS are also captured by this analysis. Because the EIS document addresses specific SMS regulatory requirements it is considered an integral part of the analysis of alternatives. However, the information contained in that document is not repeated in this section, to avoid unnecessary redundancy. Other SMS criteria are addressed within the scope of the MTCA evaluation criteria.

7.2 Detailed Evaluation of Alternatives

Table 7-1 summarizes the detailed evaluation of each of the eight remedial alternatives against the MTCA and SMS criteria listed in Section 7.1. For each of the eight remedial alternatives, these findings are discussed below. Section 7.3 then conducts a MTCA disproportionate cost analysis and identifies the preferred remedial alternatives under MTCA.

7.2.1 Alternative 1

Alternative 1 uses containment, monitored natural recovery and institutional controls to comply with SMS cleanup levels and MTCA cleanup requirements It makes the least use of active remedial technologies of all of the evaluated alternatives. Alternative 1 is illustrated in Figure 6-1.

MTCA Threshold Requirements

Alternative 1 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 1 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 1 will comply with the cleanup standards described in Section 3.1. For the portion of the inner Whatcom Waterway that does not currently meet cleanup standards and that will be allowed to naturally recover, the cleanup standards will be met at the end of the recovery period. Recovery modeling would need to be performed to verify that the recovery period will not exceed 10 years.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup

Action Plan and Consent Decree. Land use issues associated with the ASB and waterfront areas would need to be considered as part of the ongoing land use planning process.

- **Provisions for Compliance Monitoring:** Alternative 1 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery.

Restoration Time-Frame

The restoration time-frame for Alternative 1 is relatively long among the evaluated alternatives, and may exceed the SMS preference for a restoration time-frame less than 10 years. Between 1 and 2 years will be required for final alternative design and permitting. The construction period for the active phase of remediation is relatively short, requiring a single construction season. However, additional time (between 5 and 10 years) will be required for natural recovery of sediments within the Inner Whatcom Waterway area. The total restoration time-frame is estimated at between 6 and 12 years.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven factors. Factors relevant to the disproportionate costs analysis are discussed below, and are summarized in Table 7-1. The disproportionate cost analysis, comparing the costs and benefits of all project alternatives, is performed in Section 7.3.

- **Overall Protectiveness:** The overall protectiveness of Alternative 1 relies solely on the use of containment, monitored natural recovery processes and institutional controls. Incremental protections present in the other alternatives are not used. Natural recovery is used both to comply with cleanup levels (i.e., to achieve compliance with cleanup standards in areas not currently meeting those standards) as well as to maintain protection in previously-recovered areas.

- **Permanence:** Alternative 1 does not reduce the toxicity or volume of contaminated sediments. The alternative uses only containment, natural recovery and institutional control technologies. All impacted sediments and ASB sludges are managed in place, and no effort is made to integrate the cleanup with area navigation and land use planning, resulting in significant potential for future anthropogenic re-exposure of contaminated sediments.

- **Costs & Cost-Effectiveness:** Alternative 1 is the least costly of the evaluated Alternatives. Cleanup costs are $8 million, compared to costs of $21 to $146 million for the other evaluated alternatives.

Remedy cost-effectiveness is achieved by minimizing the use of higher-cost, high-preference technologies (Appendices A and B).

- **Long-Term Effectiveness:** Alternative 1 uses institutional controls, monitored natural recovery and containment to achieve cleanup levels. Long-term effectiveness of this alternative is not as high as other alternatives that use higher-preference cleanup technologies such as removal, treatment, disposal and reuse/recycling. The effectiveness of monitored natural recovery as the sole remedial strategy for Whatcom Waterway areas may conflict with navigation uses. For example, concerns about sediment re-exposure from propeller wash may prohibit navigation and dock or float construction in some areas of the waterway. Other alternatives evaluated directly address navigation issues in the waterway with active remedial measures that accommodate anticipated navigation uses and shoreline development actions. The effective depth of the Waterway will vary with location. The long-term effectiveness of Alternative 1 will require verification modeling as part of remedial design, and will require appropriate institutional controls to be established as part of the Cleanup Action Plan and project implementation activities.

- **Short-Term Risk Management:** Because Alternative 1 has the least construction activity, it has the lowest level of short-term risks. The construction activities are limited to capping of the ASB sludges, enhancements to the Log Pond cap, and capping of two areas (Unit 5-B and Unit 6-B&C) of impacted sediments. Short-term risks under this alternative would be managed using appropriate construction techniques for cap application, water quality monitoring, and construction safety provisions. These management practices would be defined as part of remedial design and permitting. Work timing would be established in appropriate "fish windows" to avoid impacts to juvenile salmonids.

- **Implementability:** From a technical standpoint, Alternative 1 is readily implementable. The alternative uses capping technologies that are readily available, with experienced contractors available locally and nationally. However, the regulatory implementability of the alternative would depend on development of appropriate institutional controls in the Whatcom Waterway to address residual sediments managed by natural recovery. Such controls could adversely impact navigation uses in some areas. These impacts are discussed as part of the Draft Supplemental EIS.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on previous public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include 1) the conflicts between the Alternative and planned land uses at the ASB, the Inner Whatcom Waterway and at the Bellingham Shipping Terminal, 2) the reliance of Alternative 1 solely on low-cost, low-preference technologies to achieve compliance with cleanup levels, 3) the longer restoration time-frame and lower certainty associated with using monitored natural recovery to comply with cleanup levels in navigation areas of the Whatcom Waterway.

7.2.2 Alternative 2

Alternative 2 uses monitored natural recovery, institutional controls and containment technologies to comply with SMS cleanup levels and MTCA cleanup requirements. However, unlike Alternative 1, dredging of sediments from within the Whatcom Waterway is conducted. That dredging is conducted consistent with the 1960s industrial channel dimensions. Dredged sediments are managed in a new Confined Aquatic Disposal (CAD) facility that would be developed offshore of the Cornwall Avenue Landfill. The Cornwall CAD site location was selected during the 2000 EIS after evaluation of potential alternative locations. The remedial alternative design concept for Alternative 2 is shown in Figure 6-2.

MTCA Threshold Requirements

Alternative 2 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 2 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 2 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using active containment measures including in-place capping, as well as dredging with containment in a newly-constructed CAD facility. Alternative 2 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery is applied only in areas that already comply with cleanup standards.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan and Consent Decree, and as part of project implementation. Land use issues associated with the ASB and waterfront areas would need to be considered as part of the ongoing land use planning process. The alternative involves the creation of a new sediment disposal site within shoreline areas. Project design and permitting would need to address water quality protection and other short-term and long-term risks associated with the CAD site development.

- **Provisions for Compliance Monitoring:** Alternative 2 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery. Additional monitoring costs are allocated for the CAD site.

Restoration Time-Frame

The restoration time-frame for Alternative 2 will be determined by the start-date of construction and the duration of work activities. As described above, the construction in shoreline areas of the Inner Whatcom Waterway will need to be integrated with shoreline redevelopment actions in order to coordinate sediment dredging with shoreline infrastructure upgrades. Such activities would require substantial funding investments by local property owners and/or local governments, and would also involve substantial design and permitting requirements. As a result, the start-date for construction would likely be at least 2-5 years from the time of Consent Decree approval. Construction activities would likely be completed within 4 years. Therefore, the restoration time-frame for this alternative is estimated at between 6 and 9 years.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The overall protectiveness of Alternative 2 is achieved through the use of active measures, and is improved over that achieved by Alternative 1. The dredging and capping in the Whatcom Waterway improves the protectiveness in this area, by reducing the potential that navigation uses in this area will resuspend residual subsurface sediments. Subsurface sediments will remain capped in some berth and waterway areas, but these remaining areas will be contained with a cap, designed to resist prop wash and to be stable under anticipated wind and wave conditions.

- **Permanence:** Alternative 2 does not reduce the toxicity or volume of sediments or ASB sludges remaining on the waterfront. The alternative does consolidate the sediments dredged from the Whatcom Waterway in a CAD facility, and Waterway navigation areas are deepened and capped, reducing the potential for future anthropogenic resuspension of contaminated sediment. This results in a greater degree of permanence than that in Alternative 1. But conflicts with planned aquatic uses of the ASB are not addressed under this alternative, resulting in a lower degree of permanence for this area of the site than in other evaluated alternatives (i.e., Alternatives 5 through 8).

- **Remedy Costs & Cost-Effectiveness:** The probable cost of Alternative 2 ($34 million) is substantially more costly than Alternative 1 (Appendices A and B). However, it is similar in cost to Alternatives 3 through 6. The increased costs of alternative 2 are associated with the active capping, sediment dredging, CAD site development, and additional long-term monitoring of the CAD facility.

- **Long-Term Effectiveness:** Alternative 2 uses a combination of institutional controls, monitored natural recovery and containment to achieve cleanup levels. However, all sediment areas that do not currently meet cleanup levels, and the navigation areas of the Whatcom Waterway are remediated using active measures. Long-term effectiveness of this alternative is higher than Alternative 1, because the removal and capping of sediments in the Whatcom Waterway reduces the potential for impacted sediments to be exposed to aquatic organisms, including benthic organisms, fish and marine mammals. Most Waterway sediments are consolidated in the CAD facility. Residual sediments not removed from the Waterway are contained by a thick sediment cap, providing a barrier against sediment resuspension and aquatic organism exposure. The alternative does not use off-site disposal, treatment or recycling which are the highest-preference technologies under MTCA preference rankings. Alternative 2 provides for a dredge depth in the federal channel consistent with the 1960s federal channel designation, but the effective water depth in berth areas will depend on investments of shoreline property owners and coordination of Waterway cleanup with development actions in those areas. As with all of the alternatives evaluated in the Feasibility Study, Alternative 2 will require appropriate institutional controls to be established as part of the Cleanup Action Plan and project implementation activities.

- **Short-Term Risk Management:** Alternative 2 involves extensive construction activities in most portions of the site. Project design and permitting will need to address appropriate construction activities and safety precautions to manage short-term risks. In particular, dredging activities in the Waterway areas will need to use appropriate environmental dredge methods to minimize water quality impacts at the point of dredging. Sediment transportation and placement at the CAD site will need to prevent adverse water quality impacts. At the conclusion of each dredging season, appropriate measures will need to be taken to stabilize the CAD site and minimize exposure of wildlife and fisheries resources prior to completion of the CAD in the fourth construction season. The other construction activities of Alternative 2 are similar to those of Alternative 1 and include the capping of the ASB sludges, enhancements to the Log Pond shoreline, and capping of two areas (Unit 5-B and Unit 6-B&C) of impacted sediments. Work in all site areas other than the ASB would be conducted in appropriate "fish windows" to avoid impacts to juvenile salmonids.

- **Implementability:** From a technical standpoint, Alternative 2 is fully implementable. Alternative 2 uses capping, dredging and other construction technologies that are readily available, with experienced contractors available locally and nationally. Regulatory implementability is also favorable, as evidenced by the general support of the Cornwall CAD alternative during the 2000 RI/FS and EIS process. The project is complex, and project permitting and logistical considerations will need to be addressed during project design and permitting. However, the principal implementation challenges for Alternative 2 are associated with land use conflicts. First, the 1960s federal channel boundaries and associated shoreline use restrictions and infrastructure requirements conflict with planned mixed-use redevelopment and habitat enhancements. Second, implementation of Alternative 2 will require complex coordination of Waterway dredging with required shoreline infrastructure investments.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on previous public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include: 1) DNR concerns about locating the CAD facility on state-owned aquatic lands, 2) potential permitting concerns with the proposed CAD site construction, 3) conflicts between the planned mixed-use redevelopment and habitat enhancements along the Inner Whatcom Waterway and the requirements of Alternative 2 for industrial shoreline infrastructure and associated land uses. The use of the Cornwall CAD site to optimize the management of dredged materials received generally favorable response during the 2000 EIS process, completed prior to many of the recent land use changes affecting the Bellingham waterfront.

7.2.3 Alternative 3

Alternative 3 uses a combination of institutional controls, monitored natural recovery and containment to achieve compliance with SMS cleanup levels. Alternative 3 uses dredging to remove sediments from the Whatcom Waterway consistent with the dimensions of the 1960s federal navigation channel. These dredged sediments are then managed by creating a nearshore fill within the majority of the ASB. The portion of the ASB not required for the fill would be retained for stormwater or cooling water treatment uses. Alternative 3 is shown in Figure 6-3.

MTCA Threshold Requirements

A comparison of Alternative 3 against applicable MTCA threshold criteria is provided below. This information is summarized in Table 7-1.

If appropriately designed and permitted, Alternative 3 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment:** Alternative 3 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 3 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using active containment measures including in-place capping, as well as dredging with containment in an ASB nearshore fill. Design and permitting of the nearshore fill will require appropriate evaluations to ensure compliance with groundwater and surface water cleanup standards. Appropriate institutional controls within the fill area will provide for long-term maintenance of the fill. Alternative 3 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery is applied only in areas that already comply with cleanup standards.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan and Consent Decree and project implementation measures. Land use issues associated with the ASB and waterfront areas would need to be considered as part of the ongoing land use planning process.. The alternative involves the creation of a new sediment disposal site within shoreline areas. Project design and permitting would need to address water quality protection and other short-term and long-term risks associated with the CAD site development..

- **Provisions for Compliance Monitoring:** Alternative 3 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery. Additional monitoring costs are allocated for the ASB fill site.

Restoration Time-Frame

The restoration time-frame for Alternative 3 will be determined by the start-date of construction and by the duration of work activities. As described above, the construction in shoreline areas of the Inner Whatcom Waterway will need to be integrated with shoreline redevelopment actions in order to coordinate sediment dredging with shoreline infrastructure upgrades. Such activities would require substantial funding investments by local property owners and governments, and would also involve substantial design and permitting requirements. As a result, the start-date for construction would likely be at least 2-5 years from the time of Consent Decree approval. Construction activities would likely be completed within 3 years. Therefore, the restoration time-frame for this alternative is estimated at between 5 and 8 years.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The overall protectiveness of Alternative 3 is achieved through the use of active measures. The dredging and capping in the Whatcom Waterway improves the protectiveness in this area, by reducing the potential that navigation uses in this area will resuspend residual subsurface sediments. Subsurface sediments would remain in some berth and waterway areas where full removal is not feasible, but these areas would be contained with a cap, designed to resist prop wash and to be stable under anticipated wind and wave conditions.

- **Permanence:** Alternative 3 does not reduce the toxicity or volume of sediments or ASB sludges remaining on the waterfront. However, Waterway navigation areas are deepened and capped, reducing the potential for future anthropogenic resuspension of contaminated sediment, and the alternative does consolidate the sediments dredged from the Whatcom Waterway and from the outer portion of the ASB within the ASB fill site. This results in a greater degree of permanence than that in Alternative 1. But conflicts between planned aquatic uses of the ASB are not addressed under this alternative, resulting in a lower degree of permanence for this area of the site than in other evaluated alternatives (i.e., Alternatives 5 through 8).

- **Remedy Costs and Cost-Effectiveness:** The probable cost of Alternative 3 ($34 million) is approximately the same as that for Alternative 2 (Appendices A and B). The cost is substantially greater than that of Alternative 1. However, it is similar in cost to Alternatives 3 through 6, and substantially less than Alternatives 7 and 8.

- **Long-Term Effectiveness:** Alternative 3 uses a combination of institutional controls, monitored natural recovery and containment to achieve cleanup levels. However, all sediment areas that do not currently meet cleanup levels, and the navigation areas of the Whatcom Waterway are remediated using active measures. Long-term effectiveness of this alternative is higher than Alternative 1, because the removal and capping of sediments in the Whatcom Waterway reduce the potential for impacted sediments to be exposed to aquatic organisms. Most Waterway sediments are consolidated in the ASB facility. Residual sediments not removed from the Waterway are contained by a thick sediment cap, providing a barrier against sediment resuspension and aquatic organism exposure. The alternative does not use off-site disposal, treatment or recycling which are the higher-preference technologies under MTCA preference rankings. Alternative 3 provides for a dredge depth in the federal channel consistent with the 1960s federal channel designation. The effective water depth in berth areas will depend on investments of shoreline property owners and coordination of Waterway cleanup with development actions in those areas. As with all of the alternatives evaluated in the Feasibility Study, Alternative 3 will require appropriate institutional controls to be established as part of the Cleanup Action Plan and project implementation activities.

- **Short-Term Risk Management:** Alternative 3 involves extensive construction activities in the Waterway and harbor areas, but the sediment disposal facility is constructed within the ASB berms,. The ASB berms reduce the short-term construction risks associated with the disposal site over Alternative 2. Project design and permitting will need to address appropriate construction activities and safety precautions to manage short-term risks. In particular, dredging activities in the waterway areas will need to use appropriate environmental dredge methods to minimize water quality impacts at the point of dredging, and sediment transportation and placement at the ASB fill site will need to prevent adverse water quality impacts. If hydraulic dredging is selected for use with the ASB fill, then the management of produced dredge waters will need to ensure protection of water quality within Bellingham Bay at the point of discharge. The other construction activities of Alternative 3 are similar to those of Alternatives 1 and 2. Work timing in all site areas other than the initial and final activities within the ASB would be established in appropriate “fish windows” to avoid impacts to juvenile salmonids.

- **Implementability:** From a technical standpoint, Alternative 3 is fully implementable. The alternative uses capping, dredging and other construction technologies that are readily available, with experienced contractors available locally and nationally. Administrative implementability would be subject to land-owner approval of the ASB as a future sediment disposal site, which use is in conflict with plans for aquatic reuse of this area. The project involves the creation of a new sediment disposal site within shoreline areas, which may be inconsistent with the provisions of the existing City of Bellingham Shoreline Master Program. As with Alternative 2, the implementation of Alternative 3 will require significant coordination of cleanup activities with infrastructure investments along the Inner Whatcom Waterway shoreline.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on previous public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include: 1) concern over the creation of a new nearshore fill site on the Bay, 2) desire by some commenters for alternatives that removed impacted materials including the ASB sludges from the waterfront, 3) inconsistency of the alternative with planned aquatic reuse of the ASB, and 4) conflicts between the dredging plan for the Inner Whatcom Waterway and planned land use and habitat enhancements in this area. Public comments received during previous RI/FS and EIS activities that were generally supportive of Alternative 3 include 1) favoring of the ASB nearshore fill because it reduced the level of in-water construction activities otherwise required at the Cornwall CAD site, and 2) favoring of the ASB nearshore fill because the alternative did not create a new disposal site on state-owned aquatic lands.

7.2.4 Alternative 4

Alternative 4 is the first of the evaluated alternatives that uses upland disposal at a Subtitle D landfill facility rather than on-site containment for management of dredged sediments. Alternative 4 also uses institutional controls, monitored natural recovery and containment to comply with SMS cleanup levels. Under

Alternative 4, Waterway dredging is performed consistent with the multi-purpose channel dimensions (refer to discussion in Section 4.2.2) and ASB sludges are capped in place. Alternative 4 is shown in Figure 6-4.

MTCA Threshold Requirements

A comparison of Alternative 4 against applicable MTCA criteria is provided below. This information is also summarized in Table 7-1. Alternative 4 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 4 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 4 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using removal and upland disposal, combined with active containment measures including thick sediment capping. Alternative 4 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery is applied only in areas that already comply with cleanup standards.

- **Compliance with applicable state & federal laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan and Consent Decree. Land use issues associated with the Waterway modifications would be considered as part of the ongoing land use planning process, project design and permitting and the site institutional controls framework.

- **Provisions for Compliance Monitoring:** Alternative 4 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery.

Restoration Time-Frame

The restoration time-frame for Alternative 4 will be determined predominantly by the start-date of construction. As described above, the construction activities can likely be completed within approximately 1 year. The project will involve significant design and permitting issues, but will not be subject to delays associated with funding, design and permitting of shoreline redevelopment actions as under Alternative 2 or 3. Approximately 2 years is assumed for completion of design and permitting. Therefore, the restoration time-frame for this alternative is estimated at between 3 and 4 years.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The overall protectiveness of Alternative 4 is achieved through the use of active measures. It is higher than that of Alternative 1, and similar to that of Alternatives 2 and 3. The dredging and capping in the Whatcom Waterway ensures protectiveness in this area, by reducing the potential that navigation uses in this area will resuspend residual subsurface sediments. The establishment of consistent waterway depths and stable side-slopes reduces risks of recontamination from future construction activities or shoreline erosion. Subsurface sediments would remain in some berth and Waterway areas, but these areas would be contained with a thick cap, designed to resist prop wash and to be stable under anticipated wind and wave conditions.

- **Permanence:** Alternative 4 reduces the volume of sediments remaining on the waterfront, managing these dredged sediments by upland disposal at off-site permitted Subtitle D facilities. Waterway navigation areas are deepened and capped, and shorelines are stabilized consistent with current land use planning for this area, reducing the potential for future anthropogenic resuspension of contaminated sediments. This results in a greater degree of permanence than that in Alternatives 1 through 4. However, the alternative uses containment for management of the ASB sludges, resulting in conflicts between planned aquatic uses of the ASB and this alternative. The permanence of Alternative 4 is lower than that of other evaluated alternatives (i.e., Alternatives 5 through 8).

