DRAFT REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT I&J WATERWAY SITE

Prepared for

Port of Bellingham
1801 Roeder Avenue
Bellingham, Washington 98225

Prepared by

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October 2014

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TABLE OF CONTENTS

List of Tables

List of Figures

List of Charts

List of Appendices

LIST OF ACRONYMS AND ABBREVIATIONS

°C	degree Celsius
°F	degree Fahrenheit
µg/kg	microgram per kilogram
2LAET	second lowest apparent effects threshold
AC	activated carbon
AET	adverse effects threshold
AFS	American Fisheries Society
BMC	Bellingham Municipal Code
BMP	best management practice
BT	bioaccumulation trigger
CAD	Confined Aquatic Disposal
CAP	Cleanup Action Plan
CFR	Code of Federal Regulations
City	City of Bellingham
cm	centimeter
cm/yr	centimeter per year
COC	constituent of concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
Cs-137	cesium-137
CSL	Cleanup Screening Level
CSM	conceptual site model
CWA	Clean Water Act
cy	cubic yard
DCA	disproportionate cost analysis
DMMP	Dredged Material Management Program
DMMU	Dredged Material Management Unit
DOI	U.S. Department of the Interior
dpm/g	disintegration per minute per gram
DPS	Distinct Population Segment
ECAP	Environmental Compliance Assessment Program
Ecology	Washington State Department of Ecology

EIS	Environmental Impact Statement
ENR	Enhanced Natural Recovery
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
ft	feet
ft/s	feet per second
ft/yr	feet per year
g/cm^2-yr	gram per square centimeter per year
g/cm^3	gram per cubic centimeter
GP	Georgia-Pacific
H:V	horizontal to vertical
hp	horsepower
HPA	Hydraulic Project Approval
HPAH	high-molecular-weight polycyclic aromatic hydrocarbon
IC	institutional control
kg	kilogram
km^2	square kilometer
LAET	lowest apparent effects threshold
LPAH	low-molecular-weight polycyclic aromatic hydrocarbon
m^3	cubic meter
m/sec	meter per second
mg/L	milligram per liter
MHHW	mean higher high water
ML	maximum level
MLLW	mean lower low water
MNR	Monitored Natural Recovery
MTCA	Model Toxics Control Act
NAVD 88	North American Vertical Datum of 1988
NCDF	nearshore confined disposal facility
NEPA	National Environmental Policy Act
ng/kg	nanogram per kilogram
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NWAPA	Northwest Air Pollution Authority Regulation
OSHA/WISHA	Occupational Safety and Health Administration/Washington State Department of Labor and Industries
PAH	polycyclic aromatic hydrocarbon
Pb-210	lead-210
PCB	polychlorinated biphenyls
Pilot	Bellingham Bay Demonstration Pilot
PLP	potentially liable parties
Port	Port of Bellingham
ppt	parts per thousand
PQL	Practical Quantitation Limit
PSDDA	Puget Sound Dredge Disposal Analysis
PSEP	Puget Sound Estuary Program
RBC	risk-based concentration
RCW	Revised Code of Washington
RI/FS	Remedial Investigation and Feasibility Study
RME	reasonable maximum exposure
SAP	Sampling and Analysis Plan
SCO	Sediment Cleanup Objective
SCUM II	Draft Sediment Cleanup Users Manual II
SEPA	State Environmental Policy Act
Site	I&J Waterway Site
SL	screening level
SMP	Shoreline Master Plan
SMS	Sediment Management Standards
SPM	settled particulate matter
SQS	Sediment Quality Standard
SVOC	semivolatile organic compound
TEF	toxic equivalency factor
TEQ	toxic equivalents quotient

TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
TTL	target tissue level
U&A	usual and accustomed
USFWS	U.S. Fish and Wildlife Service
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
Work Plan	Sediments RI/FS Work Plan
WRIA	Water Resource Inventory Area

1 INTRODUCTION

This Draft Supplemental Remedial Investigation and Feasibility Study (RI/FS) Report has been completed for the I&J Waterway Site (Site) in Bellingham, Washington, in accordance with Agreed Order No. DE1090. The RI component of the RI/FS is presented in Chapters 1 through 7 and describes the environmental setting and the nature and extent of contamination at the Site, along with a detailed conceptual site model (CSM) identifying the exposure pathways and the RI conclusions. The FS portion (Sections 8 through 12) presents the evaluation of cleanup technologies and alternatives that can be used to conduct cleanup of the Site. Section 13 identifies a preferred remedial alternative that best meets regulatory requirements. This document was prepared consistent with the requirements of the Model Toxics Control Act (MTCA) regulations and the updated Sediment Management Standards (SMS), Chapter 173-204 of the Washington Administrative Code (WAC).

1.1 Site Description and Background

The Site is located between Hilton Avenue and Bellwether Way on the Bellingham waterfront and was formerly called the Olivine-Hilton sediment site. The Site includes areas of contaminated marine sediments in the federally authorized I&J Waterway navigation channel and adjacent berthing areas, primarily located on state-owned aquatic land. The federally authorized navigation channel has a current authorized channel depth of 18 feet below mean lower low water (MLLW). The Port of Bellingham (Port) owns the berthing areas on the south side of the Site and the surrounding uplands, including the sloped beach area at the head of the Waterway. The upland areas near the Site include the former Olivine Corporation lease area and a property to its southwest that is currently leased to Bornstein Seafoods. The U.S. Coast Guard (USCG) owns the property north of the Site and berths vessels within the Waterway and northern berth areas.

The main state law that governs the cleanup of contaminated sites is MTCA. When contaminated sediments are involved, the cleanup levels and other procedures are also regulated by SMS. MTCA regulations specify criteria for the evaluation and conduct of a state cleanup action. SMS regulations dictate the standards for cleanup of sediments. 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 RI/FS, in which the nature and extent of contamination is defined and different potential alternatives for conducting a site cleanup action are developed. The alternatives are then evaluated against MTCA remedy selection criteria, and one or more preferred alternatives are identified. After reviewing the RI/FS study, and after consideration of public comment, the Washington State Department of Ecology (Ecology) then selects a cleanup method and documents that selection in the Cleanup Action Plan (CAP).