- **Remedy Costs and Cost-Effectiveness:** The probable cost of Alternative 4 ($21 million) is lower than that of Alternatives 2 and 3 which have similar degrees of permanence (Appendices A and B). Alternative 2 is the least costly of the alternatives incorporating sediment disposal in an off-site, permitted, Subtitle D facility.

- **Long-Term Effectiveness:** Alternative 4 uses a combination of institutional controls, monitored natural recovery, containment and Subtitle D disposal to achieve cleanup levels. All sediment areas that do not currently meet cleanup levels and the navigation areas of the Whatcom Waterway are remediated using active measures. However, the long-term effectiveness of the alternative is not as high as other alternatives that make greater use of Subtitle D disposal. Residual sediments not removed from the Waterway are contained by a thick sediment cap, providing a barrier against sediment resuspension and aquatic organism exposure. The alternative does not use treatment or recycling which are the highest preference technologies under MTCA preference rankings. As with all of the alternatives evaluated in the Feasibility Study, Alternative 4 will require appropriate institutional controls to be established as part of the Cleanup Action Plan and project implementation activities.

- **Short-Term Risk Management:** Alternative 4 involves a moderate level of in-water construction activities. Project design and permitting will need to address appropriate construction activities and safety precautions to manage short-term risks. In particular, dredging activities in the waterway areas will need to use appropriate environmental dredge methods to minimize water quality impacts at the point of dredging, and at sediment offloading locations. Stormwater controls will need to be applied for upland sediment staging areas. The use of rail for shipment of sediments to the disposal site will minimize traffic impacts and associated risks. The other construction activities of Alternative 2 are similar to those of Alternative 1 and include the capping of the ASB sludges, enhancements to the Log Pond cap, and capping of two areas (Unit 5-B and Unit 6-B&C) of impacted sediments. Work timing in all site areas other than the ASB would be established in appropriate "fish windows" to avoid impacts to juvenile salmonids.

- **Implementability:** From a technical standpoint, Alternative 4 is fully implementable. The alternative uses capping, dredging, and common transportation and disposal technologies that are readily available, with experienced contractors available locally and nationally. The dredging and shoreline stabilization concepts applied in the Inner Whatcom Waterway areas under this Alternative are consistent with land use, navigation and habitat enhancement planning for this area. Alternative 4 provides for reduced shoreline infrastructure requirements relative to Alternatives 2 and 3, greatly simplifying and expediting project implementation. However, the capping of the ASB sludges under Alternative 4 conflicts with the planned aquatic reuse of this area.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include: 1) conflicts between capping of the ASB and planned aquatic reuse of this area, and 2) a desire by some commenters for greater use of upland disposal for management of contaminated sediments and ASB sludges. The alternative is anticipated to be generally consistent with pubic land use priorities for the Inner Whatcom Waterway and Bellingham Shipping Terminal areas.

7.2.5 Alternative 5

Alternative 5 uses multiple technologies to comply with SMS cleanup levels. Removal, treatment for volume reduction, and upland disposal are used for ASB sludges. The remediated ASB is then reconnected with the surface waters of Bellingham Bay, and clean berm materials are reused as part of the cleanup action in other areas of the site. Waterway dredging is conducted consistent with the multi-purpose channel concept (refer to discussion in Section 4.2.2), with dredged sediments managed by upland disposal. Institutional controls, monitored natural recovery and containment are used in various portions of the site. Alternative 5 is shown in Figure 6-5.

MTCA Threshold Requirements

A comparison of Alternative 5 against applicable MTCA criteria is provided below. This information is summarized in Table 7-1. Alternative 5 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 5 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 5 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using removal, treatment and upland disposal, combined with active containment measures including thick sediment capping. Alternative 5 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery is applied only in areas that already comply with cleanup standards.

- **Compliance with Applicable State & Federal Laws**: **Assuming** compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan and Consent Decree. Land use issues associated with the Waterway modifications would be considered as part of the ongoing land use planning process, project design and permitting and the site institutional controls framework.

- **Provisions for Compliance Monitoring:** Alternative 5 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery.

Restoration Time-Frame

The restoration time-frame for Alternative 5 will be determined by both the start-date of construction and the duration of construction activities. The project will involve significant design and permitting issues, but will not be subject to delays associated with funding, design and permitting of shoreline redevelopment actions as under Alternative 2 or 3. Approximately 2 years is assumed for completion of design and permitting. Construction activities will likely require 3 to 4 years for completion. Therefore, the restoration time-frame for this alternative is estimated at between 5 and 6 years.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The protectiveness of Alternative 5 is achieved through the use of active measures. Dredging, treatment and upland disposal at off-site, permitted Subtitle D facilities are used for remediation of the ASB, increasing the level of overall protectiveness of this Alternative relative to Alternatives 1 through 4. The dredging, capping and shoreline stabilization actions in the Whatcom Waterway ensures protectiveness in this area, by reducing the potential that navigation uses in this area will resuspend residual subsurface sediments. The establishment of consistent waterway depths and stable side-slopes reduces risks of recontamination from future construction activities or shoreline erosion. Subsurface sediments would remain in some berth and waterway areas, but these areas would be contained with a cap, designed to resist prop wash and to be stable under anticipated wind and wave conditions.

- **Permanence:** Alternative 5 removes the ASB sludges, the most impacted of the contaminated materials requiring remediation. These sediments will be treated to reduce their volume prior to disposal. Removal of the ASB sludges increases the permanence of this Alternative. Sediments dredged from the Waterway areas will be managed by dredging and upland disposal. Low-level impacted sediments within deeper portions of the waterway will be managed by in-place containment, using a thick cap to ensure long-term protection of aquatic organisms. Alternative 4 has greater consistency with area land use, navigation and habitat enhancement planning than Alternatives 1 through 4, further increasing remedy permanence.

- **Remedy Costs and Cost-Effectiveness:** The probable costs of Alternative 5 ($42 million) are higher than those of Alternatives 1 through 4 (Appendices A and B). The higher costs of this alternative are principally associated with the removal, treatment and disposal of the ASB sludges. Alternative 5 is the lowest cost alternative that includes removal of the ASB sludges from the waterfront. The costs of Alternative 5 are similar to those of Alternative 6, and substantially less than those of Alternatives 7 and 8.

- **Long-Term Effectiveness:** Alternative 5 uses a hybrid remedy including a full range of remedial technologies. Those technologies include recycling, treatment, upland disposal, containment, natural recovery and institutional controls. All sediment areas that do not currently meet cleanup levels, and the navigation areas of the Whatcom Waterway are remediated using active measures. Residual sediments not removed from the Waterway are contained by a thick sediment cap, providing a barrier against sediment resuspension and aquatic organism exposure. By removing the ASB sludges, Alternative 5 allows for recycling of the clean ASB berm materials. A portion of the material is used as part of the capping and shoreline stabilization under the Alternative, and additional materials will be available and may be used in subsequent habitat enhancement and/or redevelopment actions. As with all of the alternatives evaluated in the Feasibility Study, Alternative 5 will require appropriate institutional controls to be established as part of the Cleanup Action Plan and project implementation activities.

- **Short-Term Risk Management:** Alternative 5 involves a complex, three-phase construction sequence. However, only the first and third phases of construction take place within the aquatic environment. The second phase of construction will take place within the ASB, prior to opening of the ASB berm. This will reduce the short-term risks to the extent possible. Project design and permitting will need to address appropriate construction activities and safety precautions to manage short-term risks. Dredging activities in the Waterway areas will need to use appropriate environmental dredge methods to minimize water quality impacts at the point of dredging, and at sediment offloading locations. Stormwater controls will need to be applied for upland sediment staging areas. The use of rail for shipment of sediments to the disposal site will minimize traffic impacts and associated risks. The phasing of all in-water construction activities will be timed to minimize impacts to juvenile salmonids and other aquatic organisms.

- **Implementability:** From a technical standpoint, Alternative 5 is fully implementable. The alternative uses capping, dredging, and common transportation and disposal technologies that are readily available, with experienced contractors available locally and nationally. The treatment technologies applied under this alternative are well-established methods of dewatering sludges from wastewater treatment impoundments and other sludge impoundments and have been applied during previous ASB maintenance activities by Georgia Pacific. The dredging and shoreline stabilization concepts applied in the Inner Whatcom Waterway areas under this Alternative are consistent with land use, navigation and habitat enhancement planning for this area, improving administrative implementability. Alternative 5 provides for reduced shoreline infrastructure requirements relative to Alternatives 2 and 3, greatly simplifying and expediting project implementation. Alternative 5 also remediates the ASB, enabling aquatic reuse of this area consistent with land use planning activities and land-owner objectives.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative are mainly associated with the maximizing the use of dredging and upland disposal for management of contaminated sediments. However, public comment in favor of the alternative is considered likely based on the alignment of dredging and shoreline stabilization planning for the Inner Whatcom Waterway with previous public comments regarding land use, navigation and habitat enhancement priorities for this area. Similarly, remediation of the ASB accommodates plans for aquatic reuse of this area, consistent with previous public comments and land-owner objectives. Alternative 5 also preserves the flexibility for deep draft uses at the Bellingham Shipping terminal. For these reasons, and due to the greater use of dredging and upland disposal, Alternative 5 is considered likely to address public concerns better than Alternative 4.

7.2.6 Alternative 6

Cleanup Alternative 6 is in most respects the same as Alternative 5. The difference between the alternatives, is that under Alternative 6 additional dredging is conducted adjacent to the Bellingham Shipping Terminal. Other features of the Alternative, including the cleanout of the ASB and the remedial approach to the Inner Whatcom Waterway and Harbor areas are the same as in Alternative 5.

MTCA Threshold Requirements

A comparison of Alternative 6 against applicable MTCA criteria is provided below. This information is summarized in Table 7-1. As with Alternative 5, Alternative 6 complies with all MTCA threshold criteria.

- **Protection of Human Health and the Environment**: Alternative 6 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 6 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using removal, treatment and upland disposal, combined with active containment measures including thick sediment capping. Alternative 6 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery is applied only in areas that already comply with cleanup standards.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan and Consent Decree and project implementation steps. Land use issues associated with the Waterway modifications would be addressed as part of the ongoing land use planning process, project design and permitting and the site institutional controls framework.

- **Provisions for Compliance Monitoring:** Alternative 6 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery.

Restoration Time-Frame

The restoration time-frame for Alternative 6 is estimated to be the same as for Alternative 5. Approximately 2 years will be required for design and permitting of the cleanup. Construction activities will occur in three phases and will take approximately 3 to 4 years to complete. The total restoration time-frame is therefore estimated at 5 to 6 years from the date of the Consent Decree.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The protectiveness of Alternative 6 is slightly higher than that of Alternative 5. The increased protectiveness is obtained by increasing removal and upland disposal in deep draft navigation areas near the Bellingham Shipping Terminal. Other aspects of the remedy are the same as Alternative 5.

- **Permanence:** Alternative 6 removes the ASB sludges, the most impacted of the contaminated materials requiring remediation. These sediments will be treated to reduce their volume prior to disposal. Sediments dredged from the Waterway areas will be managed by dredging and upland disposal. Low-level impacted sediments within the Inner Whatcom Waterway that do not conflict with future navigation uses will be managed by in-place containment. The consistency of Alternative 6 with area land use, navigation and habitat enhancement planning increases the permanence of this remedy relative to Alternatives 1 through 4, which do not exhibit this land use consistency.

- **Remedy Costs and Cost-Effectiveness:** The probable costs of Alternative 6 are $44 million, slightly higher than those of Alternative 5, and significantly greater than those of Alternatives 1 through 4. The additional costs (in comparison to Alternative 5) are associated with the greater use of dredging and upland disposal for sediment management under this alternative (Appendices A and B).

- **Long-Term Effectiveness:** Alternative 6 uses a hybrid remedy with a full range of remedial technologies. Those technologies include recycling, treatment, upland disposal, containment, natural recovery and institutional controls. All sediment areas that do not currently meet cleanup levels, and the navigation areas of the Whatcom Waterway are remediated using active measures. Residual sediments not removed from the Waterway are contained by a thick sediment cap, providing a barrier against sediment resuspension and aquatic organism exposure. Alternative 6 also provides for reuse of clean berm materials from the ASB for capping and habitat enhancement activities.

- **Short-Term Risk Management:** Alternative 6 involves additional dredging near the Bellingham Shipping Terminal, over that provided in Alternative 5. The additional dredging slightly increases the degree of short-term risk associated with the cleanup alternative. However, the incremental risks can be managed through appropriate design and construction practices and design of the cleanup to accommodate geotechnical and structural integrity limitations at the Bellingham Shipping Terminal.

- **Implementability:** From a technical and administrative standpoint, Alternative 6 is fully implementable. Most project elements are the same as Alternative 5. Consistency of Alternative 6 with area land use planning for the Whatcom Waterway and for the ASB enhance remedy implementability in comparison with Alternatives 1 through 4 which do not share this consistency. The differences in dredge elevations at the Shipping Terminal increase the technical complexity of the project, but facilitate long-term management of the deep draft Waterway areas.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative are mainly associated with the maximizing the use of dredging and upland disposal for management of contaminated sediments. Public comment in favor of the Alternative 6 is considered likely based on the alignment of dredging and shoreline stabilization planning for the Inner Whatcom Waterway with previous public comments regarding land use, navigation and habitat enhancement priorities for this area. Similarly, remediation of the ASB accommodates plans for aquatic reuse of this area, consistent with previous public comments and land-owner objectives. Alternative 6 also provides additional contaminated sediment removal in the vicinity of the Bellingham Shipping terminal in comparison to Alternatives 4 and 5. Alternative 6 is considered likely to address public concerns better than Alternatives 4 and 5.

7.2.7 Alternative 7

Alternative 7 uses the same technologies as Alternatives 5 and 6 to comply with cleanup levels. These include institutional controls, monitored natural recovery, containment, removal and disposal, treatment and reuse & recycling. Unlike Alternatives 5 and 6, Alternative 7 dredges sediments from the Inner Whatcom Waterway consistent with the 1960s industrial channel. Alternative 7 is shown in Figure 6-7.

MTCA Threshold Requirements

A comparison of Alternative 7 against applicable MTCA criteria is provided below. This information is also summarized in Table 7-1. Alternative 7 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 7 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 7 complies with the cleanup standards described in Section 3.1. Cleanup standards are addressed using removal, treatment and upland disposal, combined with active containment measures including thick sediment capping. Alternative 7 does not use monitored natural recovery for areas that remain above applicable cleanup standards. Monitored natural recovery and institutional controls are applied only in areas that already comply with cleanup standards for surface sediments.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan, Consent Decree and project implementation. Land use issues associated with the Waterway dredging and required shoreline infrastructure upgrades would be considered as part of the ongoing land use planning process, project design and permitting and the site institutional controls framework.

- **Provisions for Compliance Monitoring:** Alternative 7 provides for compliance monitoring in cap areas and in areas addressed through monitored natural recovery.

Restoration Time-Frame

The restoration time-frame for Alternative 7 will be determined by both the start-date of construction and the sequence and duration of construction activities. The project will involve significant design and permitting issues, and will require coordination between the cleanup activities and the development of shoreline infrastructure improvements along the Inner Whatcom Waterway. The period required for design and permitting is estimated at between 3 to 5 years, including the integrated infrastructure planning. Construction activities are estimated to require 4 years to complete. The project construction activities would be completed in three phases, similar to Alternative 6, but in-water work activities would be required in all three construction phases, not just during the first and third. The additional in-water construction period is required to provide for dredging and shipment of the incremental sediment volume under Alternative 7. The total restoration time-frame for Alternative 7 is therefore estimated at between 7 and 9 years from the date of the Consent Decree.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The protectiveness of Alternative 7 is achieved through the use of active measures. Dredging, treatment and upland disposal in an off-site, permitted Subtitle D facility are used for remediation of the ASB area. Dredging in areas of the Whatcom Waterway is expanded under the alternative to support full dredging of the 1960s industrial channel, including in the Inner Waterway area. This dredging removes some additional impacted material from the Waterway, with capping of residual sediments at elevations 5 feet below the historical channel depths. This additional removal provides additional deepening of the area that can be used for navigation, though residual sediments with similar contaminant levels will remain under both alternatives, and the concentrations of sediment constituents in those residuals are already low relative to other materials (ASB sludges) removed under Alternatives 5 and 6. The benefits of additional contaminant removal are also offset by the increased levels of short-term risk, and by the negative impacts to land use and habitat conditions in the Waterway. Management of areas outside of the Whatcom Waterway is identical to that under Alternatives 5 and 6, with no change in overall protectiveness in these areas.

- **Permanence:** Alternative 7 provides some additional reduction in the total volume of subsurface sediments remaining within the site. However, the additional materials removed under the alternative are relatively low in contaminant concentrations. Further, the alternative provides no significant reductions in site areas that are subject to capping, future monitoring or institutional control requirements.

- **Remedy Costs and Cost Effectiveness:** The probable costs of Alternative 7 ($74 million) are significantly greater than those of Alternative 6 ($44 million) or any of the preceding alternatives. They are roughly half of the cost of the most expensive alternative (Alternative 8, $145 million) evaluated in the Feasibility Study (Appendices A and B). Relative to Alternative 6, the additional costs of Alternative 7 are associated with the additional volume of contaminated sediment managed by dredging and upland disposal in order to achieve a final channel depth consistent with the historic industrial channel dimensions in the Inner Whatcom Waterway. These remedy costs do not include the additional costs associated with development of shoreline infrastructure in the Inner Whatcom Waterway (bulkheads, wharves and hardened shorelines) in order to access berth-area contamination and utilize water depths.

- **Long-Term Effectiveness:** Alternative 7 uses a greater degree of upland disposal than the preceding alternatives. However, like the preceding alternatives, the remedy relies on institutional controls, monitored natural recovery and containment to achieve cleanup levels. The overall footprint of these containment and institutional control areas is not significantly reduced, and the incremental degree of contaminant concentration reduction achieved for the residual sediments is small relative to that achieved by the preceding alternatives. For these reasons, the long-term effectiveness of Alternative 7 is considered similar to that of Alternative 6. The long-term effectiveness of Alternative 7 will also be affected by the coordinated matching of shoreline infrastructure to dredging patterns in the Waterway. If these actions are not coordinated, then the side-slopes of the Waterway will not be stable or usable for navigation, and the potential for waterway recontamination to occur will be greater.

- **Short-Term Risk Management:** Alternative 7 involves an increase in the in-water construction activities required for Waterway cleanup. A third in-water construction season will be required to complete dredging in the Waterway. This increases by 50% the level of short-term risks that must be managed under the alternative. Project design and permitting will need to address appropriate construction activities and safety precautions to manage short-term risks. Dredging activities in the waterway areas will need to use appropriate environmental dredge methods to minimize water quality impacts at the point of dredging, and at sediment offloading locations. Stormwater controls will need to be applied for upland sediment staging areas. The use of rail for shipment of sediments to the disposal site will minimize traffic impacts and associated risks. The phasing of all in-water construction activities will be timed to during the appropriate "fish windows" to avoid impacts to juvenile salmonids and other aquatic organisms.

- **Implementability:** As with Alternatives 2 and 3, the implementability of Alternative 7 will depend primarily on the ability to coordinate cleanup dredging with upgrades to shoreline infrastructure in the Inner Waterway. Given the transition in area land uses that has been occurring and the current plans for development of mixed-uses and habitat enhancements along the Inner Waterway area, it is unlikely that the infrastructure investment and use limitations required to fully dredge and maintain the 1960s federal channel will be forthcoming. This issue is discussed further as part of the companion EIS document.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on previous public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include: 1) desires by some commenters to increase the use of dredging and upland disposal beyond that used in Alternative 7, 2) concerns about conflicts between planned area land uses and the proposed dredging patterns and infrastructure requirements for the Inner Whatcom Waterway, and 3) concerns about destruction of emergent shallow-water habitat at the head and along the sides of the Inner Whatcom Waterway.

7.2.8 Alternative 8

Alternative 8 manages most site cleanup areas through sediment removal and upland disposal. The Alternative uses the same range of technologies evaluated for Alternatives 5, 6 and 7 to comply with SMS cleanup levels. However, the extent of dredging and upland disposal is expanded under Alternative 8 relative to the preceding alternatives. Alternative 8 conducts removal and upland disposal for ASB sludges, and for sediments dredged from the Whatcom Waterway 1960s industrial channel. In addition, Alternative 8 also removes sediments located in outlying portions of the site, including areas addressed by capping and monitored natural recovery under other alternatives. Alternative 8 is shown in Figure 6-8.

MTCA Threshold Requirements

A comparison of Alternative 8 against applicable MTCA criteria is provided below. This information is summarized in Table 7-1. Alternative 8 complies with MTCA threshold criteria, as do the other alternatives evaluated in the Feasibility Study.

- **Protection of Human Health and the Environment**: Alternative 8 protects human health and the environment by complying with applicable cleanup standards.

- **Compliance with Cleanup Standards:** Alternative 8 complies with the cleanup standards described in Section 3.1, primarily through the use of dredging and upland disposal. The use of capping and institutional controls is limited to management of residual contamination beneath the planned dredge depth in the Inner Whatcom Waterway.

- **Compliance with Applicable State & Federal Laws:** Assuming compliance with appropriate project design and permitting requirements this alternative will comply with applicable state and federal laws. Institutional controls will be addressed as part of the final Cleanup Action Plan, Consent Decree and project implementation actions. Land use issues associated with the Waterway dredging and required shoreline infrastructure upgrades would be considered as part of the ongoing land use planning process, project design & permitting, and the site institutional controls framework.

- **Provisions for Compliance Monitoring:** Alternative 8 provides for compliance monitoring in areas where removal of all sediments is not practicable, and capping of residual sediments is likely to be required.

Restoration Time-Frame

The restoration time-frame for Alternative 8 is relatively long due to the extensive design and permitting, and due to the anticipated duration of site construction activities. It is likely that the restoration time-frame will exceed the SMS preference for a restoration time-frame less than 10 years. The total restoration time-frame is estimated to be between 8 and 13 years from the date of the Consent Decree.

MTCA Evaluation Criteria

The MTCA disproportionate cost analysis includes comparative analysis of seven criteria. Issues relevant to the disproportionate costs analysis are discussed below, and are listed in Table 7-1.

- **Overall Protectiveness:** The protectiveness of Alternative 8 is achieved primarily through the aggressive use of removal and upland disposal. Alternative measures are used only in limited areas. This remedy represents the most permanent remedy evaluated in the Feasibility Study, and represents the initial remedy against which other alternatives are compared in the analysis of disproportionate cost analysis (Section 7.3). The use of institutional controls and containment is still required under this alternative. The additional sediments removed under Alternative 8 (relative to preceding alternatives) are obtained from outlying site areas have the lowest contaminant concentrations of all site materials. Many of the benefits of further reductions in residual sediment concentrations and volumes are offset by the extensive increase in short-term risks associated with the construction of the remedy. Benefits of additional contaminant removal are also offset by the negative impacts to land use and habitat conditions within the project area as discussed in the Draft Supplemental EIS. The overall protectiveness of Alternative 8 is considered similar to that of Alternative 7.

- **Permanence:** Alternative 8 provides the greatest reduction in the total volume of subsurface sediments remaining within the site, and makes the greatest use of permanent solutions of any alternatives evaluated in the Feasibility Study. It therefore provides the basis for evaluation of the relative costs and benefits of the other alternatives in the analysis of disproportionate costs (Section 7.3).

- **Remedy Costs and Cost Effectiveness:** The probable costs of Alternative 8 ($146 million) are the highest of the eight evaluated alternatives (Appendices A and B). The costs are roughly twice those of the second most costly alternative (Alternative 7, $74 million). The incremental costs are associated with the costs of using dredging and upland disposal rather than capping, monitored natural recovery and institutional controls for management of contaminated sediments outside of the Whatcom Waterway. As with Alternative 7, the costs of Alternative 8 exclude the costs of providing additional shoreline infrastructure in the Inner Whatcom Waterway (bulkheads, wharves and hardened shorelines) in order to access berth-area contamination and utilize water depths.

- **Long-Term Effectiveness:** Alternative 8 uses a greatest degree of dredging and upland disposal of all of the evaluated alternatives. The long-term effectiveness of the alternative is therefore considered to be high, due to the increased use of high-preference remediation technologies as defined under MTCA. The Alternative also provides the smallest areas requiring containment and institutional controls. The long-term effectiveness of Alternative 8 depends in part on the matching of shoreline infrastructure in the Inner Whatcom Waterway to dredging patterns. If these actions are not coordinated, then the side-slopes of the Waterway will not be stable or usable for navigation, and the potential for waterway recontamination to occur will be greater.

- **Short-Term Risk Management:** Alternative 8 involves the greatest in-water construction and the greatest level of short-term risks requiring management. Work activities will take place over the course of 5 to 7 construction seasons, with in-water construction during each of those seasons. Project design and permitting for this alternative will have the greatest challenge to control construction risks throughout the project life-cycle.

- **Implementability:** As with Alternatives 2, 3, and 7 the implementability of Alternative 8 will depend primarily on the ability to coordinate cleanup dredging with upgrades to shoreline infrastructure in the Inner Whatcom Waterway. Given the significant conflicts between the waterway dredging plan and the planned mixed-use redevelopment and nearshore habitat enhancements in this area, it is unlikely that the infrastructure investment and land use restrictions required to fully dredge and maintain the 1960s federal channel will be forthcoming. This conflict may pose implementation problems for this remedy. The very high cost and the significant duration of the project also create concerns regarding the ability to fully implement this alternative. The implementability of this alternative is considered less than that of Alternative 7.

- **Consideration of Public Concerns:** Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns relative to this Alternative. Based on previous public concerns noted during earlier RI/FS, EIS and land use planning activities, potential public concerns relevant to this alternative include: 1) concerns about conflicts between planned area land uses and the proposed dredging patterns and infrastructure requirements for the Inner Whatcom Waterway, and 2) concerns about destruction of emergent shallow-water habitat at the head and along the sides of the Inner Whatcom Waterway. Conversely, Alternative 8 is likely to appeal to commenters who desire the maximum use of removal and upland disposal technologies as part of the site cleanup, and for whom costs and land use conflicts are less of a concern.

7.3 MTCA Disproportionate Cost Analysis

As discussed in Section 7.1.3, MTCA requirements for remedy selection include the requirement to use permanent solutions to the maximum extent practicable. Permanent cleanup actions are defined under MTCA as those in which cleanup standards can be met without further action being required.

MTCA defines that the evaluation of whether or not a cleanup action uses permanent solutions to the "maximum extent practicable" should be based on a disproportionate cost analysis, consistent with the requirements of WAC 173-340-360(e). In that analysis, cleanup alternatives are arranged from most to least permanent, based on the criteria contained in WAC 173-340-360(f).

The disproportionate cost analysis then compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. The assessment of benefits can be qualitative as well as quantitative. Costs are disproportionate to benefits if the incremental costs of the more permanent alternative exceed the incremental degree of benefits achieved by the other lower-cost alternative (WAC 173-340-360(e)(i)). Alternatives which exhibit such disproportionate costs are considered "impracticable".

Where the quantitative and qualitative benefits of two alternatives are equivalent, MTCA specifies that department shall select the less costly alternative (WAC 173-340-360(e)(ii)(c)).

The analysis of disproportionate costs is performed below, using the information from Section 7.2 and Table 7-1. First, the alternatives are compared to the most permanent remedial alternative evaluated (Alternative 8), and the benefits of each alternative are ranked under the criteria of the disproportionate cost analysis (WAC 173-340-360(f)). Then in Section 7.3.2, the costs are compared against these benefits and the relationship between costs and benefits determined. This analysis then defines which alternatives represent the most permanent, practicable alternatives under MTCA.

7.3.1 Comparative Evaluation of Alternatives

The evaluation of disproportionate cost is based on a comparative analysis of costs against six other criteria. Relative rankings of each alternative for these six criteria are summarized in Table 7-2. These rankings are summarized below.

Overall Protectiveness

Overall protectiveness is a parameter that considers many factors. First, it considers the extent to which human health and the environment are protected and the degree to which overall risks at a site are reduced. Both on-site and off-site risks resulting from implementing the alternative are considered. The parameter also expresses the degree to which the cleanup action may perform to a higher level than specific standards in MTCA. Finally, it measures the improvement of the overall environmental quality at the site.

The overall protectiveness of Alternative 1 relies solely on the use of containment and natural recovery processes. Incremental protections present in the other alternatives are not used. Natural recovery is used both to comply with cleanup levels (i.e., to achieve compliance with cleanup standards in areas not currently meeting those standards) as well as to maintain protection in previously-recovered areas. Navigation activities in Waterway areas could trigger sediment recontamination events under this Alternative. Based on these factors, the overall protectiveness of Alternative 1 receives a low ranking.

Overall protectiveness rankings for Alternatives 2, 3 and 4 are medium. These Alternatives use active measures to address contamination within the Waterway. These measures improve protectiveness substantially relative to Alternative 1, by removing the sediments from the navigation channel areas where anthropogenic disturbances are considered likely to occur. However, Alternatives 2 and 3 both involve extensive deep dredging within the Inner Whatcom Waterway beyond that necessary to remove this re-exposure risk, and both involve creation of new sediment disposal sites on the waterfront with their own long-term management risks. Short-term construction risks associated with the deep dredging and disposal site creation reduce the overall protectiveness of Alternatives 2 and 3. These types of risks are described in detail below (see Short-Term Risk Management), and include risks to water quality, risks of sediment recontamination, and safety risks associated with implementation of a large and complex construction project. Further, these alternatives do not make use of upland disposal, a high-preference remedial strategy under MTCA. Alternative 4 uses upland disposal in off-site, permitted Subtitle D disposal facilities for management of dredged materials generated from the Waterway, rather than creation of a new disposal site. However, Alternative 4 does not use this technology to the extent applied under other Alternatives, and does not apply this technology to the ASB sludges, the most contaminated of the remaining materials requiring cleanup.

The overall protectiveness rankings for Alternatives 5 and 6 are high. Like Alternatives 2, 3 and 4, these alternatives remove contaminated sediments from areas of the Whatcom Waterway where the potential for re-exposure of contaminated materials due to navigation or land use conflicts is considered significant. The protectiveness of Alternatives 5 and 6 is further enhanced by the removal of the ASB sludges from the waterfront. These are the most heavily impacted materials requiring cleanup. Alternatives 5 and 6 use active measures to manage remediation in the Waterway. The establishment of consistent waterway depths and stable side-slopes reduces risks of recontamination from future construction activities or shoreline erosion. Subsurface sediments would remain at depth in some berth and waterway areas, but these areas would be contained with a thick cap, designed to resist prop wash and to be stable under area wind and wave conditions. The protectiveness of Alternative 6 is slightly higher than Alternative 5, because removal and upland disposal is expanded in deep draft navigation areas of Unit 1-C.

The overall protectiveness of Alternative 7 is also high, but on balance is not significantly higher than that provided by Alternatives 5 and 6. The Alternative makes extensive use of active remediation, and aggressive use of off-site disposal. Dredging in areas of the Whatcom Waterway is expanded under the alternative to full deep dredging of the 1960s federal channel. This dredging removes some additional impacted material from the Waterway. This additional removal provides little in the way of additional risk reduction, because the deep sediment is not at risk of re-exposure (due to its depth below planned navigation uses), and because the contamination levels are relatively low in the additional materials removed under Alternative 7. Residual sediments would remain under Alternative 7, as with Alternatives 5 and 6. Under Alternative 7, the deep dredging of the 1960s industrial channel requires integration of shoreline infrastructure improvements in order to ensure the stability of resulting shoreline side-slopes. The benefits of additional contaminant removal are also partially offset by the increased levels of short-term risk due to the additional dredging activity. Short-term risks are discussed further below.

Alternative 8 also receives a high ranking for overall protectiveness. Alternative 8 makes the most aggressive use of dredging and upland disposal. Other technologies are used only sparingly. However, the benefits of further reductions in residual sediment concentrations and volumes are offset by the extensive increase in short-term risks associated with the construction of the remedy. This alternative would require between 5 and 7 in-water construction seasons to complete dredging. Because the additional subsurface sediments removed under Alternative 8 have the lowest constituent concentrations of all site materials, the incremental removal activities of this alternative result in no significant improvement in overall protectiveness over Alternatives 5 and 6. The use of institutional controls and containment is still required under this alternative.

Permanence

Alternatives 1, receives a low ranking for remedy permanence. Alternative 1 makes the least use of active remedial measures. Monitored natural recovery is used to address remaining contaminated areas within the Whatcom Waterway navigation areas, and the cleanup does not address local navigation and land use needs. The result is that residual contaminated sediments would remain in locations and at elevations where the potential for future contaminated sediment re-exposure is considered significant. Additionally, Alternative 1 conducts no volume reduction or consolidation. All sediments are managed in place under this alternative. Engineering controls applied under other alternatives are not applied in the Waterway navigation areas, resulting in lower levels of remedy permanence, and a greater potential for contaminant disturbance through prop wash or other anthropogenic disturbances.

Alternatives 2 and 3 are ranked medium for permanence. These technologies do not reduce receive high rankings for permanence because they do not reduce the toxicity or volume of sediments remaining on the waterfront, and because they do not make extensive use of high-preference remedial technologies as defined under MTCA. Alternatives 2 and 3 involve extensive dredging within the Whatcom Waterway, but these dredged materials are not removed from the waterfront. These materials are managed by containment on-site within either a Cornwall CAD facility or an ASB nearshore fill. The targeted dredging depth is well below the anticipated needs of navigation and land use. This should avoid the potential future re-exposure of contaminated sediments, provided that remedial activities are coordinated with the upgrades to shoreline infrastructure required to stabilize the project shorelines during and after dredging. Under these alternatives, the ASB sludges remain in place and are managed either by containment beneath a sediment cap, or by containment within the ASB nearshore fill. Aquatic reuse of the ASB is precluded under these alternatives as part of the engineering and institutional controls for containment of the ASB sludges.

Alternative 4 is ranked medium for permanence. Like Alternatives 2 and 3, Alternative 4 removes contaminated sediment from areas and depths of the Whatcom Waterway where conflicts with navigation and land use plans may potentially result in future re-exposure of contaminated sediments. However, unlike preceding alternatives, the dredged materials generated from this action are managed by upland disposal in an off-site permitted Subtitle D facility. This reduces the overall quantity of contaminated sediments managed on-site, while avoiding the creation of a new disposal facility on the waterfront. The permanence ranking for this alternative is not as high as in Alternatives 5, 6, 7 and 8, because these other alternatives include removal of the ASB sludges, the materials with the highest residual contaminant concentrations compared to SMS cleanup levels.

Alternatives 5, 6 and 7 are each ranked medium for permanence. Permanence of these alternatives is significantly higher than for Alternatives 2, 3 and 4. However, they do not carry the removal of contaminated sediments to the logical extreme as in Alternative 8, which removes the most contaminated sediments and sludge from the waterfront of any of the evaluated alternatives. Therefore, the permanence of these alternatives is considered medium, in relation to Alternative 8. Each of these alternatives provides substantial reductions in the volume of impacted sediments and sludges remaining on the waterfront. Alternatives 5 and 6 complete the removal of the ASB sludges, the most heavily impacted materials remaining in the site cleanup areas. This removes conflicts between planned aquatic reuse of this area, and reduces the potential that contaminated sludges are re-exposed in the future. The sludges are managed using high-preference remedial technologies, with treatment to reduce volumes, and subsequent disposal in an off-site permitted Subtitle D facility. These alternatives also remove low-level sediments that are present in Waterway navigation areas to support the implementation of a multi-purpose waterway. This action removes contaminated sediments from the areas where re-exposure may occur due to conflicts with navigation and land-use planning. Alternative 7 removes additional quantities of these low-level waterway sediments from areas and depths beyond those required to accommodate planned navigation and land uses, aggressively dredging the Waterway based on the dimensions of the 1960s industrial navigation channel. Because these sediments additionally removed under Alternative 7 contain only low-level contamination, and because they are located at depths and locations unlikely to be re-exposed in the future, this additional removal does not substantially increase the permanence of the alternative over that in Alternatives 5 and 6.

Alternative 8 is ranked high for the parameter of permanence, because it makes the greatest use of dredging and upland disposal of any of the evaluated remedial alternatives. This additional volume reduction does not significantly enhance overall protectiveness relative to Alternatives 5, 6 or 7 because the additional removal is targeted at low-level contaminated sediments located in outlying site areas. The removal of this high-volume, low-concentration materials is not expected to affect residual surface sediment concentrations after completion of the remedy, and the removal is not required to prevent re-exposure of contaminated sediments due to navigation or land use conflicts. Further, the removal of these materials provides the least incremental benefit in terms of the mass of contaminant removal achieved, due to the low average concentration of contaminants in these materials. However, because

Alternative 8 makes the greatest use of high-preference removal technologies, it receives the highest ranking for remedy permanence.

Long-Term Effectiveness

Long-term effectiveness is a parameter that expresses the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards over the long-term performance of the remedy. The MTCA regulations contain a specific preference ranking for different types of technologies that is considered as part of the comparative analysis. The preference ranking places the highest preference on technologies such as reuse/recycling, treatment, immobilization/solidification, and disposal in an engineered, lined, and monitored facility. Lower preference rankings are applied for technologies such as on-site isolation/containment with attendant engineering controls, and institutional controls and monitoring. The regulations recognize that in most cases the cleanup alternatives will combine multiple technologies to accomplish remedial objectives. The preference ranking must be considered along with other site-specific factors in the ranking of long-term effectiveness.

The alternatives evaluated in this Feasibility Study were organized in Table 6-1 in order of increasing use of high-preference technologies and overall long-term effectiveness. Alternatives 1, 2 and 3 use only containment, monitored natural recovery and institutional controls to comply with cleanup objectives. Alternative 1 receives a low long-term effectiveness ranking (Table 7-2) because the alternative makes the least use of active remedial measures. The long-term effectiveness of this alternative is subject to additional verification through natural recovery modeling as part of Cleanup Action Plan development and project design and permitting.

Alternatives 2 and 3 also utilize only containment, monitored natural recovery and institutional controls to comply with cleanup objectives. However, long-term effectiveness of these Alternatives is ranked medium rather than low, because these alternatives consolidate some of the sediments in containment facilities, rather than using only in-place containment, and because contaminated materials are removed from areas of the Whatcom Waterway where such materials might be re-exposed due to land use and navigation conflicts under Alternative 1.

Alternative 4 introduces the use of disposal in a lined, engineered facility, a technology that receives a higher preference-ranking than containment under MTCA criteria. Like Alternatives 2 and 3, Alternative 4 removes contaminated sediments from areas of the Whatcom Waterway where these sediments may be re-exposed due to land use and navigation conflicts. The dredging pattern is integrated with land use planning efforts, and shoreline stabilization is performed as part of the cleanup, reducing the potential for contaminant re-exposure due to shoreline instability or due to conflicts with separate infrastructure projects. The long-term effectiveness ranking for

Altenrative 4 is medium rather than high, because removal and disposal technologies are not applied to the ASB sludges, the most-contaminated materials remaining. Land use conflicts in the ASB area are not addressed, resulting in a continued potential for re-exposure of the sludge materials in the future.

Alternatives 5, 6, 7 and 8 all earn high rankings for long-term effectiveness. Alternatives 5 and 6 conduct extensive use of upland disposal in a Subtitle D landfill facility. Removal and disposal is expanded to include the ASB sludges, the most contaminated materials remaining on the waterfront. In addition, treatment of ASB sludges is performed as part of the sludge removal under this Alternative. Finally, these alternatives enable clean berm materials from the ASB to be reused as part of cleanup activities. The use of these disposal, treatment and reuse technologies is carried forward in Alternatives 7 and 8, so these Alternatives also receive the high ranking for long-term effectiveness.

Short-Term Risk Management

Short-term risk management is a parameter that measures the relative magnitude and complexity of actions required to maintain protection of human health and the environment during implementation of the cleanup action. Cleanup actions carry risks associated with mobilization of contaminants and also safety risks typical to large construction projects. In-water dredging activities carry a relatively high risk of problems with water quality and potential sediment recontamination. In some situations the short-term risks of a dredging action can offset the long-term benefits of sediment removal. Other short-term risks associated with construction activities must be controlled through the use of best practices during project design and construction.

The lowest rankings for short-term risk management are earned by Alternative 8. While this alternative has the highest permanence rankings, the same actions that produce this high ranking for permanence trigger short-term risks that must be managed during project implementation. Specifically, this alternative makes the greatest use of dredging technology, which carries with it a significant risk of water quality and recontamination impacts. Alternative 8 is estimated to require between 5 and 7 construction seasons to complete in-water dredging. This alternative also involves deep dredging within the Inner Whatcom Waterway which must be integrated with shoreline infrastructure upgrades in order to maintain stability of project area shorelines.

Medium rankings are applied to Alternatives 2, 3 and 7. These alternatives include between two and four construction seasons for in-water dredging and construction. Alternative 2 involves the creation of a new in-water disposal site near the Cornwall Avenue landfill that adds complexity to this Alternative and that will likely extend the overall construction duration to 4 seasons. All three alternatives require the integration of deep dredging within the Inner

Whatcom Waterway with shoreline infrastructure upgrades in order to maintain stability of adjacent shorelines.

High rankings for short-term risk management are applied to Alternatives 1, 4, 5 and 6. Alternatives 1 and 4 involve the least in-water construction activities. The capping and dredging associated with these alternatives is expected to be completed within a single construction season. Note however that the high short-term risk-management ranking for Alternative 1 is offset by low long-term effectiveness, permanence and overall protectiveness rankings for the same Alternative. Alternatives 5 and 6 are expected to involve two construction seasons for in-water dredging activities. Most ASB remediation activities under these Alternatives will take place prior to opening of the ASB berm, reducing the potential for water quality or recontamination impacts for this portion of the project.