The RI/FS process for the Site was initiated with Agreed Order DE1090 signed in January 2005 by Ecology and the Port. The First Amendment to the Agreed Order was signed in October 2005 and incorporated the *Sediments RI/FS Work Plan* (Work Plan; RETEC 2005) into the Agreed Order. In 2012, Ecology determined that additional work was necessary to further characterize dioxin/furan concentrations at the Site. This additional work was conducted under a Second Amendment to the Agreed Order (April 2012), which provided a revised schedule for completion of the RI/FS and described additional investigation activities to be conducted in 2012. Further characterization of under pier sediment was conducted in 2013 to support development of remedial alternatives in the vicinity of the Bornstein Seafoods dock, as described in the *I&J Waterway RI/FS Sampling and Analysis Plan Memo* (Anchor QEA 2013a).

This RI incorporates the results of the 2005/2006, 2012, and 2013 environmental investigations and describes and evaluates cleanup alternatives. When combined with the FS, the RI/FS and public comment will inform Ecology's preliminary selection of a cleanup alternative for the Site. The preliminary selected alternative will be articulated for public review in a draft CAP, which will be an exhibit to a Consent Decree. Following public review of the Consent Decree and CAP, the cleanup will move forward into design, permitting, construction, and long-term monitoring.

1.2 Document Organization

This RI was prepared consistent with the process defined under MTCA and SMS. The RI/FS is organized as follows:

- Section 2 provides a history of the Site, an overview of previous environmental studies, and cleanup actions conducted to date.
- Section 3 summarizes the environmental Site setting, including the physical Site features, natural resources, and area land use and navigational uses.
- Section 4 summarizes the Site screening levels developed as part of the RI/FS. This section summarizes the principal environmental receptors and exposure pathways for which the screening levels are protective.
- Section 5 defines the nature and extent of Site contamination. This section summarizes environmental data collected during the previous RI/FS activities (2005/2006), during the supplemental investigation in 2012, and during the additional sampling in 2013. Information discussed in this section includes contaminant distribution in surface and subsurface sediments.
- Section 6 summarizes processes that affect the fate and transport of Site contaminants. This section includes an assessment of sediment source control and natural recovery processes and the other factors that may impact sediment stability.
- Section 7 provides an overall summary of the RI, including presentation of an overall CSM. The CSM incorporates the key findings of the RI study, including contaminants and sources, the nature and extent of contamination, contaminant fate and transport processes, and the principal human health and ecological receptors.
- Section 8 summarizes the cleanup requirements for the Site, including a definition of Site cleanup levels and remedial action objectives that are to be met by the cleanup action. This section also defines the regulations and requirements (other than those in MTCA and SMS) that are addressed by the cleanup and its implementation. Future permits or approvals that may be required for cleanup implementation are also identified.
- Section 9 describes the geographic division of the Site into a series of "Site Units" that have different characteristics and that may warrant different types of cleanup based on these characteristics.

- Section 10 presents a screening of 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 U.S. Environmental Protection Agency (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 FS, these cleanup strategies are described in this document as "cleanup alternatives."
- Section 11 describes each cleanup alternative in detail, along with a description of how each alternative achieves compliance with the cleanup requirements. Each alternative uses a different combination of the cleanup technologies.
- Section 12 provides a detailed evaluation of each remedial alternative against a set of defined criteria, consistent with MTCA and SMS regulations. The analysis is complex and will address the required factors under the regulations.
- Section 13 provides the summary and conclusions of the FS portion of the document. It will also identify a preferred alternative based on MTCA and SMS regulatory analysis, which represents the alternative that ranks best overall among the evaluated alternatives.
- Section 14 provides the report references.
- Appropriate backup information is attached as appendices.

2 SITE BACKGROUND

This section provides an overview of the history of the Site, including a summary of previous investigations. The purpose of this RI/FS is discussed, along with the relationship between the RI/FS and other Site-related documents. This information is provided as background and context to assist the reader in understanding the significance of the RI findings that are presented in the subsequent sections of this report.

2.1 I&J Waterway Site History and Ownership

The Site consists of lands located within and adjacent to I&J Waterway in Bellingham, Washington (Figure 2-1). Current land ownership and land use patterns are summarized in Figure 2-2. Metals and other contaminants have been detected within the Site at concentrations that exceed cleanup standards defined under MTCA and SMS regulations.

2.1.1 Site Area Historical Uses

The ownership and history for the Site and adjacent upland properties were defined in the Phase 2 Sediment Sampling Report (ThermoRetec 2001). The Whatcom Falls Mill Company owned and operated a lumber mill in the vicinity of the Site between the early 1900s and 1940. In 1944, these properties were acquired by the Port and leased to tenants, including Bayshore Lumber, which operated a lumber company (1947 to 1962) and H&H Products, which managed the same lumber mill (1963 to 1972) at the head of the Waterway. The Olivine Corporation operated a rock crushing plant for the mineral olivine between 1963 and 1992. Fugitive dusts and wastewaters from that plant were released to I&J Waterway at times during plant operation. North Pacific Frozen Products managed a food processing plant between 1946 and 1959 in the location of the current Bornstein lease. Bornstein Seafoods has operated a seafood processing plant from 1959 to present in that location. Bornstein Seafoods provided diesel fuel to boats at its dock between 1960 and the early 1980s. A fire destroyed the main Bornstein Seafoods building in July 1985. Fire suppression efforts lasted for two days, during which time fire control water was discharged directly to the Site.

The adjacent northern upland area was constructed in the early 1980s as part of the Inner Squalicum Harbor Marina development. The Bellwether peninsula was created from dredge material and subsequent structural base to support construction of the Bellwether Hotel and other commercial buildings. USCG constructed its Bellingham facility along the northern shoreline of I&J Waterway during the 1990s.

Surface sediments tested in 2000 contained bis(2-ethylhexyl)phthalate elevated above SMS criteria in the vicinity of the Bornstein Seafoods lease area. Sources of phthalate contamination were previously investigated in leachate from the Roeder Avenue landfill and compressor oil from a compressor on the Bornstein dock. Concentrations of bis(2-ethylhexyl)phthalate in leachate from the Roeder Avenue landfill were determined to be below MTCA criteria under a direct discharge scenario (ThermoRetec 2001). In addition, as part of the Port's Environmental Compliance Assessment Program (ECAP), following the Phase 2 investigation, phthalates were measured in trace amounts in compressor oil from a compressor located on Bornstein's dock. It was determined that thousands of gallons of compressor oil would have needed to have been spilled to create the existing condition in the sediments. There is no historical record of such a release from the Bornstein Seafoods facility.