Implementability

Implementability is an overall measurement expressing the relative difficulty and uncertainty of implementing the project. It includes technical factors such as the availability of mature technologies and experienced contractors to accomplish the cleanup work. It also includes administrative factors associated with permitting, funding and completing the cleanup. All of the alternatives are complex and require significant actions during design, permitting and construction to achieve a successful project. Yet all alternatives are sufficiently implementable to pass the threshold criteria under MTCA. The following rankings express the relative implementation challenges associated with each of the evaluated alternatives.

The lowest scores for implementability apply to Alternative 1 and to Alternative 8. The *technical* implementability of Alternative 1 is high, because it has the least construction activities of any of the Alternatives. However, the lack of active remedial measures for cleanup in the Whatcom Waterway and the conflicts between the alternative and planned land use, navigation and habitat restoration activities in the Whatcom Waterway result in a low *administrative* implementability. The low implementability ranking for Alternative 8 is associated with the logistical complexity of the project, and the conflicts between the dredging plan with planned land uses.

Medium implementability rankings apply to Alternatives 2, 3 and 7. These alternatives are technically implementable, but the reliance of these alternatives on dredging of the obsolete 1960s federal channel is inconsistent with current zoning and land use planning for the waterfront area. The alternatives would require substantial investments in new shoreline infrastructure that conflict with current planning for land use, navigation and habitat enhancement. The land use and navigation restrictions associated with maintenance of the federal channel to the head of the Inner Whatcom Waterway conflict with the need for a multi-purpose waterway. As with Alternative 8, the implementation of one of these three alternatives would require a reversal in land use and navigation planning, inconsistent with current requirements and community priorities. Finally, Alternatives 2 and 3 conflict with planned aquatic uses and landowner objectives for the ASB.

Alternative 4 receives a medium score for implementability. The construction activities associated with Alternative 4 are less complex than those of most of the other alternatives, and the dredging approach to the Waterway is consistent with the concept of the locally-managed multi-purpose channel. However, the alternative does not enable future aquatic use of the ASB area. This would likely lead to conflicts between the alternative and land use planning and land owner objectives for the ASB.

High implementability rankings are applied to Alternatives 5 and 6. Like the other alternatives, these actions will involve complex construction activities and will require the development of appropriate permits and institutional controls. However, the construction methods used all rely on available technologies for which experienced contractors are available within the region. The administrative implementability of these alternatives is high, because these alternatives directly address the identified community land use, navigation and habitat priorities, both in the Waterway area and also in the ASB area. The strong net gain in habitat benefits associated with these alternatives also improves the permitting implementability of Alternatives 5 and 6 relative to other project alternatives.

Consideration of Public Concerns

Public review of this RI/FS and of the companion EIS document will be used to solicit public concerns regarding the remedial alternatives and to inform Ecology's cleanup decision for the Site.

However, the analysis of remedial alternatives presented in this Feasibility Study builds on nearly 10 years of community involvement in the investigation, cleanup and redevelopment of the Bellingham Waterfront. That community involvement has taken place in a number of different forums, including but not limited to the following:

- Site-specific community involvement activities for the Whatcom Waterway site
- Community involvement efforts associated with the Bellingham Bay Demonstration Pilot
- Early land use priority setting conducted by the Waterfront Futures Group, and subsequent formal adoption of the Waterfront Futures Group land use principles by the City of Bellingham
- Land use studies conducted for the Central Waterfront area

- Master Planning efforts for the Bellingham Shipping terminal and vicinity
- Alternatives evaluations for siting of new marina facilities to meet regional moorage demand, and Port marina and waterfront infrastructure planning including community-based design charette activities
- Outreach activities conducted by the Port of Bellingham as part of the GP due diligence process during 2004 and 2005, including soliciting of extensive stakeholder and public input on potential waterfront cleanup actions, land use alternatives and navigation priorities for the Whatcom Waterway
- Community land use planning efforts planning and redevelopment of the New Whatcom area leading to rezoning of the area for mixed-use development
- Outreach activities associated with the Port's amendment to its Comprehensive Scheme of Harbor Improvements identifying the need for future aquatic use of the ASB area and associated with updates to the federal navigation channel in the Whatcom Waterway
- Extensive additional contributions by community groups, research institutions, and project stakeholders

The composite rankings listed in Table 7-2 represent an attempt to summarize the potential for each alternative to address public concerns and interests that have been raised in past public involvement activities. Given the range of opinions previously offered, including conflicting opinions from different groups, no one alternative can be 100% compliant with all community input. The rankings provided in Table 7-2 are intended to reflect on balance, how well the alternatives address the cross-section of comments received to date.

Alternative 1 receives a low ranking in reflection of three key factors. First, the alternative makes the least use of active measures to implement site cleanup, and provides the least overall protectiveness of the evaluated alternatives. Second, it is not clear that Alternative 1 would provide for planned navigation uses in and adjacent to the Waterway. Third, the alternative does not provide sufficiently for future aquatic uses of the ASB, in direct conflict with area land use planning and landowner objectives.

Alternative 2 receives a medium ranking under this criterion. The use of the Cornwall CAD site under Alternative 2 to optimize the management of dredged materials received generally favorable response during the 2000 EIS process. Based on this response, the CAD site location and design concept appears to address community concerns. State-owned land issues associated with the disposal site location would need to be addressed as part of the institutional controls for the project, and project design and permitting would need to address disposal site monitoring and other considerations. Alternative 2 receives a medium ranking because 1) it relies on dredging of the obsolete 1960s federal channel dimensions which are inconsistent with area zoning, land use actions and navigation priorities, and 2) the alternative does not provide for future aquatic uses of the ASB, in direct conflict with area land use planning. The positive habitat benefits associated with the CAD site development likely make alternative more responsive to public concerns than Alternative 3.

Alternative 3 receives a low ranking for responsiveness to public concerns. The use of the ASB site under Alternative 3 for a sediment nearshore fill received mixed comment during public comment on the 2002 Supplemental Feasibility Study (Anchor 2002). The proposal was favored by some commenters because the ASB reduced the level of in-water construction activities otherwise required at the Cornwall CAD site. The alternative also moved the location of the disposal site off of state-owned aquatic lands. However, other commenters expressed concern over the creation of a new fill site on the Bay, and expressed a desire for alternatives that removed impacted materials including the ASB sludges from the waterfront. The Port and City commented that the ASB fill proposal was inconsistent with the Shoreline Master Program and did not address future land uses for the filled areas or vicinity. In addition, area land use planning efforts identified as a priority the integrated use of the ASB for public access, habitat enhancement and marina navigation uses. As with Alternative 2, there are additional concerns related to the waterway dredging patterns proposed under Alternative 3. Specifically, the 1960s federal channel boundaries, shoreline use restrictions and infrastructure requirements are not consistent with the current mixed-use zoning, or with the land use and habitat enhancement priorities identified for the Inner Whatcom Waterway areas. These critical issues are considered to be better addressed in other alternatives evaluated in the Feasibility Study (i.e., Alternatives 4, 5 and 6).

Alternative 4 receives a medium ranking for responsiveness to public concerns. The use of the locally-managed multi-purpose Waterway concept under Alternative 4 is more consistent with the waterfront land use, navigation and habitat enhancement planning for the Inner Whatcom Waterway. However, the Alternative does not provide for future multi-purpose uses of the ASB. The ASB was identified as the preferred location for a future marina, integrating navigation, public access and habitat enhancement uses. The continued presence of the highly-impacted ASB sludges would prevent development of these uses or alternative aquatic uses. Alternative 4 uses upland disposal for management of dredged sediments, consistent with many of the comments received in previous site evaluations. However, the proportion of sediments managed by upland disposal is less than in other evaluated alternatives, and the most-impacted materials (the ASB sludges) are managed by containment-in-place.

Alternative 5 is highly responsive to community concerns that have been raised during previous cleanup and land use planning efforts and receives a high ranking. The Alternative makes extensive use of removal, treatment and upland disposal technologies for management of contaminated sludges and sediments. The locally-managed multi-purpose Waterway concept supported under Alternative 5 is consistent with the land use vision of the Waterfront Futures Group and the local land use planning process. The Alternative also provides for aquatic uses of the ASB. These uses include the development of an environmentally-sustainable marina, development of extensive shoreline public access areas, and development of new habitat enhancement features. Alternative 5 also preserves the flexibility for continued deep draft uses at the Bellingham Shipping terminal. Some commenters will likely state a desire for additional removal and upland disposal of contaminated sediments, beyond that conducted in Alternative 5.

As with Alternative 5, Alternative 6 is highly responsive to public concerns that have been raised during previous cleanup and land use planning efforts, and receives a high ranking. Extensive public comment and input from regulatory agencies and project stakeholders was used to shape this alternative during the Port's due diligence process in 2004, prior to purchase of the GP properties. The Alternative makes extensive use of removal, treatment and upland disposal technologies for management of contaminated sludges and sediments. The locally-managed multi-purpose Waterway concept supported under Alternative 6 is consistent with waterfront land use priorities. The Alternative also provides for aquatic uses of the ASB. The main incremental benefit of Alternative 6 (compared to Alternative 5) is that it removes impacted sediments to the maximum extent technically feasible within Unit 1-C, and reduces the need for capping in the portion of the Outer Whatcom Waterway adjacent to the Bellingham Shipping Terminal. As with Alternative 5, some commenters will likely state a desire for additional removal and upland disposal of contaminated sediments, beyond that conducted in Alternative 6.

Alternative 7 receives a medium ranking for consideration of public concerns. The alternative conducts a greater degree of dredging and upland disposal than does Alternative 5 or Alternative 6. Alternative 7 will likely be favored by commenters seeking a greater quantity of upland disposal for the Whatcom Waterway area. Secondly, Alternative 7 supports aquatic reuse of the ASB, consistent with local land use planning. However, the alternative will likely receive unfavorable comments relating to 1) the destruction of habitat at the head and along the sides of the Inner Whatcom Waterway, 2) concerns about the conflicts between the shoreline infrastructure requirements of this alternative and the planned land uses, navigation patterns and habitat enhancement objectives in the Inner Whatcom Waterway, 3) concerns about the high costs of the alternative. Based on these considerations, a medium ranking is included in Table 7-2 for Alternative 7.

Alternative 8 is ranked low in Table 7-2 for consideration of public concerns. Alternative 8 is likely to receive favorable comment from commenters who desire the site cleanup to maximize the use of dredging and upland disposal and minimize the use of other technologies, and who are not concerned about costs, land use impacts, short-term environmental affects or habitat impacts of the alternative. However, a variant of Alternative 8 was evaluated previously during the 2000 RI/FS and EIS process. That previous alternative was determined to be inappropriate for application, even under an industrial land use scenario. The alternative was determined by Ecology to have substantial and disproportionate costs, and did not provide the level of habitat benefits provided under the 2000 EIS preferred alternative. The dredging activity under Alternative 8 creates short-term risks and habitat disruptions that offset benefits associated with additional sediment removal. The change in area land use and the desire to incorporate public access and habitat enhancements into the Inner Whatcom Waterway create direct conflicts between the area land use priorities and Alternative 8. Alternatives 5 and 6 achieve a much higher degree of integration with area land use and habitat enhancement priorities.

7.3.2 MTCA Disproportionate Cost Analysis

Consistent with MTCA requirements for remedy selection, the costs and benefits associated with the evaluated remedial alternatives are compared using a disproportionate cost analysis. The disproportionate cost analysis compares the relative environmental benefits of each alternative against those provided by the most permanent alternative evaluated. Costs are disproportionate to benefits if the incremental costs of the more permanent alternative exceed the incremental degree of benefits achieved by the other lower-cost alternative (WAC 173-340-360(e)(i)). Alternatives which exhibit such disproportionate costs are considered “impracticable”. Where the quantitative and qualitative benefits of two alternatives are equivalent, MTCA specifies that Ecology shall select the less costly alternative (WAC 173-340-360(e)(ii)(c)).

Relationship Between Remedy Costs and Benefits

Table 7-2 summarizes for each alternative the remedy cost, as well as the remedy benefits discussed in Section 7.3.1. Appendices A and B contain a detailed cost break down for each alternative. Costs are presented based on the probable remedy costs from Figure 6-9. Detailed cost assumptions are documented in Appendices A and B of this Feasibility Study. Excluding project contingencies, the probable costs of the Alternatives range from a low value of $8 million to a high value of $146 million. These costs are expressed in 2005 dollars without adjustments for future cost inflation and without present value discounting of future costs. Actual project costs are expected to vary within a range of +/- 30% around these probable estimates, as shown in Figure 6-9.

Table 7-2 summarizes the overall benefits associated with each alternative using a composite benefit ranking. The composite ranking is shown in Section 3 of Table 7-2. The composite ranking integrates the rankings for individual evaluation criteria discussed in Section 7.3.1. The composite ranking is expressed as an average (i.e., a remedy with three low benefits rankings and three high benefits rankings is considered on average to provide a medium level of overall benefit in the composite ranking).

Consistent with MTCA requirements, the relative benefits and costs of each alternative are compared to Alternative 8. Alternative 8 makes the greatest use of high-preference remedial technologies, and represents the most permanent remedial alternative evaluated in the Feasibility Study. It therefore provides the benchmark against which the relationship between incremental remedy benefits and incremental costs are evaluated.

Alternative 8 receives an overall benefit ranking of medium. Because the alternative uses the greatest degree of dredging and upland disposal, the remedy is considered to provide high benefit rankings under overall protectiveness, permanence and long-term effectiveness. However, the alternative has low rankings for short-term risk management, implementability and consideration of public concerns. The composite ranking of medium is the same or slightly lower than that for Alternative 7, though Alternative 8 is almost twice the cost of Alternative 7. Because the costs of Alternative 8 are substantially higher than those of Alternative 7, whereas the level of benefits is the same or lower, the incremental costs of Alternative 8 are considered disproportionate.

Alternative 7 likewise receives a composite benefit ranking of medium. The alternative has high rankings for overall protectiveness and long-term effectiveness, but medium rankings for permanence, short-term risk management, implementability and consideration of public concerns. The costs of Alternative 7 are approximately $30 million greater than those of Alternative 6, though the level of benefits achieved is slightly lower than those of Alternative 6. Because the costs of Alternative 7 are substantially higher than those of Alternative 6, whereas the level of benefits is the same or lower, the incremental costs of Alternative 7 are considered disproportionate.

The composite rankings of Alternatives 5 and 6 are both high. The alternatives are ranked high for overall protectiveness, long-term effectiveness, short-term risk management, implementability and consideration of public concerns. The alternatives have medium rankings for permanence relative to Alternative 8, because they do not carry the use of dredging and disposal to the logical extreme as in Alternative 8. Costs of Alternatives 5 and 6 are $42 million and $44 million respectively. These costs are significantly higher than the next group of alternatives (Alternatives 2, 3 and 4). However, Alternatives 5 and 6 provide a higher level of benefits as measured against MTCA criteria. Therefore, the incremental costs of Alternatives 5 and 6 are not considered disproportionate.

Figure 7-1 provides graphical illustrations of the relationship between remedy costs and benefits for each of the alternatives. Remedy benefits are plotted in red using the composite rankings from Table 7-2. Probable costs from Figure 6-9 are plotted on the figure along with the other information. The substantial increase in costs between Alternatives 5 and 6 and those of Alternative 7 and 8 is readily apparent from the graph of remedy costs. Because the increases in costs are not accompanied by a corresponding increase in remedy benefits, MTCA specifies that these alternatives are impracticable, and that the lower cost alternatives should be selected. Whereas, the incremental costs associated with Alternatives 5 and 6, while higher than those of Alternatives 2-4, are accompanied by an increase in remedy benefits. Because the incremental costs of these alternatives are proportionate to increases in remedy benefits, these incremental costs are not considered disproportionate. Alternatives 5 and 6 are not considered impracticable. Because Alternatives 5 and 6 have a greater degree of overall benefit than the remaining alternatives, these alternatives are considered "permanent to the maximum extent practicable" under MTCA.

An additional way of expressing the benefits of an environmental cleanup action is to measure the quantity of contamination removed by the action. *Assuming hypothetically that all other parameters are equal between two alternatives*, an alternative that removes a greater quantity of contamination from a site can be considered to provide greater benefits. For instance, if two different remedies each removed 1 cubic yard of sediment from the site, and all other factors were identical (cost, short-term risk management, etc.), the remedy that removed sediment containing a higher contaminant concentration would be considered to be more permanent and produce greater environmental risk reduction under MTCA.

Consistent with the above-described hypothetical example, Figure 7-1 expresses the relative concentration of the sediments that are managed using containment technologies rather than removal for each of the alternatives. The relative concentration is expressed using the cumulative enrichment ratio, a measurement of all of the contaminants measured in a sample relative to their sediment cleanup standards. The enrichment ratio is plotted for the most contaminated sediment volume removed by the subsequent alternatives. Alternatives 1, 2, and 3 all use containment technology to manage contaminated sediments and ASB sludges. Therefore, the cumulative enrichment ratio remains high for each of these alternatives. Actual benefits increase from low in Alternative 1 to medium in Alternative 2 and 3 due to the other actions taken in the alternatives. Likewise, Alternative 4 is environmentally protective, but does not remove the highest-concentration materials from the waterfront. Alternatives 5 and 6 both complete removal and upland disposal of the ASB sludges, the most contaminated remaining materials. Containment technologies are used only for sediments containing lower contaminant levels. The increase in remedy costs results in a corresponding reduction in the contaminant concentrations as shown on Figure 7-1. In contrast, the incremental sediment removals performed in Alternatives 7 and 8 produce only modest further decreases in the concentration of sediments managed by containment. Most of the incremental sediment removal is directed at low-level sediment contamination located in deep-water and outlying site areas. The removal of these sediments requires a high dredging volume and corresponding high costs, but produces little additional environmental benefit.

Conclusions of Disproportionate Cost Analysis

The conclusions of the disproportionate cost analysis are summarized in the top row of Table 7-2. This analysis is central to the MTCA selection of a preferred alternative.

Alternative 1 receives a low overall preference ranking, because of its low overall protectiveness, low permanence, its poor implementability, and its poor responsiveness to community concerns. It is a low-cost alternative, but it is not sufficiently permanent as defined under MTCA to be selected as a preferred alternative. Alternative 1 is not permanent to the maximum extent practicable.

Alternatives 2, 3 and 4 receive medium overall preference rankings. These alternatives provide improved overall protectiveness and long-term effectiveness relative to Alternative 1. However, these alternatives do not provide the degree of permanence achieved by other practicable alternatives making a greater use of higher-preference technologies under MTCA. These alternatives also do not address the community concerns regarding future land use as discussed in the EIS. Alternatives 2, 3 and 4 are not considered permanent to the maximum extent practicable, and are not considered preferred alternatives under MTCA.

Alternatives 5 and 6 are identified as preferred alternatives, based on the MTCA analysis of disproportionate costs. These alternatives make the greatest use of high-preference technologies and provide the greatest remedy permanence and long-term effectiveness while remaining practicable. The high-cost dredging and removal actions performed under these alternatives are appropriately targeted at the materials that 1) have the highest constituent levels, 2) that conflict with land use and navigation needs and are likely to be disturbed in the future, 3) that can be removed safely without an excessive level of short-term risk, and 4) that consider community concerns raised during previous public involvement activities. Alternatives 5 and 6 are permanent to the maximum extent practicable under MTCA, and are identified as the preferred alternatives.

Alternatives 7 and 8 both receive low rankings, because these alternatives are impracticable. The additional removal activities conducted in Alternatives 7 and 8 expand the use of high-preference technologies, but apply these additional efforts only to subsurface sediments with low contaminant levels that are safely managed using other technologies in the preceding alternatives. As shown in Figure 7-1 the incremental costs of these alternatives are substantial and disproportionate relative to the additional degree of contaminant removal achieved and to the incremental remedy benefits achieved. Based on the environmental protections present in the other alternatives, there is no significant reduction in residual risk in Alternatives 7 and 8, despite a doubling or tripling of cleanup costs. Alternatives 7 and 8 are therefore not identified as preferred remedial alternatives, but rather are considered impracticable.