Surface sediments are also contaminated with nickel in the southeastern portion of the Waterway adjacent to the former Olivine Corporation lease area. Nickel is a constituent within olivine ore.

Additional contaminants present in subsurface sediments include mercury, phenols, and polycyclic aromatic hydrocarbon (PAH) compounds (ThermoRetec 2001). Like much of Bellingham Bay, dioxin/furans are also present in surface and subsurface sediments in I&J Waterway at levels that are elevated above natural background and are likely from a variety of sources.

I&J Waterway includes a federally authorized navigation channel with a current authorized channel depth of -18 feet MLLW. The federal dredging of I&J Waterway was completed in 1966, with subsequent maintenance dredging of selected areas completed by the U.S. Army Corps of Engineers (USACE) in 1992.

2.1.2 Current Area Land Use

Current land use and zoning is presented in Figure 2-2. The Port owns a majority of upland and aquatic land in the vicinity of I&J Waterway. Other land is owned by the USCG, City of Bellingham (City) right-of-way (Hilton Avenue), and Sanitary Services to the south. Land use in the vicinity is generally through leases by the Port to tenants. Leases are in place for seafood processing at the Bornstein Seafoods facility, boat storage and maintenance at Hilton Harbor, and commercial buildings at the northern upland areas. The former Olivine lease area and head of the Waterway is currently vacant with no aboveground structures.

2.2 Summary of Previous Investigations

The I&J Waterway Site is one of 12 cleanup sites in the Bellingham Bay Demonstration Pilot Project (Pilot), a coordinated bay-wide effort by federal, tribal, state, and local governments to clean up contamination, control pollution sources, and restore habitat, with consideration for land and water uses. Earlier investigations were conducted for the Whatcom Waterway site, which includes more than 200 acres within the inner portion of Bellingham Bay from I&J Waterway down to Boulevard Park. The I&J Waterway Site overlaps the Whatcom Waterway site. This RI relies on relevant information and analysis developed during earlier investigations at the Whatcom Waterway site for the Whatcom Waterway RI, which are identified in this section and further described in Section 2.3. In addition, Whatcom Waterway and I&J Waterway share a number of relevant characteristics, and some of the analysis conducted for Whatcom Waterway is informative for the I&J Waterway Site.

Contamination at the I&J Waterway Site was originally identified in 1995 as part of the Whatcom Waterway investigation, which prompted additional sampling in 1996 (Hart Crowser 1997), 1998 (Anchor Environmental and Hart Crowser 2000), and 2000 (ThermoRetec 2001). Ecology identified the Port and Bornstein Seafoods as potentially liable parties (PLPs) for I&J Waterway in 2004. In January 2005, Agreed Order DE1090 was signed by Ecology and the Port and required an RI/FS to be completed for the Site. Agreed Order Amendment No. 1 was signed in October 2005 and incorporated the Work Plan (RETEC 2005) into the Agreed Order. The Port and Ecology executed a Second Amendment to the Agreed Order in April 2012, which incorporated the Work Plan Addendum (Anchor QEA 2012).

Sediment chemical and biological testing occurred in 2005, and additional bioassay testing was repeated on samples collected in early 2006 based on quality control criteria. Subsurface sediment cores were collected and tested in 2006 for suitability of open-water disposal under the Dredged Material Management Program (DMMP). These studies are collectively referred to as the 2005/2006 investigations, which are documented in the *Preliminary Sediment Data Summary* (RETEC 2006a).

Ecology determined that additional work was necessary to complete the RI/FS. This additional work was conducted under a Second Amendment to the Agreed Order, signed in April 2012, and a Work Plan Addendum (Anchor QEA 2012). This amendment provided a revised schedule for completion of the RI/FS and required that supplemental investigation activities be conducted. These additional activities included supplemental surface sediment chemical and biological testing, subsurface sediment chemical testing, storm drain solid chemical testing, a multi-beam bathymetric survey, and structural conditions surveys in April and May 2012. As part of this work, additional chemical and biological tests were conducted on archived samples beyond what was identified in the Work Plan Addendum (Anchor QEA 2012) to define the extent of contamination, as required by Ecology.

Separate from the cleanup studies, sediment cores were collected from I&J Waterway by USACE in 2011 to evaluate the suitability of open-water disposal at the Bellingham Bay open-water disposal site of sediments dredged from federal navigation channels. The sediment from -20 to -22 feet MLLW represents the Z-layer, or sediment that represents the predicted post-dredge surface concentrations if maintenance dredging were to occur to the federally authorized channel limits with a 2-foot overdredge (to -20 feet MLLW). Additional testing of archived samples collected by USACE was conducted as part of the I&J Waterway supplemental investigation activities, which were provided to Ecology in the *Supplemental Investigation Memorandum* in 2013 (Anchor QEA 2013b).

During development of the draft FS, the Port identified data gaps that were key to developing the remedial alternatives. These data gaps included the need for additional information on sediment quality and strength beneath the Bornstein Seafoods dock, as described in the *Sampling and Analysis Plan Memorandum* (Anchor QEA 2013a). Additional surface and subsurface sampling and strength testing was conducted in the area beneath the Bornstein Seafoods dock in August 2013. These results are described in Section 5.

2.3 Relationship of the Remedial Investigation/Feasibility Study to Other Documents

As described above, the Site is located in the vicinity of other MTCA cleanup sites and subject to land use planning efforts being conducted for the Bellingham Bay waterfront. This section describes the relationship of the I&J Waterway Site to the other MTCA sites and applicable site documents.

The Whatcom Waterway sediment cleanup site overlaps the I&J Waterway Site (Figure 2-1). The primary constituent of concern (COC) at the Whatcom Waterway site is mercury, and the required cleanup (under Consent Decree No. 07-2-02257-7 [Ecology 2007]) in the area of the I&J Waterway Site is monitored natural recovery. Monitoring is expected to begin in 2016 following Phase I implementation of active cleanup measures in other areas of the Whatcom Waterway site. Remedial activities for the I&J Waterway Site will be planned and coordinated with the Whatcom Waterway cleanup activities.

The upland Central Waterfront site is located adjacent to I&J Waterway, as shown in Figure 2-2. An RI/FS is concurrently being prepared for the Central Waterfront site under a separate Agreed Order (No. DE3441). The RI will include evaluation of potential sources to I&J Waterway. Any ongoing sources identified will be controlled as part of the remediation. Upland cleanup levels for the Central Waterfront site will be protective of I&J Waterway sediments.

3 ENVIRONMENTAL SETTING

This section describes the environmental setting of the Site. Information discussed in this section includes the physical site features, area natural resources, and land use and navigation patterns.

3.1 Physical Conditions

Physical conditions are relevant at contaminated sites because they affect the fate of impacted sediments and because they are relevant to the discussion of natural resources, land use, and navigation patterns. Physical conditions discussed below include the following:

- Site Bathymetry (Section 3.1.1)
- Shoreline Features and Structures (Section 3.1.2)
- Historical Anthropogenic Modifications (Section 3.1.3)
- Surface Water Movement (Section 3.1.4)
- Area Groundwater (Section 3.1.5)
- Sediment Physical Properties (Section 3.1.6)
- Sediment Lithology (Section 3.1.7)

3.1.1 Site Bathymetry

Figure 3-1 presents existing bathymetric conditions within the Site area. This map incorporates 2012 multi-beam bathymetric soundings collected as part of the RI/FS. The following general elevation trends were observed within the Site:

- The depths in I&J Waterway have been influenced by navigation dredging in the federal channel and berth areas. The current authorized project depth for the federal channel is -18 feet MLLW. Mudline elevations within the channel are generally between 3 and 5 feet shallower than the authorized depth. Areas of shoaling are present at the head of the Waterway where the channel transitions to the sloping beach area.
- Bathymetry contours in under-pier areas were surveyed using multibeam methods in 2012 and are generally at a slope of 2 horizontal:1 vertical (2H:1V) or steeper from the channel boundary up to the bulkhead.

3.1.2 Shoreline Features and Structures

Shoreline features and structures within the Site area are summarized in Figure 3-1. The following is a brief summary of key shoreline characteristics:

- The northern shoreline of I&J Waterway, located along the Bellwether Peninsula, consists of an armored slope and rock/gravel toward the head of the Waterway. Dock structures have been constructed as part of the USCG facility located near the head of the Waterway.
- A relatively flat intertidal area is present at the head of the Waterway.
- The southern shoreline of I&J Waterway, located along the Central Waterfront shoreline, has been engineered for commercial navigation uses using wooden bulkheads. An overwater dock structure is located at the Bornstein Seafoods facility and at the Hilton Harbor location. The Bornstein Seafoods dock was constructed in two phases in 1947 and 1963, and also contains a float extending east of the dock. A condition inspection of the Bornstein Seafoods dock was conducted in 2012 and provided in the I&J Waterway RI/FS Supplemental Investigation Memorandum (Anchor QEA 2013b). Additional investigations of existing dock pile length were conducted in 2013, which is included in Appendix F. A second dock is located at Hilton Harbor.
- Two timber bulkheads are present along the south shoreline. The west bulkhead is located adjacent to the Bornstein Seafoods facility. The east bulkhead is located adjacent to the former Olivine area. Both bulkheads extend from a few feet below the mudline (at approximately 0 or +1 foot MLLW) up to the elevation of the adjacent upland areas of +17 feet MLLW. A condition inspection of these bulkheads was conducted in 2012 and provided in the Supplemental Investigation Memorandum (Anchor QEA 2013b).
- The shoreline beneath the Bornstein Seafoods facility contains some assorted debris, including rocks and pieces of concrete; however, the subtidal slope beneath the dock is not armored.
- A USCG dock and float is present along the north side of the Waterway and extends into the federal navigation channel. The float extends farther into the navigation channel than the dock, which provides covered moorage for USCG vessels.
- Multiple stormwater outfalls are located within the area of I&J Waterway along with two 6-inch drains in the west bulkhead, as shown in Figure 3-1.

3.1.3 Historical Anthropogenic Modifications

Changes to the I&J Waterway area have resulted from dredging, nearshore filling, and shoreline infrastructure construction. Major events affecting lithology in the area include the following:

- **Early Waterway Dredging and Filling:** I&J Waterway was identified on state land maps as early as 1891. Early dredging activities in I&J Waterway areas included dredging of shallow channels, with side-casting of the dredge materials behind bulkheads for creation of shoreline fill areas. Portions of the Central Waterfront areas were filled in this manner.
- **I&J Waterway Dredging:** I&J Waterway was initially dredged to depths of approximately -12 feet MLLW in the early 1900s. The federal channel in the Waterway was authorized in May 1965, with a project depth of -18 feet MLLW. Federal dredging of I&J Waterway was completed in 1966. In 1992, USACE dredged approximately 68,000 cubic yards (cy) during maintenance dredging (West Central Environmental and ThermoRetec 2000). Approximately 25,000 cy were found to be unsuitable for unconfined, open-water disposal due to exceedance of the mercury bioaccumulation trigger, including a portion east/north of the Bornstein dock in and adjacent to the federal navigation channel.
- **Central Waterfront Shoreline Changes:** The Central Waterfront shoreline was initially created during early development of the Whatcom and I&J Waterways. The shoreline was subsequently reconstructed in places to replace or upgrade bulkheads and wharf structures. The bulkheads and Bornstein Seafoods dock along I&J Waterway were constructed before the federal navigational channel dredging to -18 feet MLLW in 1966. Since that time, the shoreline infrastructure has remained. The west bulkhead is considered to be in poor condition, the east bulkhead is considered to be in fair condition, and the Bornstein dock is considered to be in fair to good condition (Echelon Engineering 2012).
- **North Shoreline Changes:** The northern shoreline of I&J Waterway was developed as part of the Inner Squalicum Harbor Marina construction during the early 1980s. This area was predominantly created from dredged sediment (mostly sand and gravel) and, later, from base fill for infrastructure development for the Bellwether peninsula. The

USCG facility was constructed in early 2000. Testing of the fill in 1998 indicated no elevated contaminant concentrations (GeoEngineers 1998).

3.1.4 Surface Water Movement

Bellingham Bay is part of a system of interconnected bays that exchange water with the Rosario Strait and, ultimately, the Pacific Ocean through a complex network of channels and passages. Collias et al. (1966), Shea et al. (1981), and Broad et al. (1984) have previously described the physical oceanography of Bellingham Bay. More recent studies of Bellingham Bay currents were performed by Colyer (1998), and Wang et al. (2010). In addition, tidal circulation modeling was conducted for Whatcom Waterway (located to the southeast of I&J Waterway) in support of the remedial design for that site (Anchor QEA 2013c).