Table 7-1. Detailed MTCA Evaluation of Alternatives

Alternative Number	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Probable Cost ($Million)	$8	$34	$34	$21	$42	$44	$74	$146
Design Concept	Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Alternative Description								
Waterway Remedy								
Waterway Uses	Limited-Use: Water depths are restricted throughout the Inner and Outer Waterway. Shorelines are not stabilized as part of project.	Industrial: Whatcom Waterway is dredged consistent with dimensions of 1960s industrial channel. Uses conflict with local land use and navigation planning.	Industrial: Whatcom Waterway is dredged consistent with dimensions of 1960s industrial channel. Uses conflict with local land use and navigation planning.	Multi-Purpose: Remedy provides for continued deep draft uses in Outer Waterway. Inner Waterway is managed as multi-purpose channel consistent with planned mixed-Use redevelopment, including infrastructure and navigation planning.	Multi-Purpose: Remedy provides for continued deep draft uses in Outer Waterway. Inner Waterway is managed as multi-purpose channel consistent with planned mixed-Use redevelopment, including infrastructure and navigation planning	Multi-Purpose: Remedy provides for continued deep draft uses in Outer Waterway. Inner Waterway is managed as multi-purpose channel consistent with planned mixed-Use redevelopment, including infrastructure and navigation planning.	Industrial: Whatcom Waterway is dredged consistent with dimensions of 1960s industrial channel. Uses conflict with local land use and navigation planning.	Industrial: Whatcom Waterway is dredged consistent with dimensions of 1960s industrial channel. Uses conflict with local land use and navigation planning.
Sediment Disposal	None -- All impacted sediments are managed in place through capping and natural recovery.	Cornwall CAD: Sediments dredged from Whatcom Waterway are consolidated within a containment area constructed near Cornwall Avenue Landfill.	ASB Fill: Aquatic sediments dredged and considated along with the ASB sludges within the ASB nearshore fill.	Upland: Sediments dredged will be disposed and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: Sediments dredged will be disposed and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: Sediments dredged will be disposed and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: Sediments dredged will be disposed and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: Sediments dredged will be disposed and managed by upland disposal in a permitted off-site Subtitle D facility.
ASB Remedy								
Future Uses	Non-Aquatic: Capping of ASB sludges. Area remains isolated from Bellingham Bay.	Non-Aquatic: Capping of ASB sludges. Area remains isolated from Bellingham Bay.	Non-Aquatic: Nearshore Fill is Constructed within ASB, Converting Area Permanently to Upland Characteristics	Non-Aquatic: Capping of ASB sludges. Area remains isolated from Bellingham Bay.	Aquatic Uses: ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	Aquatic Uses: ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	Aquatic Uses: ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay	Aquatic Uses: ASB Sludges are Removed and Berm is Opened, Restoring Connection of ASB Basin with Bellingham Bay
Sludge Disposal	None: No removal of the ASB sludges will be conducted.	None: No removal of the ASB sludges will be conducted.	None: No removal of the ASB sludges will be conducted.	None: ASB sludges are managed in place through capping.	Upland: ASB sludges are removed, dewatered and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: ASB sludges are removed, dewatered and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: ASB sludges are removed, dewatered and managed by upland disposal in a permitted off-site Subtitle D facility.	Upland: ASB sludges are removed, dewatered and managed by upland disposal in a permitted off-site Subtitle D facility.
Basis for Alternative Ranking Under MTCA & SMS								
1 Compliance with MTCA Threshold Criteria [1] *(WAC 173-340-360(2)(a))*								
Protection of Human Health & Environment	Yes -- Protectiveness of Alternative 1 is contingent on ability to demonstrate compliance with cleanup standards, which requires additional modeling in remedial design.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.	Yes -- Alternative will protect human health and the environment.
Compliance with Cleanup Standards	Yes -- However, Alternative 1 is the only alternative that relies on natural recovery for cleanup of site areas that do not already compliy with cleanup goals. Requires additional modeling as part of remedial design to verify effectiveness.	Yes -- Alternative 2 is expected to comply with cleanup standards. Additional modeling in remedial design will be required for the CAD site to verify compliance with surface water criteria for groundwater discharging through fill material.	Yes -- Alternative 3 is expected to comply with cleanup standards. Additional modeling in remedial design will be required for the ASB fill site to verify compliance with surface water criteria for groundwater discharging through fill material.	Yes -- Alternative is expected to comply with cleanup standards. Active remedial measures are used in all site areas not currently complying with cleanup levels.	Yes -- Alternative is expected to comply with cleanup standards. Active remedial measures are used in all site areas not currently complying with cleanup levels.	Yes -- Alternative is expected to comply with cleanup standards. Active remedial measures are used in all site areas not currently complying with cleanup levels.	Yes -- Alternative is expected to comply with cleanup standards. Active remedial measures are used in all site areas not currently complying with cleanup levels.	Yes -- Alternative is expected to comply with cleanup standards. Active remedial measures are used in all site areas not currently complying with cleanup levels.
Compliance with Applicable State & Federal Laws	Yes -- However, Alternative 1 will affect navigation and land use planning for Whatcom Waterway, and will prevent future aquatic reuse of the ASB. Requires accomodations to be made as part of ongoing local land use planning efforts.	Yes -- However, this alternative requires the development of a new sediment disposal site which may be inconsistent with the current Shoreline Master Program. This alternative also restricts future aquatic reuse of the ASB, conflicting with local land use planning efforts. Addtionally, local planning activities will need to address the funding and construction of shoreline infrastructure and restrictions.	Yes -- However, this alternative requires the development of a new sediment disposal site which may be inconsistent with the current Shoreline Master Program. This alternative also restricts future aquatic reuse of the ASB, conflicting with local land use planning efforts. Addtionally, local planning activities will need to address the funding and construction of shoreline infrastructure and restrictions.	Yes -- Alternative complies with applicable laws and is consistent with local land use planning efforts for the Waterway. However, Alternative 4 restricts future aquatic reuse of the ASB, conflicting with local land use planning efforts.	Yes -- Alternative complies with applicable laws and is consistent with local land use planning efforts for the Waterway, ASB and Central Waterfront areas.	Yes -- Alternative complies with applicable laws and is consistent with local land use planning efforts for the Waterway, ASB and Central Waterfront areas.	Yes -- Alternative complies with applicable laws. However, local planning activities will need to address the funding and construction of shoreline infrastructure and restrictions on shoreline land uses for the Inner Waterway in order to support this alternative.	Yes -- Alternative complies with applicable laws. However, local planning activities will need to address the funding and construction of shoreline infrastructure and restrictions on shoreline land uses for the Inner Waterway in order to support this alternative.
Provision for Compliance Monitoring	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.	Yes -- Alternative includes provisions for compliance monitoring.
2 Restoration Time-Frame *(WAC 173-340-360(2)(b)(ii))*	Restoration time-frame is relatively long, at 6 to 12 years. Time-frame is contingent on performance of natural recovery in meeting cleanup levels in Inner Waterway.	Restoration time-frame is 6 to 9 years required for design and construction. Shoreline infrastructure must be upgraded in Inner Waterway in parallel with cleanup.	Medium -- Restoration time-frame is 5 to 8 years required for design and construction. Shoreline infrastructure must be upgraded in Inner Waterway in parallel with cleanup.	Restoration time-frame is 3 to 4 years required for design and construction.	Restoration time-frame is 5 to 6 years required for design and construction.	Restoration time-frame is with 5 to 6 years required for design and construction.	Restoration time-frame is 5 to 8 years for design and construction. Shoreline infrastructure must be upgraded in Inner Waterway in parallel with cleanup.	Restoration time-frame is 8 to 13 years for design and construction. Shoreline infrastructure must be upgraded in Inner Waterway in parallel with cleanup.

Table 7-1. Detailed MTCA Evaluation of Alternatives

Alternative Number	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Probable Cost ($Million)	$8	$34	$34	$21	$42	$44	$74	$146
Design Concept	Figure 6-1	Figure 6-2	Figure 6-3	Figure 6-4	Figure 6-5	Figure 6-6	Figure 6-7	Figure 6-8
Basis for Alternative Ranking Under MTCA & SMS (Cont'd)								
3 Evaluation of Permanence Using MTCA Disproportionate Cost Analysis *(WAC 173-340-360(2)(b)(i) & WAC 173-340-360(3)(f))*								
Overall Protectiveness	Protectiveness relies solely on the use of containment and natural recovery. Incremental protections present in other alternatives are not used.	Remedy uses active measures to address Waterway. However, Alternative requires creation of a new disposal site on waterfront. Alternative requires extensive shoreline infrastructure improvements to prevent shoreline instability in Inner Waterway.	Remedy uses active measures to address Waterway. However, Alternative requires creation of a new disposal site on waterfront. Alternative requires extensive shoreline infrastructure improvements to prevent shoreline instability in Inner Waterway.	Remedy uses active measures to address Waterway and uses upland disposal. However, extent of risk reduction achieved through upland disposal is not as great as in other alternatives.	Protectiveness of alternative is enhanced by the removal of ASB sludges from the waterfront. Establishment of consistent waterway depths and stable side-slopes reduces risk of recontamination and/or shoreline erosion.	Protectiveness of alternative is high, including removal of ASB sludges from the waterfront. Establishment of consistent waterway depths and stable side-slopes reduces risk of recontamination and/or shoreline erosion.	Alternative makes extensive uses of active remediation and off-site disposal. Alternative requires extensive shoreline infrastructure improvements to prevent shoreline instability in Inner Waterway.	Alternative makes greatest use of active remediation and off-site disposal. Alternative requires extensive shoreline infrastructure improvements to prevent shoreline instability in Inner Waterway.
Permanence	Remedy does not remove impacted sediments or sludges from the waterfront, and does not provide for consolidation of impacted materials.	Sediments are dredged from Waterway navigation areas. Remedy does not remove impacted sediments or sludges from the waterfront. Materials are managed by capping of ASB and partial sediment consolidation within Cornwall CAD site.	Sediments are dredged from Waterway navigation areas. Remedy does not remove impacted sediments or sludges from the waterfront. Materials are managed by consolidation within the new ASB nearshore fill.	Sediments are dredged from Waterway navigation areas. Remedy provides for some reduction in remaining sediment volumes in the Whatcom Waterway. ASB sludges are not removed from the waterfront.	Remedy provides substantial reductions in the volume of impacted sediments and sludges remaining on the waterfront. Provides for complete removal of ASB sludges. Removes impacted sediments in navigation areas of the waterway, consistent with needs of multi-purpose channel concept.	Remedy provides substantial reductions in the volume of impacted sediments and sludges remaining on the waterfront. Provides for complete removal of ASB sludges. Removes impacted sediments in navigation areas of the waterway, consistent with needs of multi-purpose channel concept.	Remedy removes ASB sludges from the waterfront. Extent of sediment removal in waterway is increased beyond that required for multi-purpose channel.	Remedy provides the greatest reduction in the volume of impacted subsurface sediments remaining on the waterfront.
Remedy Costs	$8 Million	$34 Million	$34 Million	$21 Million	$42 Million	$44 Million	$74 Million	$146 Million
Long-Term Effectiveness	Alternative 1 makes the least use of active remedial measures. Long-term effectiveness is subject to verification during remedial design.	Alternative uses only containment and institutional controls. Some increase in effectiveness achieved through sediment consolidation within the Cornwall CAD.	Alternative uses only containment and institutional controls. Some increase in effectiveness achieved through sediment consolidation within the ASB Nearshore Fill.	Application of upland disposal is limited to waterway sediments only. Most contaminated materials (ASB sludges) remain present on the waterfront.	Alternative makes extensive use of upland disposal. Dewatering treatment performed on ASB sludges. Alternative enables reuse of clean ASB berm materials.	Alternative makes extensive use of upland disposal. Dewatering treatment performed on ASB sludges. Alternative enables reuse of clean ASB berm materials.	Alternative makes extensive use of upland disposal, treatment and reuse.	Alternative makes extensive use of upland disposal, treatment and reuse.
Short-Term Risk Management	Alternative 1 involves the least in-water construction activities, with lowest anticipated short-term risks to safety and water quality.	Alternative requires four in-water construction seasons. New in-water disposal site construction adds complexity relative to other Alternatives. Deep dredging within Inner Waterway will destabilize shorelines and must be coordinated with upgrades in shoreline infrastructure.	Alternative requires two or three in-water construction seasons. Use of ASB as disposal site reduces short-term risks slightly over Alternative 2. Deep dredging within Inner Waterway will destabilize shorelines and must be coordinated with upgrades in shoreline infrastructure.	Alternative 4 involves second least in water construction activities. Waterway construction likely to be completed within single construction season. Low anticipated short-term risks to safety and water quality.	Work in Waterway and harbor areas to be completed within two construction seasons. Most ASB remediation activities to take place prior to opening of ASB berm, reducing short-term risks to water quality.	Work in Waterway and harbor areas to be completed within two construction seasons. Most ASB remediation activities to take place prior to opening of ASB berm, reducing short-term risks to water quality.	Alternative requires three to four in-water construction seasons. Extensive off-site transportation of sediments and sludges required. Deep dredging within Inner Waterway will destabilize shorelines and must be coordinated with upgrades in shoreline infrastructure.	Alternative involves between 5 and 7 construction seasons to complete in-water dredging and off-site sediment transport. Highest degree of water quality and safety risks of evaluated Alternatives. Deep dredging within Inner Waterway will destabilize shorelines and must be coordinated with upgrades in shoreline infrastructure.
Implementability	Technical implementability of alternative is high. However, Alternative 1 has low administrative implementability due to conflicts with local land use and navigation planning.	Alternative is technically implementable. However, capping of ASB and dredging plan for Inner Waterway conflict with local land use and navigation priorties. Requires extensive upgrades in waterfront infrastructure that must be coordinated with Waterway dredging.	Alternative is technically implementable. However, filling of ASB and dredging plan for Inner Waterway conflict with plans for aquatic reuse of this area. Requires extensive upgrades in waterfront infrastructure that must be coordinated with Waterway dredging.	Construction activities are less complex than most other alternatives, resulting in high technical implementability. Waterway dredging approach is consistent with local land use and navigation priorities. However, capping restricts future aquatic reuse of the ASB, in conflict with local priorities.	Construction activities are complex, but use only established technologies. Administrative implementability is high due to consistency with planned land and navigation uses. Alternative produces strong net gain in habitat benefits, enhancing permittability of alternative.	Construction activities are complex, but use only established technologies. Administrative implementability is high due to consistency with planned land and navigation uses. Alternative produces strong net gain in habitat benefits, enhancing permittability of alternative.	Alternative has greater complexity and short-term risks than Alternatives 5 and 6. Dredging plan for Inner Waterway conflicts with local land use and navigation planning. Requires extensive upgrades in waterfront infrastructure, that must be coordinated with Waterway dredging.	Alternative has greaterest complexity and short-term risks. Dredging plan for Inner Waterway conflicts with local land use and navigation planning. Requires extensive upgrades in waterfront infrastructure, that must be coordinated with Waterway dredging.
Consideration of Public Concerns	Alternative 1 conflicts with planned land use and navigation in the Whatcom Waterway and in the ASB. Alternative relies solely on low-cost, low-preference technologies to comply with cleanup levels. Remedy has longer restoration time-frame and lower level of certainty due to use of natural recovery to comply with cleanup levels in navigation areas.	Potential DNR concerns about locating new CAD facility on state-owned aquatic lands. Alternative does not remove impacted sediments or sludges for off-site disposal. Remedy for Inner Waterway conflicts with planned land uses in this area. Remedy conflicts with planned aquatic reuse of ASB. Cornwall CAD received favorable comment during 2000 EIS for dvelopment of additional nearshore habitat.	Previous concerns raised by Port and City over creation of new nearshore fill on waterfront. Alternative does not remove impacted sediments or sludges for off-site disposal. Remedy for Inner Waterway conflicts with planned land uses in this area. Remedy conflicts with planned aquatic reuse of ASB. Use of ASB fill avoids creation of new disposal site on state-owned aquatic lands as in Alternative 2. ASB fill use reduces level of in-water construction over Alternative 2.	Waterway dredging plan is consistent with priorities identified in local land use planning process. However, Alternative does not provide for aquatic reuse of ASB. Remedy removes some contaminated sediments from waterfront, but not ASB sludges.	Alternative is consistent with planned land and navigation uses, including both Waterway and ASB areas. Provides for locally-managed multi-purpose waterway, including continued deep draft capabilities in Outer Waterway. Makes extensive use of subtitle D landfill disposal.	Alternative is consistent with planned land and navigation uses, including both Waterway and ASB areas. Provides for locally-managed multi-purpose waterway, including continued deep draft capabilities in Outer Waterway. Makes extensive use of subtitle D landfill disposal, including additional dredging near Bellingham Shipping Terminal over that performed in Alternative 5.	Dredging plan for waterway conflicts with local land and navigation planning. Emergent shallow-water habitat removed at head and along sides of waterway. Remedy requires extensive new shoreline infrastructure inconsistent with land use and navigation planning. Remedy makes greater use of Subtitle D landfill disposal, but with significant additional costs.	Dredging plan for waterway conflicts with local land and navigation planning. Emergent shallow-water habitat removed at head and along sides of waterway. Remedy requires extensive new shoreline infrastructure inconsistent with land use and navigation planning. Remedy makes greater use of Subtitle D landfill disposal, but with significant additional costs.

Notes:

Refer to Table 6-2 for a detailed description of each alternative by site unit.

1: All evaluated alternatives comply with the MTCA threshold criteria, as required by regulation.

2. These alternatives involve the creation of a new sediment disposal site which may be inconsistent with the current Shoreline Master Program.

3. Additional verification modeling would be required to demonstrate the protectiveness of this alternative for waterway areas.

4. The public comment period for the RI/FS and EIS will be used to solicit public concerns. Information contained in this table represents a concise summary of signifciant comments received during past public involvement activities.

Table 7-2. Summary of MTCA Alternatives Evaluation and Ranking

Alternative Number	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Probable Cost ($Million)	$8	$34	$34	$21	$42	$44	$74	$146
Overall Alternative Ranking	Low	Medium	Medium	Medium	High	High	Low [4]	Low [4]
Alternative Description								
Waterway Remedy								
Waterway Uses	Limited-Use	Industrial	Industrial	Multi-Purpose	Multi-Purpose	Multi-Purpose	Industrial	Industrial
Sediment Disposal	None	Cornwall CAD	ASB Fill	Upland	Upland	Upland	Upland	Upland
ASB Area Remedy								
Future Uses	Non-Aquatic	Non-Aquatic	Non-Aquatic	Non-Aquatic	Aquatic	Aquatic	Aquatic	Aquatic
Sediment Disposal	None	None	ASB Fill	None	Upland	Upland	Upland	Upland
Basis for Alternative Ranking Under MTCA & SMS								
1 **Compliance with MTCA Threshold Criteria** [1] *(WAC 173-340-360(2)(a))*	Yes [3]	Yes [2]	Yes [2]	Yes	Yes	Yes	Yes	Yes
2 **Restoration Time-Frame** *(WAC 173-340-360(2)(b)(ii))*	6 to 12 yrs	6 to 9 yrs	5 to 8 yrs	3 to 4 yrs	5 to 6 yrs	5 to 6 yrs	5 to 8 yrs	8 to 13 yrs
3 **Relative Benefits Ranking for Disproportionate Cost Analysis** *(WAC 173-340-360(2)(b)(i) & WAC 173-340-360(3)(f))*	Low	Medium	Medium	Medium	High	High	Medium	Medium
Overall Protectiveness	L	M	M	M	H	H	H	H
Permanence	L	M	M	M	M	M	M	H
Long-Term Effectiveness	L	M	M	M	H	H	H	H
Short-Term Risk Management	H	M	M	H	H	H	M	L
Implementability	L	M	M	M	H	H	M	L
Consideration of Public Concerns	L	M	L	M	H	H	M	L
	L							
4 **Disproportionate Cost Analysis**								
Probable Remedy Cost ($Million)	$8	$34	$34	$21	$42	$44	$74	$146
Costs Disproportionate to Incremental Benefits	--	--	--	--	No	No	Yes	Yes
Practicability of Remedy	Practicable	Practicable	Practicable	Practicable	Practicable	Practicable	Impracticable	Impracticable
Remedy Permanent to Maximum Extent Practicable	No	No	No	No	Yes	Yes	No	No

Notes:

Refer to Table 7-1 and FS Seciton 7 for additional description of the basis for this alternatives evaluation under MTCA and SMS.

1: All evaluated alternatives comply with the MTCA threshold criteria, as required by regulation.

2. Alternatives involves creation of a new sediment disposal site which may be inconsistent with the current Shoreline Master Program.

3. Additional verification modeling would be required to demonstrate the protectiveness of this alternative for waterway areas.