3.1.4.1 Freshwater and Sediment Inflow

The only direct source of freshwater to I&J Waterway is stormwater. Direct stormwater and sediment input to I&J Waterway is provided by four outfalls (Figure 3-1) and sheet flow from surrounding uplands. Indirect sources of freshwater and sediment load to I&J Waterway include the Nooksack River, Squalicum Creek, Whatcom Creek, and other small creeks and various stormwater discharges to Bellingham Bay (Figure 3-2).

Bellingham Bay is primarily influenced by tidal circulation and drainage from three watersheds. The largest is the Nooksack River Watershed, which drains approximately 1,500 square kilometers (km^2). Not all of the Nooksack flow drains directly into Bellingham Bay. Part of the flow drains into Lummi Bay (located west of Bellingham Bay) by way of the Lummi River. The Nooksack River is also the primary source of sediments to the bay, with an annual discharge of 650,000 cubic meters (m^3) of solids. The Nooksack River is influenced by anthropogenic factors that include agriculture and logging.

The Squalicum Creek Watershed drains an area of 65 km^2 via Squalicum Creek, which originates at Squalicum Lake and flows through the City. The creek is influenced by channelization, vegetation removal, and urban stormwater runoff.

The Whatcom Creek Watershed drains an area of approximately 26 km^2. Whatcom Creek flows from Lake Whatcom through the City to the bay. The City occupies much of the watershed. Presently, Whatcom Creek is influenced by channelization, vegetation removal, and urban stormwater runoff. Five other smaller watersheds also contribute freshwater to Bellingham Bay.

3.1.4.2 Water Levels

Water levels in I&J Waterway are dominated by tidal fluctuations in Bellingham Bay. The tides in Bellingham Bay and I&J Waterway are generally mixed and semi-diurnal, having two low and two high tides of unequal magnitude over the tidal cycle. The mean tide range is approximately 5.2 feet and the typical diurnal tidal range is about 8.5 feet, based on National Oceanic and Atmospheric Administration (NOAA) Tidal Station No. 9449211 (Bellingham, Washington). During spring tides, when the lowest and highest tides occur consecutively, the tide range can increase to approximately 12.5 feet. Typical tidal elevations for I&J Waterway in reference to MLLW based on NOAA Tidal Station No. 9449211 are listed in Chart 3-1.

Chart 3-1
Datum Elevations (Station No. 9449211)

Tide Level	Meters (MLLW)[1]	Feet (MLLW)
Highest Observed (1/5/1975)[2]	3.177	10.4
Mean Higher High Water	2.594	8.5
Mean High Water	2.375	7.8
Mean Tide Level	1.546	5.1
Mean Sea Level	1.510	5.0
Mean Low Water	0.718	2.4
NAVD 88[3]	0.147	0.5
Mean Lower Low Water	0.000	0.0
Lowest Observed (12/30/1974)[2]	-1.057	-3.5

Notes:
1. MLLW = mean lower low water
2. Station No. 9449211 was active from March 30, 1973, to July 21, 1975. Tidal predictions for the area have been higher and lower than those observed.
3. NAVD 88 = North American Vertical Datum of 1988

In addition to tides, wind and wave setup associated with storm events (usually referred to as storm surge) can temporarily impact water levels at I&J Waterway, increasing them above anticipated tidal elevations. Typical storm events in the Site area can increase local tidal elevations by 0.5 to 1.0 foot, depending on the direction of the wind and the duration of the storm event.[1]

3.1.4.3 Near-bottom Currents in Bellingham Bay

Most oceanic waters enter Bellingham Bay at depth through the northern end of Rosario Strait between Lummi and Vendovi islands. Some water also enters through Bellingham Channel. Exchange of water to the west through Hale Passage is limited by a shallow sill. The residence time for water in Bellingham Bay is typically 4 to 5 days but varies between 1 and 11 days.

The available data indicate that there is a net southward flow throughout Bellingham Bay at depth, largely resulting from the lateral and vertical spreading of the Nooksack River discharge. Overall, bottom currents are relatively consistent throughout the year and typically range from 0.2 to 0.3 meter per second (m/sec). As described by Colyer (1998), deep current velocities typically range from 0.04 to 0.18 m/sec in the inner bay and can be as high as 0.40 m/sec. Based on generalized relationships between bottom current velocities and sediment resuspension thresholds, bottom velocities above approximately 0.3 to 0.4 m/sec may be capable of re-suspending fine-grained sediments (i.e., silt and clay particles). Accordingly, inner Bellingham Bay appears to be primarily a net depositional environment, though periodic resuspension of sediments in the inner bay is possible, particularly in shallow-water areas where bottom velocities can be influenced by wave action. This interpretation is consistent with the predominance of fine-grained sediment textures throughout the inner bay, except in higher-energy shallow-water areas.

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[1] Typical storm surge elevations were obtained from comparisons of empirical water level data and tidal predictions in the Site, as well as estimates of storm surge elevations calculated for Whatcom Waterway and other sites within Bellingham Bay.

3.1.4.4 Surface Currents in Bellingham Bay

Surface currents throughout Bellingham Bay vary primarily in response to wind stress (Shea et al. 1981). Winds over the bay are from the south or southwest during much of the year, typical of foul-weather low-pressure systems in winter months, resulting in the forcing of surface water toward the northern part of the bay with return flow along the shorelines of the Lummi Peninsula, Portage Island, and Lummi Island. Fair-weather winds from the west or northwest cause surface flow to the east and south along the eastern shoreline.

In response to seasonal wind forcing, both clockwise and counter-clockwise circulation patterns are set up in Bellingham Bay, with net circulation in a clockwise direction. The salinity distribution maps of Collias et al. (1966) delineate freshwater discharges from the Nooksack River. The brackish river plume sometimes exits the bay along the western shoreline near Lummi Peninsula and Lummi Island (counter-clockwise circulation), but at other times exits primarily along the eastern shoreline near the City and Post Point where it is then directed southwestward across the bay toward the southern tip of Lummi Island (clockwise circulation). In both configurations, surface water enters Rosario Strait mainly near the southern tip of Lummi Island and Vendovi Island. The compensating inflow of seawater to Bellingham Bay occurs partly via surface waters along the opposite shoreline from the brackish river plume and partly via bottom waters.

Typical surface currents range between 0.02 to 0.06 m/sec in the inner bay, reaching maximum velocities of 0.36 m/sec.

3.1.4.5 Near-bottom and Surface Currents in I&J Waterway

Empirical measurements of current velocities in I&J Waterway are not available. Current velocities within I&J Waterway are assumed to be relatively low, as they are influenced only by tidal fluctuations in Bellingham Bay or local winds. There are no creeks or other large freshwater flows that directly influence current velocities within I&J Waterway; therefore, current velocities in I&J Waterway should be similar in magnitude to those in the inner bay:

- Maximum surface currents are likely around 0.3 foot per second (ft/s).
- Maximum near-bottom currents are likely around 0.1 ft/s.

Empirical data and numerical modeling of current velocities are available for Whatcom Waterway (Anchor QEA 2013c). However, maximum surface and near bottom velocities in Whatcom Waterway are influenced by Whatcom Creek, which drains directly into Whatcom Waterway. Because I&J Waterway is not influenced by creek flows, current velocities within the inner bay are considered more representative of I&J Waterway than currents in other areas, including Whatcom Waterway.

3.1.4.6 Salinity, Temperature, and Total Suspended Solids

In the surface waters of Bellingham Bay (approximately the top 30 feet of the water column), salinity varies with depth and over time. Below that depth, bottom water salinities typically range from 29 to 31 parts per thousand (ppt), are relatively constant with depth, and are relatively stable throughout the year (Colyer 1998).

The observed variability in surface salinity is primarily the result of freshwater input to the bay, wind-induced circulation, and wind-induced vertical mixing. Because most freshwater input comes from the Nooksack River, brackish surface water (between approximately 10 and 25 ppt) is most extensively distributed in the northern part of Bellingham Bay, but a lower salinity surface layer has been observed to extend throughout the bay and south of Post Point (Colyer 1998). This surface layer is typically less than 6 feet thick.

Water temperatures in Bellingham Bay vary with depth and over time, primarily as the result of seasonal air temperature changes. Water temperatures range from 8 to 13 degrees Celsius (°C) and are warmest in summer and early fall and coldest during winter and spring.

The concentration of total suspended solids (TSS) within the inner Bellingham Bay area was recently measured by Colyer (1998). Surface water TSS concentrations ranged from 3 to 25 milligrams per liter (mg/L). Deep water TSS concentrations were similar and ranged from 1 to 32 mg/L. TSS concentrations averaged approximately 10 mg/L in both surface and deep waters.

No empirical salinity, temperature, or TSS data are available for I&J Waterway. However, salinity, temperature, and TSS values within the Waterway are assumed to be similar to surface water conditions in Bellingham Bay.

3.1.4.7 Sea Level Rise and Tsunamis

Physical processes within Bellingham Bay and I&J Waterway can be influenced in the long term by local sea level rise and in the short term by an extreme event, such as a tsunami.

Predictions for sea level rise are uncertain; global averages for sea level rise by the year 2100 range from 0.7 foot to 6.6 feet (NOAA 2012). In addition, predictions of sea level rise can be site specific depending on land subsidence and other factors in the local area. The National Research Council (NRC) has published *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future* (NRC 2012), which provides predictions of sea level rise for these areas. This publication projects that sea level will rise 24 inches (2 feet) by 2100 (with a range of 4 to 56 inches) for coastal waters within the State of Washington. The sea level rise assumed in the Waterfront District Redevelopment Final Environmental Impact Statement (EIS; Port of Bellingham 2010) was 2.4 feet, which is slightly higher than the projection stated in the NRC report for the State of Washington. A 2.4-foot increase in mean sea levels at I&J Waterway by 2100 would result in a future predicted mean higher high water (MHHW) elevation of 11.4 feet MLLW (in comparison to the current MHHW elevation of 8.5 feet based on MLLW defined by the current tidal epoch).

Tsunami impacts to physical processes in I&J Waterway would include short-term increase in water surface elevations and current velocities compared to typical conditions. NOAA has conducted tsunami inundation modeling for Bellingham Bay based on a Cascadia Subduction Zone Earthquake (Priest et al. 1997). Results of this effort are summarized in Walsh et al. (2004). In the Site area, the tsunami depth of inundation is estimated to be between 0 and 1.6 feet based on the modeled seismic event. If a tsunami were to occur, this inundation depth would be added to the water elevation in the bay at that time. This means that the water elevation in the site area may increase by up to 1.6 feet above the tidal elevation at the time. Current velocities (depth-averaged) predicted by Walsh et al. (2004) in I&J Waterway range from 0 to 5 ft/s. While these are higher than anticipated tidal velocities in the

Waterway, they are likely lower than velocities induced by propeller wash (discussed further in Section 6.3.3).

3.1.5 Area Groundwater

Groundwater in the vicinity of the Site generally discharges to surface waters of Bellingham Bay. Groundwater patterns and water quality have been studied in consultation with Ecology as part of the Central Waterfront site RI/FS.

3.1.5.1 Central Waterfront RI/FS Groundwater Studies

Under an Ecology Agreed Order (No. DE3441), the Port is in the process of conducting a RI/FS of the Central Waterfront site. Numerous environmental investigations have been conducted within subareas of the Central Waterfront site. The Central Waterfront site comprises four historically separate cleanup sites: the Roeder Avenue Landfill site, the Chevron site, the Colony Wharf site, and the Olivine Uplands site. These individual sites have been combined into a single site by Ecology to comprehensively address commingled groundwater contamination. The former Olivine Uplands site is adjacent to I&J Waterway.

In 2001, a preliminary draft RI/FS for the Roeder Avenue Landfill site (RETEC 2001) described generalized groundwater flow features within the Central Waterfront area, between I&J Waterway and Whatcom Waterway. This effort was updated in 2009 for the Central Waterfront Draft RI/FS (AECOM 2009). Key observations from these studies included the following:

- Groundwater is predominantly present as a shallow unconfined layer within shallow fill material and underlying native sandy soils. The fill/sand layer varies from approximately 15 feet to more than 20 feet thick adjacent to I&J Waterway. Silty clay soils of the glacial marine drift are located beneath the sandy soils and these soils do not contain significant water-bearing zones. The depths to bedrock are more than 100 feet below ground surface in most of the Central Waterfront area.
- Groundwater in the Central Waterfront area consists of groundwater flow from across Roeder Avenue and infiltration from precipitation within the Central Waterfront area.
- Groundwater gradients adjacent to I&J Waterway generally slope toward I&J Waterway.