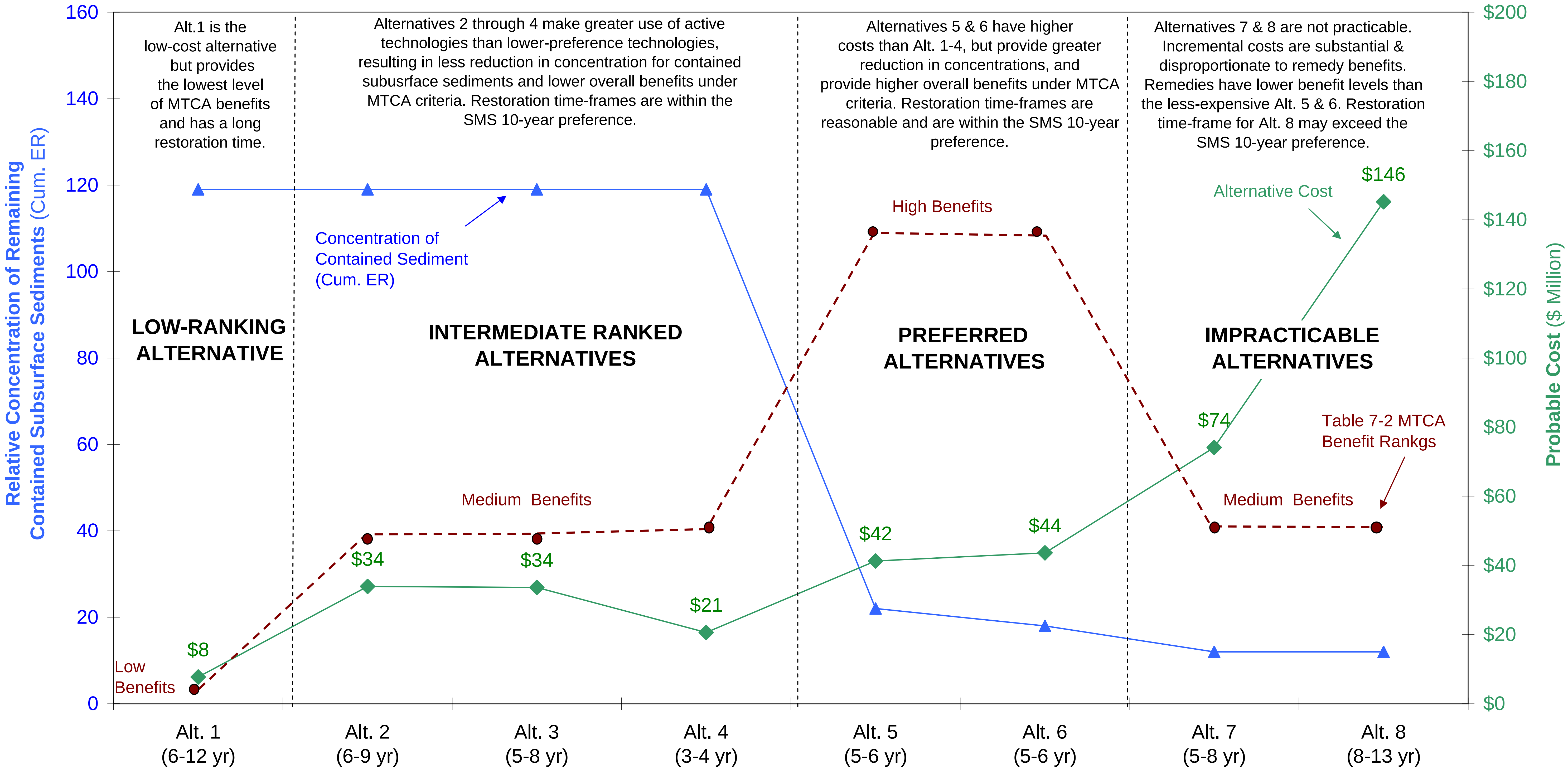
4. These alternatives are considered impracticable under MTCA, because their costs are substantial and disproportionate to the incremental benefits over the next lower-cost alternative.

5. Analysis of environmental impacts of the alternatives and of their consistency with the goals of the Bellingham Bay Demonstration Pilot is conducted in the companion EIS document. That analysis is summarized in Section 8.

Legend

- L — Low: Alternative ranks unfavorably under this criterion.
- M — Medium: Alternative ranks intermediate between high and low under this criterion.
- H — High: Alternative ranks favorably under this criterion.

Figure 7-1.
Relationship Between Remedy Costs and Benefits



Notes:

Refer to Section 7.3 of the Feasibility Study for a discussion of MTCA benefit rankings and the disproportionate cost analysis under MTCA criteria.

8 Summary of EIS Evaluation

Section 7 of this document evaluates remedial alternatives consistent with MTCA and SMS remedy selection requirements. In addition to that evaluation, the companion Draft Supplemental EIS document provides two additional evaluations of the project alternatives consistent with SEPA and Pilot criteria.

Table 8-1 summarizes the findings of the companion EIS document. Results of the SEPA analysis are summarized in Section 8.1, and the results of the Pilot analysis are summarized in Section 8.2 below.

8.1 SEPA Impacts Analysis

The first function of the EIS is to document the environmental impacts of each of the project alternatives, consistent with the requirements of SEPA regulations. Review of potential SEPA impacts of site cleanup is also required under SMS regulations.

Where the project alternatives as described in Section 6 have significant adverse impacts that can be mitigated, appropriate mitigation measures are defined in the EIS. Where project alternatives result in net adverse impacts that are integral to the alternatives and cannot be mitigated, these are identified and discussed.

8.1.1 Elements of the Environment

SEPA regulations (WAC 197-11-444) define different elements of the environment that should be considered in the development of an EIS. Following EIS scoping, the Comprehensive Strategy 1999 draft and 2000 final EIS documents organized these SEPA environmental elements into five categories. These five categories were used in analysis of remedial alternatives as part of the Supplemental EIS. The five elements of the environment included the following:

- **Geology, Water, Environmental Health:** These factors include both the natural and built environment. The geology element includes soil and sediment stability issues. The water element focuses on water quality. The environmental health element incorporates both the pollution control benefits of conducting the cleanup, as well as potential impacts/benefits associated with implementation of the cleanup itself.

- **Fish and Wildlife:** This category includes the fish and wildlife in the project area, the different existing habitats, and the potential changes (positive and negative) to those habitats that may occur as part of the cleanup.

- **Land Use, Navigation and Public Shoreline Access:** This category includes the uses of the project area, including the aquatic areas and nearby shorelines and waterfront properties. The elements within this category focus on existing community priorities that have been defined in previous and ongoing land use planning efforts, and how these priorities are either furthered or adversely impacted by the cleanup alternatives.

- **Air and Noise:** These elements address potential impacts to existing air quality and noise levels, particularly during the construction of the cleanup.

- **Cultural Resources:** Cultural resources include existing archaeological, cultural and historical resources that may be impacted by the proposed project.

Refer to Section 3 of the companion EIS document for a complete description of the affected environment. Section 4 of that document provides the complete SEPA evaluation of the remedial alternatives. Significant SEPA findings of the remedial alternatives are described below.

8.1.2 SEPA Evaluation of Alternatives

Table 8-1 summarizes the findings of the SEPA evaluation for each of the eight RI/FS alternatives. For each element of the environment, the conclusions are summarized based on the level of net impacts to the environment, and whether any adverse impacts are mitigated within the scope of the alternative as defined in Section 6. Where additional measures may be required above-and-beyond the remedial alternative as described in the RI/FS, such mitigation measures are discussed. Significant SEPA findings for the project alternatives are as follows:

- **Alternative 1:** Alternative 1 accomplishes sediment cleanup consistent with MTCA requirements. However, the cleanup actions do not stabilize project shorelines. Because residual impacted sediments are left adjacent to unstabilized project shorelines under this alternative, net adverse impacts were noted under the first SEPA category (geology, water, environmental health). Net beneficial impacts were noted under the fish and wildlife category, because Alternative 1 retains existing nearshore aquatic habitat within the Inner Whatcom Waterway, and creates a new area of improved shallow-water habitat offshore of the ASB. Under the third SEPA category (land use, navigation & shoreline public access) Alternative 1 was found to have net adverse impacts. Alternative 1 does not address land use or navigation needs within the Whatcom Waterway channel, leaving residual contaminated sediments at locations and elevations that conflict with planned waterway uses. Further, Alternative 1 conflicts with aquatic reuse plans for the ASB. Like all of the remediation alternatives, cleanup implementation will result in some impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 1 does not involve dredging within the Whatcom Waterway, minimizing the risk of disturbance of historical or cultural artifacts.

- **Alternative 2:** Alternative 2 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will including the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at $30 million, not including long-term maintenance. Alternative 2 was found to have net beneficial impacts under SEPA category 2 (fish & wildlife), through anticipated net gains in the quantity of shallow-water, nearshore habitat. Sediments removed from the Whatcom Waterway by dredging the would be managed using a new containment facility constructed near the Cornwall Avenue Landfill. The design and operation of the facility would be generally consistent with that defined in the 2000 Pilot FEIS. The containment facility is assumed under this alternative to be constructed so that the top layer of the facility remained submerged, with an elevation suitable for development of premium shallow-water habitat. This habitat would offset losses of existing nearshore aquatic habitat in the Inner Whatcom Waterway associated with dredging of the 1960s federal channel. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 2 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure are in direct conflict with planned habitat enhancements and the construction of deep draft infrastructure will be in conflict with community land use planning efforts. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. The capping in-place of the ASB sludges is in direct conflict with planned aquatic reuse of this area. The land use and navigation impacts of

Alternative 2 cannot be mitigated, but are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 2 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

- **Alternative 3:** Alternative 3 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will including the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at $30 million, not including long-term maintenance. Alternative 3 is likely to produce net adverse impacts under SEPA category 2 (fish & wildlife), through anticipated net loss in the quantity of shallow-water, nearshore habitat. Sediments removed from the Whatcom Waterway by dredging the would be managed by construction a nearshore fill within the ASB, without creation of new nearshore habitat as in Alternative 2. Some nearshore habitat is constructed offshore of the ASB, but this habitat enhancement may not be sufficient to offset losses of existing nearshore aquatic habitat in the Inner Whatcom Waterway associated with dredging of the 1960s federal channel. Additional habitat mitigation is likely to be required. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 3 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure are in direct conflict with planned habitat enhancements. and the construction of deep draft infrastructure will be in conflict with community land use planning efforts. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. The construction of the nearshore fill within the ASB is in direct conflict with planned aquatic reuse of this area. The land use and navigation impacts of Alternative 3 cannot be mitigated, but are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 3 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

- **Alternative 4:** Alternative 4 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. Unlike previous alternatives 1-3, Alternative 4 conducts remediation of the Inner Whatcom Waterway area consistent with the multi-purpose waterway concept. Capping and stabilization of Inner Whatcom Waterway shorelines will be accomplished as part of the implementation of this alternative, in a manner consistent with planned land and navigation uses in this area. Alternative 4 therefore achieves net beneficial impacts under SEPA category 1 (geology, water, environmental health). There are some habitat impacts under Alternative 4, but these are offset by habitat gains through preservation and construction of nearshore habitat. Alternative 4 produces a net beneficial impact under SEPA category 2 (fish & wildlife). Under SEPA category 3 (land use, navigation & shoreline public access), this alternative results in net adverse impacts that cannot be mitigated. The alternative avoids the deep dredging and associated shoreline infrastructure requirements of Alternatives 2 and 3, and hence avoids navigation and land use conflicts in the Inner Whatcom Waterway. However, the capping of the ASB sludges results in direct conflicts with planned aquatic reuse of this area. The land use and navigation impacts of Alternative 4 cannot be mitigated, and are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 4 will involve dredging in the Whatcom Waterway, but dredging at the head of Whatcom Waterway is minimized, increasing protection for potential historical or cultural resources. Potential impacts under SEPA category 5 can be mitigated through appropriate project design and archeological review.

- **Alternative 5:** Alternative 5 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. Like Alternative 4, this alternative conducts remediation of the Inner Whatcom Waterway area consistent with the multi-purpose waterway concept. Dredging, capping and stabilization of Inner Whatcom Waterway shorelines will be accomplished as part of the implementation of this alternative, in a manner consistent with planned land and navigation uses in this area. Alternative 5 therefore achieves net beneficial impacts under SEPA category 1 (geology, water, environmental health). There are some habitat impacts under Alternative 5, but these are offset by a substantial net gain in the quantity of nearshore habitat. In addition to the habitat improvements included in Alternative 4, Alternative 5 accomplishes remediation of the ASB, and the ASB is reconnected to the surface waters of Bellingham Bay. This increases open-water habitat by approximately 28 acres, and introduces nearly 4,500 linear feet of salmonid migration corridor in an area formerly cut off from Bellingham Bay. Alternative 5 produces a net beneficial impact under SEPA category 2 (fish & wildlife). Under SEPA category 3 (land use, navigation & shoreline public access), this alternative results in net beneficial impacts. The alternative accomplishes implementation of the multi-purpose channel concept, including deep dredging at the Bellingham Shipping Terminal, and dredging, capping and shoreline stabilization in the Inner Whatcom Waterway. Shorelines in this area are reconstructed in a manner consistent with planned mixed use redevelopment of the Inner Whatcom Waterway. Remediation of the ASB facilitates planned aquatic reuse of this area for construction of a marina with integrated public access and habitat enhancements. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 5 will involve dredging in the Whatcom Waterway, but dredging at the head of Whatcom Waterway is minimized, increasing protection for potential historical or cultural resources. Potential impacts under SEPA category 5 can be mitigated through appropriate project design and archeological review.

- **Alternative 6:** Most elements of Alternative 6 are identical to those of Alternative 5. Alternative 6 results in net beneficial impacts under the first three of the SEPA categories, and results in mitigated impacts under the fourth and fifth category. The main difference between Alternative 6 and Alternative 5 is the increased use of dredging near the Bellingham Shipping Terminal. This increased dredging is compatible with planned navigation and land uses, and does not result in requirements for new shoreline infrastructure. The deeper dredging does not trigger new habitat impacts, because the dredging is confined to deep-water areas. As a result, the additional dredging does not result in new adverse impacts under SEPA categories. In fact, the additional dredging provides additional benefits under the third SEPA category (land use, navigation & shoreline public access) by supporting potential future deepening of the Outer Whatcom Waterway, should that be required in the future.

- **Alternative 7:** Alternative 7 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will including the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at $30 million, not including long-term maintenance. Alternative 7 is likely to produce mitigated adverse impacts under SEPA category 2 (fish & wildlife), through anticipated impacts to existing shallow-water, nearshore habitat. As with Alternatives 5 and 6, nearshore habitat improvements are accomplished as part of the remediation of the ASB, and construction of a sediment cap offshore of the ASB. This additional habitat is expected to offset the destruction of nearshore habitat at the head and along the sides of the Whatcom Waterway. Additional habitat mitigation is not likely to be required under Alternative 7. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 7 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure are in direct conflict with planned habitat enhancements, and the construction of deep draft infrastructure will be in conflict with community land use planning efforts. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. These land use and navigation impacts cannot be mitigated, but are intrinsic to this alternative. Like all of the remediation alternatives, cleanup implementation will result in some adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 7 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

- **Alternative 8:** Alternative 8 is expected to comply with MTCA cleanup requirements, protecting water quality and environmental health. However, the alternative requires deep dredging within the Inner Whatcom Waterway area, which will destabilize project shorelines. This shoreline destabilization represents a net adverse impacts under SEPA category 1 (geology, water, environmental health) that will require mitigation. Mitigation will including the construction of bulkheads and hardened shoreline infrastructure to prevent shoreline collapse and permit use and maintenance of target dredge depths. Probable costs for the construction of this deep draft infrastructure are estimated at $30 million, not including long-term maintenance. Alternative 8 is likely to produce net adverse impacts under SEPA category 2 (fish & wildlife), through anticipated impacts to existing shallow-water, nearshore habitat. As with Alternatives 5 and 6, nearshore habitat improvements are accomplished as part of the remediation of the ASB. However, Alternative 8 converts nearshore habitat to deep-water habitat in areas offshore and adjacent to the ASB. These conversions represent net adverse impacts to juvenile salmonid habitat. In addition to the destruction of nearshore habitat at the head and along the sides of the Whatcom Waterway, Alternative 8 is likely to result in a net adverse impacts to fish and wildlife. Additional habitat mitigation is likely to be required under Alternative 8. Under SEPA category 3 (land use, navigation & shoreline public access) Alternative 8 is expected to result in net adverse impacts. The deep dredging and associated shoreline infrastructure requirements of this alternative are inconsistent with planned mixed-use redevelopment of the Inner Whatcom Waterway. The bulkheads and other infrastructure is in direct conflict with planned habitat enhancements in this area, and the construction of deep draft infrastructure will be in conflict with area redevelopment planning. The use restrictions associated with the 1960's federal channel also conflict with local priorities for public shoreline access and environmental enhancements in the Inner Whatcom Waterway areas. These land use and navigation impacts cannot be mitigated, but are intrinsic to this alternative. Of the evaluated remediation alternatives, implementation of Alternative 8 will result in the greatest adverse impacts under SEPA category 4 (air and noise impacts), though these can be mitigated through compliance with applicable regulatory requirements and best practices. Alternative 8 will involve dredging at the head of Whatcom Waterway, raising a potential for disturbance of historical or cultural resources (SEPA category 5). These impacts would need to be mitigated through appropriate planning, archaeological monitoring and/or other measures.

8.2 Pilot Comparative Analysis

In addition to its strict SEPA regulatory role, the EIS also evaluates each of the project alternatives for its consistency with the seven goals of the Bellingham Bay Demonstration Pilot. Consistency with these goals is not required under MTCA or SMS regulations. However, the Pilot Goals capture the results of over ten years of coordinated cleanup, source control and habitat restoration planning in Bellingham Bay. Alternatives that have a high degree of consistency with the Pilot goals are considered to provide greater overall benefits relative to the stated priorities of the Pilot team members.

8.2.1 Seven Pilot Goals

As described in the project EIS document, the Bellingham Bay Demonstration Pilot was established in 1996 with the stated mission to use a new cooperative approach to expedite source control, sediment cleanup and associated habitat restoration in Bellingham Bay. The Pilot Team included regulatory and resource agencies, the City of Bellingham, the Port of Bellingham, the Lummi Nation, the Nooksack Tribe and other key community groups and stakeholders. The Pilot included extensive community involvement and public outreach activities.

Using consensus-based decision-making, the Pilot Team established seven “baywide” goals that it wanted to ultimately achieve. The goals were formally adopted by the multi-agency work group in 1997, and these goals provide an additional benchmark against which the appropriateness of the preferred alternatives can be measured. The seven Pilot goals are as follows:

Goal 1 -- Human Health and Safety: *Implement actions that will enhance the protection of human health.*

Goal 2 – Ecological Health*: Implement actions that will protect and improve the ecological health of the bay.*

Goal 3 – Protect and Restore Ecosystems: *Implement actions that will protect, restore or enhance habitat components making up the bay’s ecosystem.*

Goal 4 – Social and Cultural Uses: *Implement actions that are consistent with or enhance cultural and social uses in the bay and surrounding vicinity.*

Goal 5 – Resource Management: *Maximize material re-use in implementing sediment cleanup actions, minimize the use of non-*

renewable resources, and take advantage of existing infrastructure where possible instead of creating new infrastructure.

Goal 6 – Faster, Better, Cheaper: *Implement actions that are more expedient and more cost-effective, through approaches that achieve multiple objectives.*

Goal 7 – Economic Vitality: *Implement actions that enhance water-dependent uses of shoreline property.*

8.2.2 Pilot Ranking of Alternatives

As shown in Table 8-1, each of the alternatives was qualitatively ranked under each of the seven goals based on the ability of the alternative to further that goal. Qualitative rankings were applied as either "Low," "Medium," or "High." A "high" ranking indicates that the alternative provides better progress toward that Pilot goal than other alternatives ranked as "Low," or "Medium." Composite rankings were then applied based on the average results of the seven individual rankings for each alternative.

The following discussion presents the composite Pilot rankings for each of the eight RI/FS alternatives, along with a summary of key differences among the alternatives. For additional discussion, refer to Section 5 of the EIS document.

- **Alternative 1:** Alternative 1 received a low composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). Though the cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA, and hence does not receive a high ranking under these two goals. Alternative 1 was ranked medium under Goal 3 (habitat protection & restoration). Under Alternative 1, shallow-water habitat areas are preserved at the head and along the sides of the Inner Whatcom Waterway, and capping produces a beneficial change in sediment elevation and energy levels in the area offshore of the ASB. However, the alternative does not facilitate the removal of Inner Whatcom Waterway bulkheads or over-water structures as in Alternatives 5 and 6, nor does it achieve restoration of aquatic uses for the ASB as in Alternatives 5 through 8. Alternative 1 receives low rankings for Goal 4 (social & cultural uses), because the dredging plan for the Inner Whatcom Waterway is not consistent with land use and navigation planning for this area, and the capping of the ASB is inconsistent with planned aquatic reuse of the ASB. Alternative 1 ranks low for Goal 5 (resource management). Even though Alternative 1 conserves resources by minimizing construction activity, the alternative does not allow for reuse of clean ASB berm material, and it impedes the continued use of the deep draft navigation infrastructure present at the Bellingham Shipping Terminal. For Goal 6 (faster, better, cheaper) Alternative 1 receives a low ranking. Though the alternative provides short-term cost savings over the other more costly alternatives, Alternative 1 does not address the long-term waterfront land and navigation uses. Therefore, this alternative is cheaper, but is not necessarily better. Under Goal 7 (economic vitality, shoreline land use) Alternative 1 receives a low ranking, because the alternative is not consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area.

- **Alternative 2:** Alternative 2 received a medium composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). Though the cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA, and hence does not receive a high ranking under these two goals. Alternative 2 receives a high ranking under Goal 3 (habitat protection & restoration). Alternative 2 produces negative habitat impacts in the Inner Whatcom Waterway, through the removal of emergent shallow-water habitat from the head and sides of the waterway, the triggering of shoreline infrastructure requirements that further affect habitat quality in the Inner Whatcom Waterway, and through prevention of aquatic reuse of the ASB. However, Alternative 2 creates new premium shallow-water aquatic habitat at the Cornwall CAD facility, offsetting other habitat losses and providing an anticipated net gain of nearshore habitat. Alternative 2 receives a low ranking under Goal 4 (social and cultural uses) because the dredging plan for the Whatcom Waterway is not consistent with planed mixed-use redevelopment of this area, and because the alternative triggers shoreline infrastructure requirements that are in conflict with area land use and navigation priorities. The dredging performed under these alternatives results in potential disturbance to cultural or historical resources in the former Citizen's Dock area at the head of Whatcom Waterway, and Alternative 2 also does not support planned aquatic reuse of the ASB. Alternative 2 receives a medium ranking under Goal 5 (resource management). Alternative 2 minimizes the use of non-renewable fuel resources required to transport dredged materials off of the waterfront. However, Alternative 2 triggers the creation of new infrastructure that will be costly to create, will produce redundancies with the existing infrastructure present at the Bellingham Shipping Terminal, and will be in conflict with community land use priorities for the Inner Whatcom Waterway. Alternative 2 receives a medium ranking under Goal 6 (faster, better cheaper). While the costs of the alternative are lower than those of the MTCA preferred alternatives, this cost-effectiveness is eliminated after the costs of additional shoreline infrastructure requirements are taken into account. Further, the alternative does not capture new funding sources (i.e., marina revenues) which the Port plans to apply to offset a portion of the cleanup costs under Alternatives 5 through 8. Under Goal 7 (economic vitality, shoreline land use) Alternative 2 receives a low ranking, because the alternative is not consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area.