- Groundwater discharges in shoreline areas are subject to significant tidally influenced mixing. This mixing is greatest in the area within 100 and 200 feet of the shoreline.

The studies also included three-dimensional groundwater flow modeling for the Central Waterfront area, groundwater quality testing, and a source control analysis. The groundwater flow model was updated in 2009 as part of the Central Waterfront RI/FS and included updated groundwater monitoring and groundwater quality testing. Conclusions of the updated testing and modeling were consistent with the previous Roeder Avenue Draft RI/FS and indicated that groundwater is not a source of contamination to I&J Waterway (AECOM 2009). The Central Waterfront RI/FS is ongoing and will continue to evaluate and address any ongoing sources of contamination.

3.1.6 Sediment Physical Properties

The physical properties of Bellingham Bay sediments have been characterized during historical investigations and RI/FS studies. Historical and RI/FS sampling locations are shown in Figure 3-3.

3.1.6.1 Surface Sediment Grain Size

Visual descriptions and grain size analysis information from RI/FS sampling locations were compiled to describe generalized sediment distribution patterns.

In general, the surface (0 to 12 centimeters [cm]) sediment grain size distribution in the subtidal portions of the Site consists of fine-grained materials. Coarser sediments are noted in intertidal areas. Surface sediment samples generally consisted of clayey silt. Intertidal areas tended to contain more sand and/or gravel material.

3.1.6.2 Sediment Organic Carbon

The distribution of total organic carbon (TOC) content in 2005/2006, 2012, and 2013 surface sediment ranges from 2.01% (IJW-SS-09) to 5.4% (IJ13-SS-102). Most of the samples contained TOC concentrations between 2% and 4%, with an average concentration of 2.9%.

Subsurface sediment TOC content within the Site sediments ranged from a low of 2.45% to a maximum of 20.1% (IJ13-VC-102; 2 to 4 feet depth). The average TOC concentration in subsurface sediment is 7%.

3.1.6.3 Wood Material Distribution

Wood material has been observed in I&J Waterway sediments to a depth of approximately 5.2 to 7 feet below the mudline. The material consisted of rootlets, chips, splinters, fragments (up to 3 inches in length), shredded wood, and sticks. Some of the woody material has been noted to be in a state of decomposition. The woody material has been observed at the head of the Waterway, in the federal navigation channel, and along the southern perimeter of the Site, including beneath the Bornstein Seafoods dock. Wood material may be associated with the historical log rafting activities that have been documented in historical photographs of the Site.

3.1.6.4 Fish Matter

Fish matter, including decomposing fish tissue, bones, and scales, has been observed to varying degrees in surface and subsurface sediments in the vicinity of the Bornstein Seafoods dock, and occasionally in less substantial deposits in subsurface sediments in other parts of the Waterway (Appendix D). The greatest concentration of fish matter was observed in the deeper subsurface sediments near the dock, with decreasing amounts closer to the sediment surface. The Bornstein facility currently does not discharge such materials to the Waterway.

Berth area and underpier areas tend to be subject to vessel propeller wash forces, potentially minimizing additional sediment deposition. A core collected underneath the dock (IJ13-VC-101) and cores collected adjacent to the dock (IJ-26, IJ-27, and IJ-28) contained a significant percentage of fish matter in surface and subsurface sediments. Silt with fish matter was observed from 0 to 2.6 feet below mudline in core IJ13-VC-101 and from 0 to 2.7 feet below mudline in core IJ-26, and less significant deposits of fish matter were observed from 0 to 4.6 feet below mudline in core IJ-27 and 0 to 2 feet below mudline in core IJ-28. Some cores in other parts of the Waterway also contained fish matter in subsurface sediments, but in significantly lower amounts.

3.1.6.5 Subsurface Sediment Physical Properties

Throughout most of the Site, core samples of subsurface sediments are dominated by silt, including in deep-water depositional areas and in portions of the Waterway that were historically dredged and have accumulated recent sediment deposits. The distribution of subsurface sediment textures varies with the wave energy environment and is also influenced by native subsurface geologic patterns and patterns of historical dredge and fill activity. Some geotechnical testing has been performed on sediments from underneath the Bornstein Seafoods dock and from the nearby Whatcom Waterway site (RETEC 2006b; Anchor QEA 2010), which is similar to I&J Waterway in subsurface sediment composition. Observations from these tests include the following:

- **Atterberg Limits:** Atterberg limit analyses were completed on two surface samples (IJ13-SS-101 and IJ13-SS-102) and in co-located subsurface samples from underneath the Bornstein Seafoods dock. Atterberg limits, which include the liquid limit, plastic limit, and plasticity index, were used to define plasticity characteristics of clays and other cohesive sediments. These results help define dredgability and compression properties of fine-grained sediments. Surface samples were classified as low-plasticity clay to silt (IJ13-SS-101 and IJ13-SS-151) and high plasticity silt (IJ13-SS-102). Subsurface samples were classified as low-plasticity silt (IJ13-VC-101-2-3.9 and IJ13-VC-102-4-5.4) and high plasticity silt (IJ13-VC-101-2-4). Historic Atterberg limit analyses are also available from samples collected in Whatcom Waterway. Atterberg limit analyses were completed on ten selected cohesive core samples representing a variety of depths. The majority of cohesive samples were classified as a medium to high elastic silt or clay. Two samples characterized the compact Glacial Marine Drift unit that is also present in deeper areas of I&J Waterway as clay with low plasticity (HC-VC-72-S4 and HC-VC-79-S4).
- **Sediment Density:** Profiles of sediment density were determined for four natural recovery cores in and near Whatcom Waterway. Sediment wet density was calculated using an empirical formula derived by Battelle (1995) for sediment compositions typical of Puget Sound. Sediment wet density calculations were volumetrically corrected for compaction compression, which occurred during coring. Average surface (0 to 2 cm) wet density in inner Bellingham Bay ranged from approximately 1.23 to 1.30 grams per cubic centimeter (g/cm^3). Wet density

increased with depth in the cores to a maximum of approximately 1.32 to 1.42 g/cm^3 at a depth of 1 meter below the mudline.