- **Alternative 3:** Alternative 3 receives a medium composite ranking under the Pilot evaluation. The Alternative ranked medium for Goal 1 (human health & safety) and Goal 2 (ecological health). The cleanup is expected to comply with MTCA cleanup levels protective of human health and the environment, but the alternative does not conduct cleanup using solutions considered to be permanent to the maximum extent practicable under MTCA. Alternative 3 receives a low ranking under Goal 3 (habitat protection & restoration). Alternative 3 produces negative habitat impacts in the Inner Whatcom Waterway, through the removal of emergent shallow-water habitat from the head and sides of the waterway, the triggering of shoreline infrastructure requirements that further affect habitat quality in the Inner Whatcom Waterway. The Alternative includes some enhancement of habitat quality offshore of the ASB, but does not enhance habitat to the extent conducted in other project alternatives. Alternative 3 receives a low ranking under Goal 4 (social and cultural uses) because the dredging plan for the Whatcom Waterway is not consistent with planed mixed-use redevelopment of this area, and because the alternative triggers shoreline infrastructure requirements that are in conflict with area land use and navigation priorities. The dredging performed under these alternatives results in potential disturbance to cultural or historical resources in the former Citizen's Dock area at the head of Whatcom Waterway, and Alternative 3 also does not support planned aquatic reuse of the ASB. Alternative 3 receives a medium ranking under Goal 5 (resource management). Alternative 3 minimizes the use of non-renewable fuel resources required to transport dredged materials off of the waterfront. However, Alternative 3 triggers the creation of new infrastructure that will be costly to create, will produce redundancies with the existing infrastructure present at the Bellingham Shipping Terminal, and will be in conflict with community land use priorities for the Inner Whatcom Waterway. Alternative 3 receives a medium ranking under Goal 6 (faster, better cheaper). While the costs of the alternative are lower than those of the MTCA preferred alternatives, this cost-effectiveness is eliminated after the costs of additional shoreline infrastructure requirements are taken into account. Further, the alternative does not capture new funding sources (i.e., marina revenues) which the Port plans to apply to offset a portion of the cleanup costs under Alternatives 5 through 8. Under Goal 7 (economic vitality, shoreline land use) Alternative 3 receives a low ranking, because the alternative is not consistent with planned land or navigation uses for either the Whatcom Waterway or the ASB area. Alternative 3 creates new fill areas in the Central Waterfront that will be encumbered by geotechnical concerns and environmental use restrictions.

- **Alternative 4:** Alternative 4 ranked medium overall against the seven Pilot Goals. As with Alternatives 1-3, the alternative complies with cleanup standards, but does not use permanent solutions to the maximum extent practicable. This results in medium rankings under Pilot Goals 1 and 2. The ranking against Goal 3 (habitat protection & restoration) is medium. Alternative 4 preserves and restores some nearshore, shallow-water habitat within the Inner Whatcom Waterway and offshore of the ASB, but the alternative does not restore aquatic use of the ASB as under Alternatives 5 through 8. Alternative 4 earns a "medium" ranking under Goal 4 (social & cultural uses). The alternative provides for multiple uses of the Whatcom Waterway consistent with land use and navigation planning, and avoids disturbance of potential historical and cultural resources at the head of the Whatcom Waterway near former Citizen's dock. However, the alternative does not support aquatic reuse of the ASB. Alternative 4 receives a medium ranking for Goal 5 (resource management). Alternative 4 reduces the non-renewable resources consumed during construction activities, and avoids the redundant shoreline infrastructure requirements of alternatives 2 and 3. However, Alternative 4 does not provide for reuse of clean ASB berm materials. Alternative 4 receives a medium ranking for Goal 6 (faster, better, cheaper). While the alternative can be implemented quickly, and the project is cost-effective, the alternative does not achieve restoration of aquatic uses within the ASB, and does not provide the degree of habitat, navigation and public access enhancements achieved by Alternatives 5 and 6. Further, the alternative does not capture the additional funding source (marina revenues) of these other alternatives. Alternative 4 achieves partial consistency with shoreline land use priorities, and receives a "medium" ranking under Pilot Goal 7 (economic vitality, shoreline land use). The alternative tailors the dredging and shoreline modifications within the Whatcom Waterway to the multi-purpose channel concept. However, the alternative is inconsistent with planned aquatic reuse of the ASB.

- **Alternative 5:** Alternatives 5 receives a high composite ranking based on evaluation against the seven Pilot goals. Cleanup under Alternative 5 is conducted using solutions that are permanent to the maximum extent practicable under MTCA, resulting in high rankings under Goal 1 (human health & safety) and Goal 2 (ecological health). Alternative 5 receives a high ranking under Goal 3 (habitat protection & restoration) because it preserves nearshore, shallow water habitat within the Inner Whatcom Waterway and offshore of the ASB and restores aquatic use of the ASB. Under Alternatives 5 and 6, the ASB is cleaned up and then reconnected to Bellingham Bay. This restores nearly 4,500 linear feet of salmonid migration corridor, and opens approximately 28 acres of open water habitat. The restoration of the ASB will represent one of the largest habitat restoration projects achieved in the Puget Sound area. Alternative 5 also ranks high under Goal 4 (social & cultural uses). The alternative provides for multiple uses of the Whatcom Waterway consistent with land use and navigation planning. The alternatives enhance social and cultural uses by directly supporting revitalization of the Bellingham waterfront. The cleanup actions within the ASB and the Whatcom Waterway are consistent with land use and navigation planning., while avoiding disturbance of potential historical and cultural resources at the head of the Whatcom Waterway near former Citizen's dock. Alternative 5 receives a "high" ranking under Pilot Goal 5 (resource management). The alternative uses significant energy resources to accomplish project construction. However, these resources are used appropriately to manage the most heavily-contaminated materials requiring cleanup, and the cleanup action provides for reuse of the clean ASB berm materials. Alternative 5 avoid the creation of redundant shoreline infrastructure that conflicts with area land use priorities. Under Goal 6 (faster, better, cheaper), Alternative 5 is ranked high because it provides a high-quality cleanup action consistent with planned land uses, while maintaining overall cost-effectiveness. The cleanup actions of Alternative 5 are more costly than Alternatives 1-4, but overall costs are reasonable if mitigation costs costs are considered as part of the analysis. Additionally, Alternative 5 provides for planned aquatic reuse of the ASB, which is expected to generate additional revenues (marina moorage fees) that help offset the costs of ASB sludge removal. Alternative 5 receives a high ranking for Goal 7 (economic vitality, shoreline land use) by enhancing water-dependent uses of shoreline property, providing for a full range of waterfront uses, and contributing to the revitalization of Bellingham Bay waterfront.

- **Alternative 6:** Like Alternative 5, Alternative 6 receives a high composite ranking relative to the seven Pilot goals. Most elements of Alternative 6 are the same as for Alternative 5. The principal difference is that Alternative 6 conducts additional deep dredging adjacent to the Bellingham Shipping Terminal, reducing the area of capping required within Whatcom Waterway. This additional dredging results in some increases to project costs, but with a corresponding potential benefit to future navigation uses at Bellingham Shipping Terminal, should additional navigation depths be required. Therefore, the additional costs of Alternative 6 do not affect rankings of the alternative under Goals 5 (resource management), or under Goal 6 (faster, better, cheaper). All other rankings are high, as in Alternative 5.

- **Alternative 7:** Alternative 7 receives a medium composite ranking relative to the seven Pilot Goals. Alternative 7 receives high rankings for Goal 1 (human health & safety) and for Goal 2 (ecological health), because the level of cleanup meets or exceeds MTCA requirements. The use of dredging and upland disposal beyond the point considered the maximum extent practicable under MTCA does not affect the rankings against these goals, though it does impact the Goal 6. Alternative 7 receives a medium ranking under Goal 3 (habitat protection and restoration). Alternative 7 enhances habitat quality through aquatic reuse of the ASB, and through creation of a cap and habitat bench offshore of the ASB. However, the dredging of the 1960s industrial channel removes emergent shallow-water habitat at the head and along the sides of the Inner Whatcom Waterway, and triggers requirements for hardened shoreline infrastructure that further limit habitat quality in this area. The ranking of Alternatives 7 against Goal 4 (social & cultural uses) is low. The dredging of the 1960s federal channel and the associated requirements for hardened shoreline infrastructure are inconsistent with area land use and navigation planning, and could disturb historical or archaeological resources that may be present near the former Citizen's Dock area. Ranking under Goal 5 (resource management) is low, due to the higher consumption of non-renewable fossil fuel resources during dredging and infrastructure construction, and due to likely redundancy of newly-constructed infrastructure with existing infrastructure at the Bellingham Shipping Terminal. Alternative 7 receives a low ranking for Goal 6 (faster, better, cheaper) because costs of this alternative are substantially higher than those of Alternative 6, and environmental, land use and habitat benefits are equivalent or lower. This poor cost/benefit relationship is compounded when the costs of required shoreline infrastructure are incorporated into project estimates. Finally, Alternative 7 receives a low ranking for Goal 7 (economic vitality, shoreline land use) due to the poor cost-effectiveness of the alternative, and due to the conflicts between the alternative and planned land uses in the Inner Whatcom Waterway.

- **Alternative 8:** Alternative 8 receives a low composite ranking relative to the seven Pilot criteria. Rankings for Goal 1 (human health & safety) and for Goal 2 (ecological health) were high, because this alternative makes the greatest use of permanent solutions. However, the use of dredging and upland disposal beyond the point at which it is considered practicable under MTCA results in low rankings for Goal 6 (faster, better, cheaper). Alternative 8 receives a low ranking under Goal 3 (habitat protection and restoration). Alternative 8 removes emergent shallow-water habitat from the head and sides of the Inner Whatcom Waterway. In addition, Alternative 8 converts shallow-water habitat in the area offshore of the ASB to less-productive deep-water habitat, rather than enhancing habitat quality of this area as in preceding alternatives. Despite habitat enhancements conducted within the ASB, this alternative likely results in a net loss of premium nearshore aquatic habitat. The ranking of Alternatives 7 against Goal 4 (social & cultural uses) is low. The dredging of the 1960s federal channel and the associated requirements for hardened shoreline infrastructure are inconsistent with area land use and navigation planning, and could disturb historical or archaeological resources that may be present near the former Citizen's Dock area. Ranking under Goal 5 (resource management) is low, because Alternative 8 has the highest consumption of non-renewable fossil fuel resources during dredging and infrastructure construction, and because the new shoreline infrastructure will likely be redundant with existing infrastructure at the Bellingham Shipping Terminal. Alternative 7 receives a very low ranking for Goal 6 (faster, better, cheaper) because costs of this alternative are over three times higher than the MTCA preferred alternative, without producing a significant enhancement to site environmental conditions or other benefits. This poor cost-effectiveness is compounded when the costs of required shoreline infrastructure are incorporated into project estimates. Finally, Alternative 8 receives a low ranking for Goal 7 (economic vitality, shoreline land use) due to the poor cost-effectiveness of the alternative, and due to the conflicts between the alternative and planned land uses in the Inner Whatcom Waterway.

8.3 Comparison of RI/FS and EIS Findings

Table 8-1 summarizes the results of the EIS analysis. These findings can be compared to the results of the MTCA alternatives rankings shown in Table 7-2.

Based on the SEPA analysis as summarized in Section 8.1 above, most of the project alternatives will require mitigation measures over-and-above the elements of the MTCA remedy design concepts. Mitigation measures defined in the SEPA analysis should be considered as part of cleanup planning and implementation. Incremental costs of mitigation will affect the overall cost of each alternative. Alternatives 5 and 6 had net beneficial impacts or mitigated impacts under the SEPA criteria, indicating that required mitigation measures will be minimal for implementation of these alternatives.

The Pilot analysis of alternatives summarized in Section 8.2 is different from MTCA or SEPA in that it is not required under existing regulatory authorities. Consistency with the Bellingham Bay Comprehensive Strategy and the Pilot Goals is voluntary. However, the use of the Pilot goals provides an additional basis by which the qualitative benefits or short-comings of a remedial alternative can be measured. In general, the relative Pilot rankings were similar to the MTCA alternatives rankings. Alternatives 1 and 8 ranked lowest. Alternatives 2, 3, 4 and 7 ranked medium. Alternatives 5 and 6, which were the MTCA preferred remedial alternatives, also received the highest rankings against Pilot goals.

Table 8-1. Summary of EIS Alternatives Analysis

Alternative Number	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**	**Alt. 5**	**Alt. 6**	**Alt. 7**	**Alt. 8**
Probable Cost ($Million)	$8	$34	$34	$21	$42	$44	$74	$146
Alternative Description	Fig 6-1	Fig 6-2	Fig 6-3	Fig 6-4	Fig 6-5	Fig 6-6	Fig 6-7	Fig 6-8
Waterway Remedy								
Waterway Uses	Limited-Use	Industrial	Industrial	Multi-Purpose	Multi-Purpose	Multi-Purpose	Industrial	Industrial
Sediment Disposal	None	Cornwall CAD	ASB Fill	Upland	Upland	Upland	Upland	Upland
ASB Area Remedy								
Future Uses	Non-Aquatic	Non-Aquatic	Non-Aquatic	Non-Aquatic	Aquatic	Aquatic	Aquatic	Aquatic
Sediment Disposal	None	None	ASB Fill	None	Upland	Upland	Upland	Upland
SEPA Analysis of Impacts, Benefits & Mitigation (EIS Section 4)								
Elements of the Environment *(WAC 197-11-444)* [1]								
1 Geology, Water, Environmental Health	Net Adverse Impacts	Net Adverse Impacts	Net Adverse Impacts	Net Beneficial Impacts	Net Beneficial Impacts	Net Beneficial Impacts	Net Adverse Impacts	Net Adverse Impacts
2 Fish & Wildlife	Net Beneficial Impacts	Net Beneficial Impacts	Net Adverse Impacts	Net Beneficial Impacts	Net Beneficial Impacts	Net Beneficial Impacts	Mitigated Impacts	Net Adverse Impacts
3 Land Use, Navigation & Shoreline Public Access	Net Adverse Impacts	Net Adverse Impacts	Net Adverse Impacts	Net Adverse Impacts	Net Beneficial Impacts	Net Beneficial Impacts	Net Adverse Impacts	Net Adverse Impacts
4 Air & Noise	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts
5 Historic & Cultural Preservation	-- No Change	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts	Mitigated Impacts
Pilot Comparative Analysis of Alternatives (EIS Section 5)								
Overall Ranking of Alternative Against Pilot Goals	Low	Medium	Medium	Medium	High	High	Medium	Low
1 *Human Health & Safety*	Medium	Medium	Medium	Medium	High	High	High	High
2 *Ecological Health*	Medium	Medium	Medium	Medium	High	High	High	High
3 *Habitat Protection & Restoration*	Medium	High	Low	Medium	High	High	Medium	Low
4 *Social & Cultural Uses*	Low	Low	Low	Medium	High	High	Low	Low
5 *Resource Management*	Low	Medium	Medium	Medium		High	Low	Low
6 *Faster, Better, Cheaper*	Low	Medium	Medium	Medium	High	High	Low	Very Low
7 *Economic Vitality, Shoreline Land Use*	Low	Low	Low	Medium	High	High	Low	Low

Notes:

1. Consistent with WAC 197-11-444(3), the SEPA environmental elements have been combined to improve readability and to focus on significant issues. Categorization of the environmental elements was performed consistent with the Comprehensive Strategy 2000 FEIS.

9 Summary and Conclusions

This Feasibility Study presents a comprehensive analysis of cleanup requirements applicable to the Whatcom Waterway site. After establishing Site Units and screening potentially applicable cleanup technologies, eight comprehensive cleanup alternatives were evaluated and ranked for compliance with regulatory requirements. The alternatives are described in detail in Section 6. The evaluation of alternatives under MTCA and SMS regulations is included in Section 7.

9.1 Description of the Preferred Alternatives

Based on the analysis described in Section 7, two preferred alternatives (Alternatives 5 and 6) have been identified. Key elements of the two MTCA Preferred Alternatives include the following:

- **Remedial Technologies:** Contaminated sediments are remediated using both active and passive remedial technologies including dredging, sediment treatment, upland Subtitle D disposal, reuse and recycling, capping, monitored natural recovery and institutional controls.

- **ASB Cleanup:** The ASB will be remediated by removing, treating and disposing of the accumulated sludges, the most impacted site materials requiring remediation. As part of the cleanup action, the ASB area will be remediated and restored to aquatic uses. The cleanup is consistent with plans for aquatic reuse of the ASB for construction of an environmentally sustainable marina with integrated habitat enhancement and public access improvements.

- **Whatcom Waterway Cleanup:** The Whatcom Waterway will be remediated consistent with the requirements of a locally-managed, multi-purpose channel. Sediment removal is conducted in the Outer Whatcom Waterway to maintain deep draft navigation uses with water depths of at least 30 feet, consistent with area land use planning and existing infrastructure at the Bellingham Shipping Terminal. The Inner Whatcom Waterway is managed to accommodate multiple uses including habitat enhancement, public shoreline access, and sustainable navigation uses consistent with area mixed-use zoning. The cleanup action is consistent with updates to the federal navigation channel that are being performed in accordance with Port Resolution 1230. Final effective water depths (the water depths available for use by vessels at the face of docks and navigation improvements) in the Inner Whatcom Waterway navigation areas will range from 18 to 22 feet. Under the updated channel dimensions, these effective water depths can be maintained without requiring the use of bulkheads, over-water wharves and hardened shorelines common to deep draft navigation channels.

- **Cleanup of Other Site Areas:** Capping, monitored natural recovery and institutional controls will be applied to outlying areas of the site with low-level subsurface sediment impacts, and where those actions are consistent with planned land and navigation use. Capping in the ASB shoulder area (Unit 5-B) will result in enhancement of nearshore aquatic habitat in this area if implemented using the design concept from Appendix C.

- **Sediment Disposal:** Sediments and sludges removed from the site during the cleanup will be managed by upland disposal at off-site, permitted Subtitle D facilities, rather than by creating a new sediment disposal site on Bellingham Bay.

9.2 Basis for Alternative Identification

The preferred remedial alternatives were identified consistent with MTCA and SMS alternatives evaluation and remedy selection criteria. These criteria include the following:

- **Compliance with MTCA Threshold Criteria**: Both alternatives 5 and 6 comply with MTCA threshold criteria. The compliance of these alternatives with MTCA Threshold criteria is discussed in Section 7.2.

- **Use of a reasonable restoration time-frame:** Of the evaluated alternatives, Alternatives 5 and 6 have relatively short restoration time-frames of 5 to 6 years, including the time required for design, permitting and construction. The restoration time-frames for each of the evaluated alternatives are discussed in Section 7.2.

- **Use of Permanent Solutions to the Maximum Extent Practicable:** As described in Section 7.3, Alternatives 5 and 6 use permanent solutions to the maximum extent practicable, based on the findings of the MTCA disproportionate cost analysis. Alternatives 5 and 6 are both costly, with probable costs of $42 million and $44 million, respectively. However, significant environmental benefits are achieved through the investments required under these alternatives, and the costs are not disproportionate to these benefits. Other lower-cost alternatives provide a lower degree of environmental benefit than Alternatives 5 and 6. Higher-cost alternatives were determined to be impracticable, because their incremental costs were substantial and disproportionate to the incremental benefits of those alternatives.

In addition to the alternatives analysis conducted in this Feasibility Study, project alternatives were evaluated in the companion EIS document as described in Section 8. The EIS analysis included an evaluation of environmental impacts and potentially required mitigation measures consistent with SEPA regulations. The two preferred remedial alternatives were found to provide net beneficial impacts, and to include appropriate mitigation measures. Neither of the preferred alternatives resulted in adverse impacts that were not mitigated.

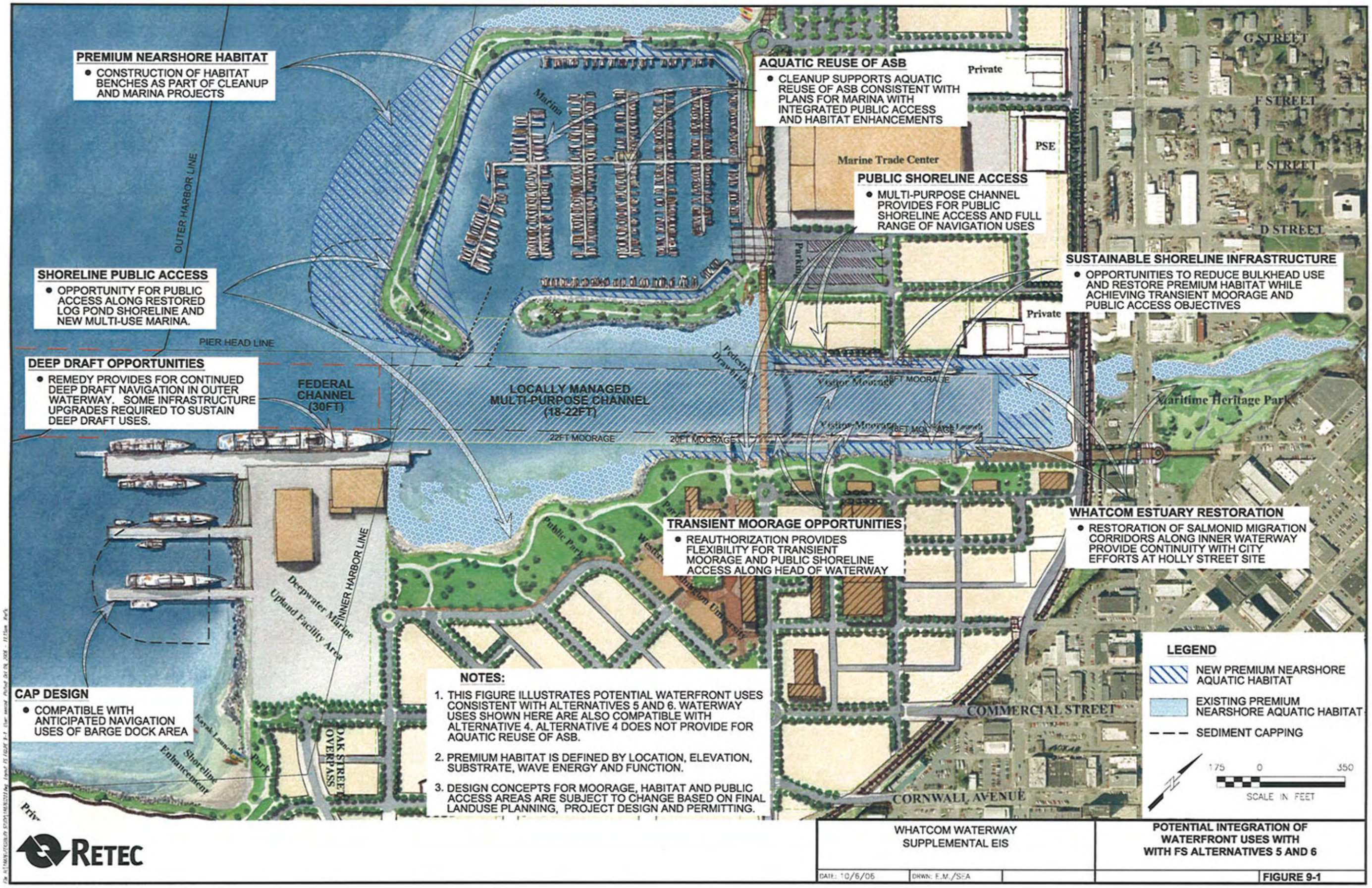
The companion EIS document also included an evaluation of the project alternatives against the goals of the Bellingham Bay Demonstration Pilot. Both Alternatives 5 and 6 were found to further each of the Pilot goals, and these alternatives were ranked highest of the eight evaluated alternatives. The high Pilot rankings indicate that Alternatives 5 and 6 have a high degree of consistency with the Bellingham Bay Comprehensive Strategy.

9.3 Implementation of Site Cleanup

This RI/FS, the companion EIS document, and public comment on both documents will inform Ecology's preliminary selection of a cleanup alternative for the Whatcom Waterway site. The preliminary selected alternative will be articulated for public review in a draft Cleanup Action Plan (CAP). Following public review of the CAP, the cleanup will move forward into design, permitting, construction and long-term monitoring.

The Port has stated that it has the financial resources necessary to implement Alternative 5 or Alternative 6 in a timely manner. During completion of the 2004 and 2005 due diligence evaluations prior to purchase of the GP waterfront properties, the Port developed a funding plan for implementation of "Alternative K", on which the preferred remedial alternatives are based. That funding plan includes anticipated grant funding from Ecology's Solid Waste and Financial Assistance Program and funds from moorage revenues generated by planned aquatic reuse of the ASB.

The Port also believes that implementation of the preferred alternatives can be conducted in a manner that is consistent with and that directly supports waterfront revitalization efforts. Figure 9-1 illustrates conceptually how the preferred remedial alternatives can be integrated with ongoing waterfront revitalization efforts, as identified in the September 2006 New Whatcom Draft Framework Plan. Final details of the remedial alternatives and how they are integrated with land use planning will be subject to Ecology's cleanup decisions, project design and permitting, and the results of on-going land use planning efforts.



PREMIUM NEARSHORE HABITAT
• CONSTRUCTION OF HABITAT BENCHES AS PART OF CLEANUP AND MARINA PROJECTS
AQUATIC REUSE OF ASB
• CLEANUP SUPPORTS AQUATIC REUSE OF ASB CONSISTENT WITH PLANS FOR MARINA WITH INTEGRATED PUBLIC ACCESS AND HABITAT ENHANCEMENTS
Private
G STREET
F STREET
E STREET
D STREET
PSE
Marine Trade Center
Marina
OUTER HARBOR LINE
PUBLIC SHORELINE ACCESS
• MULTI-PURPOSE CHANNEL PROVIDES FOR PUBLIC SHORELINE ACCESS AND FULL RANGE OF NAVIGATION USES
Parking
SUSTAINABLE SHORELINE INFRASTRUCTURE
• OPPORTUNITIES TO REDUCE BULKHEAD USE AND RESTORE PREMIUM HABITAT WHILE ACHIEVING TRANSIENT MOORAGE AND PUBLIC ACCESS OBJECTIVES
SHORELINE PUBLIC ACCESS
• OPPORTUNITY FOR PUBLIC ACCESS ALONG RESTORED LOG POND SHORELINE AND NEW MULTI-USE MARINA.
PIER HEAD LINE
Park
Private
DEEP DRAFT OPPORTUNITIES
• REMEDY PROVIDES FOR CONTINUED DEEP DRAFT NAVIGATION IN OUTER WATERWAY. SOME INFRASTRUCTURE UPGRADES REQUIRED TO SUSTAIN DEEP DRAFT USES.
FEDERAL CHANNEL (30FT)
LOCALLY MANAGED MULTI-PURPOSE CHANNEL (18-22FT)
Visitor Moorage
18FT MOORAGE
22FT MOORAGE
20FT MOORAGE
Maritime Heritage Park
Public Park
Western Washington University
TRANSIENT MOORAGE OPPORTUNITIES
• REAUTHORIZATION PROVIDES FLEXIBILITY FOR TRANSIENT MOORAGE AND PUBLIC SHORELINE ACCESS ALONG HEAD OF WATERWAY
WHATCOM ESTUARY RESTORATION
• RESTORATION OF SALMONID MIGRATION CORRIDORS ALONG INNER WATERWAY PROVIDE CONTINUITY WITH CITY EFFORTS AT HOLLY STREET SITE
INNER HARBOR LINE
Deepwater Marine Upland Facility Area
LEGEND
NEW PREMIUM NEARSHORE AQUATIC HABITAT
EXISTING PREMIUM NEARSHORE AQUATIC HABITAT
SEDIMENT CAPPING
175 0 350
SCALE IN FEET
CAP DESIGN
• COMPATIBLE WITH ANTICIPATED NAVIGATION USES OF BARGE DOCK AREA
Kayak Launch
Shoreline Enhancement
OAK STREET OVERPASS
COMMERCIAL STREET
CORNWALL AVENUE
NOTES:
1. THIS FIGURE ILLUSTRATES POTENTIAL WATERFRONT USES CONSISTENT WITH ALTERNATIVES 5 AND 6. WATERWAY USES SHOWN HERE ARE ALSO COMPATIBLE WITH ALTERNATIVE 4. ALTERNATIVE 4 DOES NOT PROVIDE FOR AQUATIC REUSE OF ASB.
2. PREMIUM HABITAT IS DEFINED BY LOCATION, ELEVATION, SUBSTRATE, WAVE ENERGY AND FUNCTION.
3. DESIGN CONCEPTS FOR MOORAGE, HABITAT AND PUBLIC ACCESS AREAS ARE SUBJECT TO CHANGE BASED ON FINAL LANDUSE PLANNING, PROJECT DESIGN AND PERMITTING.
RETEC
WHATCOM WATERWAY SUPPLEMENTAL EIS
POTENTIAL INTEGRATION OF WATERFRONT USES WITH WITH FS ALTERNATIVES 5 AND 6
DATE: 10/6/06
DRWN: E.M./SEA
FIGURE 9-1

10 References Cited

Anchor Environmental (Anchor) and Hart Crowser, 2000. Remedial Investigation and Feasibility Study for the Whatcom Waterway Site. Prepared for Georgia Pacific Corporation.

Anchor Environmental (Anchor), 2002. Supplemental Feasibility Study for the Whatcom Waterway Site. Prepared for Georgia Pacific Corporation.

Anchor Environmental (Anchor), 2003b. *Literature Review of Effects of Resuspended Sediments Due to Dredging Operations*. Prepared for the Los Angeles Contaminated Sediments Task Force, Los Angeles, California. Prepared by Anchor Environmental CA LP, Seattle, Washington. June.

Anchor Environmental (Anchor) and Landau Associates, 2003a. Pre-Remedial Design Evaluation Data Report for the Whatcom Waterway Site. Prepared for Georgia Pacific Corporation, the City of Bellingham, Port of Bellingham and the Department of Natural Resources.

Apitz, S. E., J. W. Davis, K. Finkelstein, D. L. Hohreiter, R. Hoke, R. H. Jensen, J. M. Jersak, V. J. Kirtay, E. E. Mack, V. Magar, D. Moore, D. Reible and R. Stahl, 2002. *Critical Issues for Contaminated Sediment Management*, MESO-02-TM-01, March 2002. Marine Environmental Support Office, United States Navy.
http://meso.spawar.navy.mil/docs/MESO-02-TM-01.pdf

Averett, D., 1997. "Data Requirements for Advancing Techniques to Predict Dredge-Induced Sediment and Contaminant Releases—A Review." In: *Dredging, Remediation, and Containment of Contaminated Sediments*. ASTM STP 1293, K. R. Demars, G. N. Richardson, R. N. Yong, and R. C. Chancey (ed.). American Society of Testing and Materials, Philadelphia. p. 128–135.

Averett D., M. R. Palermo and R. Wade, 1988. *Verification of Procedures for Designing Dredged Material Containment Areas for Solids Retention*. Miscellaneous Paper D-88-2. United States Army Corps of Engineers, Dredging Operations Technical Support Program. United States Army Corps of Engineers Waterways Experiment Station, Vicksburgh, Mississippi.

Averett, D., E. Daniel, B. D. Perry, and E. J. Torrey, 1990. *Review of Removal, Containment and Treatment Technologies for Remediation of Contaminated Sediment in the Great Lakes*. United States Army Corps of Engineers, Miscellaneous papers, EL-90-25.

Averett, D., D. F. Hayes, and P. R. Schroeder, 1999. *Estimated Contaminant Losses During Dredging*. World Dredging Association, 19th Technical Conference.

Brannon et al., 1990. *Comprehensive Analysis of Migration Pathways (CAMP): Contaminant Migration Pathways at Confined Dredged Material Disposal Facilities*.

Cleland, J., 2000. *Results of Contaminated Sediment Cleanups Relevant to the Hudson River: An Update to Scenic Hudson's Report "Advances in Dredging Contaminated Sediment."* Prepared for Scenic Hudson, Poughkeepsie, New York. October.

Cunningham, K., T. Thompson, C. Houck, P.E., L. Mortensen, and K. Smayda, 2001. "Environmental Monitoring During Construction of a Subaqueous Sand Cap," from the Proceedings of Wetlands & Remediation - An International Conference, September 5-6, 2001.

Department of Natural Resources (DNR), 2005. Memorandum of Understanding by and Between the Port of Bellingham and the Department of Natural Resources. DNR MOU #06-129. Signed by the Washington Department of Natural Resources and the Port of Bellingham.

DOF, 2004. Remedial Action Construction Report, Head of Thea Foss Waterway. Tacoma, WA. Report prepared by Dalton, Olmsted and Fuglevand, Inc. Kirkland, WA.

Davis, J., T. Dekker, M. Erickson, V. Magar, C. Patmont, and M. Swindoll. 2004. Framework For Evaluating The Effectiveness Of Monitored Natural Recovery (MNR) As A Contaminated Sediment Management Option Working Draft, June 2004. Remediation Technologies Development Forum (RTDF) Sediment Subgroup. Working Draft available at http://www.rtdf.org/public/sediment/mnrpapers.htm

Demars, K. R., G. N. Richardson, R. Yong, and R. Chaney, 1995. *Dredging, Remediation and Containment of Contaminated Sediments*. American Society for Testing and Materials Publication STP 1293.

Ecology, 1991. *Sediment Cleanup Users Manual.* Sediment Management Unit, Washington Department of Ecology. Olympia, Washington. December 1991.

Hart Crowser and Pentec Environmental, 2002. *Final (100 Percent) Design Documents Olympic View Resource Area Non-Time-Critical Removal Action, Tacoma, Washington.* Prepared for the City of Tacoma. January.

Havis, R. N., 1988. *Sediment Resuspension by Selected Dredges, Effects on Dredging*. Technical Notes EEDP-09-02. United States Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Herbich, J., 1997. "Removal of Contaminated Sediments: Equipment and Recent Field Studies. In: *Dredging, Remediation, and Containment of Contaminated Sediments*. ASTM STP 1293.

Herbich, 2000. *Handbook of Dredging Engineering*. Second Edition. New York, McGraw Hill.

Makers. 2004. Bellingham Bay Potential Marina Site Survey. Prepared for the Port of Bellingham.

McLaughlin, D. F., S. V. Dighe, D. L. Keairns and N. H. Ulerich, 1999. *Decontamination and Beneficial Reuse of Dredged Estuarine Sediment: The Westinghouse Plasma Vitrification Process*. May. p. 6-22.

McLellan and Hopman, 2000. *Innovations in Dredging Technology: Equipment, Operations, and Management*. ERDC-TR-DOER-5. Prepared for the United States Army Corps of Engineers, DOER Program. April 5.

National Research Council (NRC), 1997. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies*. National Research Council, Committee on Contaminated Marine Sediments. National Academy Press, Washington, D.C.

National Research Council (NRC), 2001. *A Risk-Management Strategy for PCB-contaminated Sediments*. Committee on Remediation of PCB-contaminated sediments. National Research Council. Prepared for the National Academy of Sciences and the United States Environmental Protection Agency. National Academy Press, Washington, DC.

Office of Solid Waste and Emergency Response (OSWER), 2004. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. Draft. February.

Palermo, M. 2002. "A State of the Art Overview of Contaminated Sediment Remediation in the United States." In (A. Porta and R.E. Hinchee, eds) *Proceedings of the First International Conference on Remediation of Contaminated Sediments, 10-12 October 2001, Venice, Italy*. Battelle Press. Website: http://www.battelle.org/bclscrpt/bookstore/booktemplate.cfm?ISBN=1%2D57477%2D125%2D6.

Palermo, M. R., J. E. Clausner, M. P. Rollings, G. L. Williams, T. E. Myers, T. J. Fredette and R. E. Randall, 1998a. *Guidance for Subaqueous Dredged Material Capping*. Technical Report DOER-1. United States Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. Website: http://www.wes.army.mil/el/dots/doer/pdf/doer-1.pdf.

Palermo, M. R., J. Miller, S. Maynord and D. Reible, 1998b. *Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*. EPA 905/B-96/004. Prepared for the Great Lakes National Program Office, United States

Environmental Protection Agency, Chicago, Illinois. Website: http://www.epa.gov/glnpo/sediment/iscmain.

Sumeri, A., 1984. "Capped In-Water Disposal of Contaminated Dredged Material," in "Dredging and Dredged Material Disposal" (Vol 2), R. L. Montgomery and J. W. Leach, eds., *Proceedings of Conference Dredging '84*, American Society of Civil Engineers, Clearwater Beach, FL.

Sumeri, A. 1989. "Confined Aquatic Disposal and Capping of Contaminated Sediments in Puget Sound," *Proceedings of WODCON XII*; Dredging: Technology, Environmental, Mining, World Dredging Congress, Orlando, FL.

Thompson, T., G. Hartman, C. Houck, J. Lally, and R. Paulson, 2003. Methods And Considerations For Cap Design, Contracting, Construction, And Monitoring Over Soft, Unconsolidated Sediments. Proceedings of the In-Situ Contaminated Sediment Capping Workshop. May, 2003.

U.S. Army Corps of Engineers (USACE), 1987. *Engineering and Design – Confined Disposal of Dredged Material*. Engineer Manual No. 1110-2-5027. United States Army Corps of Engineers, Washington, D.C.

U.S. Army Corps of Engineers (USACE), 1994. *Sediment Chemistry Profiles of Capped Deposits Taken 3 to 11 Years After Capping*. Dredging Research Technical Notes. DRP-549. May.

U.S. Army Corps of Engineers (USACE), 1995. Geotechnical Descriptors for Dredgeability. Waterways Experiment Station, Dredging Research Technical Notes. DRP-2-13. January 1995. Available on the web at http://el.erdc.usace.army.mil/elpubs/pdf/drp2-13.pdf .

U.S. Army Corps of Engineers (USACE), 2000. *Innovative Dredged Sediment Decontamination and Treatment Technologies*. U.S. Army Corps of Engineers, ERDC TN-DOER-T2. December, 2000

U.S. Army Corps of Engineers (USACE), 2003. *Puget Sound Confined Disposal Site Study, Washington*. United States Army Corps of Engineers.

U.S. Army Corps of Engineers (USACE), Washington State Department of Ecology, and Washington State Department of Natural Resources, 1999. *Puget Sound Confined Disposal Site Study Programmatic NEPA/SEPA Environmental Impact Statement*. Prepared in cooperation with Striplin Environmental Associates, Anchor Environmental, Ogden Beeman Associates, ECO Resource Group, EnviroIssues, and Marshal and Associates. Two volumes. October.

U.S. Environmental Protection Agency (EPA), 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. EPA/540/G-89/004. United States Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA), 1989. Superfund Record of Decision: Commencement Bay, Near Shore/Tide Flats. Pierce County, WA. EPA/ROD/R10-89/020.

U.S. Environmental Protection Agency (EPA), 1994a. *Assessment and Remediation of Contaminated Sediments (ARCS) Program, Final Summary Report*. EPA 905-S-94-001. United States Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA), 1994b. *Assessment and Remediation of Contaminated Sediments (ARCS) Program. Remediation Guidance Document*. United States Environmental Protection Agency, Great Lakes National Program Office. EPA 905-R94-003. October.

U.S. Environmental Protection Agency (EPA), 1996. *Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5*. Contract Document 68-CO-0068-43. United States Environmental Protection Agency, Region 5, Chicago, Illinois.

U.S. Environmental Protection Agency (EPA), 1999. *A Guide for Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*. EPA/540/R-98/031, OSWER Directive 92001.1-23P, July 1999.

U.S. Environmental Protection Agency (EPA), 2000. Equilibrium partitioning sediment guidelines (ESGs) for the protection of benthic organisms: Metal mixtures (cadmium, copper, lead, nickel, silver and zinc). EPA 822-R-00-005. Office of Science and Technology, Office of Research and Development. Washington, DC.

U.S. Environmental Protection Agency (EPA), 2002. *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites*. United States Environmental Protection Agency.

U.S. Environmental Protection Agency (EPA), 2004. *Hudson River PCBs Superfund Site. Engineering Performance Standards*. Volumes 1–5. United States Environmental Protection Agency Region 2. Prepared for the United States Army Corps of Engineers, Kansas City District by Malcom Pirinie and TAMS Consultants.

Wang, T. K. Larm, and D. Hotchkiss. 2003. *Evaluation of Closed Buckets for Remedial Dredging and Case Histories*. In (S. Garbaciak, ed.) Dredging 2002: Key Technologies for Global Prosperity 3rd Specialty Conference on Dredging and Dredged Material Disposal. May 5–8, 2002, Orlando, Florida, USA. American Society of Civil Engineers Publications, Reston, VA: ASCE/COPRI, 0-7844-0680-4, 2003.

Waterfront Futures Group (WFG), 2004. Waterfront Vision and Framework Plan: Waterfront Futures Group Final Recommendations. Sponsored by the City of Bellingham and Port of Bellingham.

Appendix A

Unit Cost and Volume Assumptions

Appendix B

Remedial Cost Estimates

Appendix C

Habitat Bench Design Issues for Areas Offshore of ASB

Appendix D

Proposed Enhancements to Shoreline Conditions within the Log Pond