3.1.7 Sediment Lithology

The subsurface geology of the Site area has been characterized in multiple investigations since the early 1990s. The discussion below is based on investigation findings, historical and current bathymetry maps, dredging histories for the Waterway, and upland borings and reports from existing environmental and geotechnical studies.

The sedimentary sequence within the site sediments is a function of fluvial sediment loads, deltaic growth rate, and the local depositional environment. A rapidly advancing delta front is characterized by an abundance of sands. Slower growth periods are characterized by finer grained sediments, principally silts, being deposited in lower energy environments. The distributary channels within a delta also meander and shift, resulting in erosion and channel backfilling. Discharges from the Nooksack River, Whatcom Creek, and Squalicum Creek all contribute to the area sediment profiles, which commonly display sediment stratigraphy consisting of soft silts, inter-layered sands, gravelly sands, silty sands, and sandy silts.

The natural depositional environment of the Waterway has been altered by dredging (including excavation of the original Waterway), maintenance dredging, and fill replacement during nearshore construction. The Waterway area sediments can be divided into the following major sediment units:

- **Recent Deposits:** Recent deposits consist primarily of very soft, brown-black, slightly sandy, clayey silt with shell fragments and varying amounts of wood debris overlying a soft, dark gray silt with trace wood fragments. The thickness of the recent deposits varies between less than 1 foot and greater than 7 feet. In some cases, the physical sequences of the sediments have been disturbed, for example by shoreline construction, or by shoreline erosion. Contamination is present in the recent deposits, above the post-glacial fluvial deposits or glacial marine drift (described below).
- **Post-Glacial Fluvial Deposits:** This unit consists of medium dense, gray, non-silty to silty, fine to medium sand with multi-colored grains, shell fragments, and occasional

gravel and silt lenses grading to gray silt with clay. This unit represents native fluvial sediments, primarily from Whatcom Creek, deposited prior to industrialization of the area. The base of this sand unit is gradational in nature and tends to be present between an elevation of approximately -18 to -21 feet MLLW near the head of I&J Waterway, especially beyond the head of the federal navigation channel.

- **Glacial Marine Drift:** The third major unit is a stiff to very stiff, damp to moist, gray, silty clay to clay with scattered gravels and occasional fine to medium sand layers. The drift was encountered at elevations ranging from -18 to -22 feet MLLW in the federal channel, based on results of sediment cores collected in 2006. Figure 3-4 presents the elevation of the glacial marine drift layer observed in sediment cores. The layer also incorporates soundings collected after the original 1966 waterway dredging, which excavated out of the glacial marine drift layer throughout the federal navigation channel and berthing areas near Bornstein Seafoods. This glacial outwash unit was also confirmed in adjacent upland borings advanced through fill at the Central Waterfront site.

Figure 3-5 presents a conceptual geologic cross section of I&J Waterway, based on observations of upland borings and sediment cores in the area.

3.2 Natural Resources

This section summarizes information on natural resources in the Site area, including fish and wildlife, existing habitats, and plant and animal species.

3.2.1 Types and Functions of Habitats

Detailed information on bay-wide habitat conditions and habitat maps can be found in the Data Compilation Report (PIE and Anchor Environmental 1999a). Most of the habitats in Bellingham Bay are used by a variety of marine and terrestrial species for feeding, reproduction, rearing, and refuge. I&J Waterway specifically hosts various benthic macroinvertebrates (e.g., bivalves, crabs, and polychaetes), as well as providing habitat or passage for various fish species (both bottom fish and pelagic species such as salmon).

The different elevations of habitat are discussed below in three groups: intertidal, shallow subtidal, and subtidal. Although separated by only a few feet, these three strata have distinct soil textures and support varying plant and animal communities. Each stratum has two types of substrata: sand/mud/cobble and gravel/rocky shore. The habitat typically found in these strata is summarized here to preface more detailed descriptions of fish and wildlife habitat in the bay.

- **Intertidal: -4 Feet to +11 Feet MLLW**
  - **Sand/mud/cobble:** This area supports rooted plants to varying degrees, with increased numbers and variety occurring at higher elevations. Native eelgrass is most commonly found at 0 to -4 feet MLLW, while rushes, sedges, and pickleweed can be found at +11 feet to +8 feet MLLW. These plants provide food and refuge to various organisms, including juvenile salmon, shrimp, crab, and flat fish. Mudflats found in this substratum support epibenthic prey that are consumed by juvenile salmon migrating through the area. Pacific herring may also use the eelgrass and macroalgae found in the intertidal zone as spawning habitat. The finer substrate at higher elevations (+8 to +11 feet MLLW) provides spawning habitat for sand lance and surf smelt. Intertidal habitat of this kind is limited to areas at the head of I&J Waterway and areas along portions of the sides of I&J Waterway.
  - **Gravel/rocky shore:** Native eelgrass is occasionally found in pools and channels on the rocky shores at about 0 foot MLLW. Brown, green, and red algae are also found throughout this area. The higher elevations of this substratum are affected by higher tides; plant material can consist of lichens, some flowering plants, and leadwort. Animals commonly encountered include crabs, shrimp, sponges, sea anemones, worms, sea stars, oysters, and various fish (e.g., perch, prickleback, flat fish, and some juvenile salmon). Fish use this area for feeding, refuge, and reproduction. Armored and rocky areas of I&J Waterway with this type of habitat are located along the north side of the Waterway.
- **Shallow Subtidal: -4 to -10 Feet MLLW**
  - **Sand/mud/cobble:** The plant and animal communities and functions in this substratum are similar to those described in lower elevations of the intertidal habitat; a notable exception is native eelgrass, which is typically more common

  within the -4 to -10 feet MLLW zone. Mudflats within this substratum support epibenthic prey that is consumed by juvenile salmon migrating through the area. The substrate within this elevation can also provide suitable habitat for Dungeness crab mating and egg brooding. Shallow subtidal areas are located at the heads and along portions of the sides of I&J Waterway.
  - **Gravel/rocky shore:** Native eelgrass is occasionally found in this area, as are a variety of brown, red, and green algae. Animals common to this substratum include crabs, shrimp, sponges, sea anemones, worms, sea stars, oysters, and a variety of fish such as perch, prickleback, flat fish, and some juvenile salmon. The fish use this area for feeding, refuge, and reproduction. Rocky shallow subtidal habitats are located along northern portions of I&J Waterway.

- **Subtidal: Greater than -10 Feet MLLW**
  - **Sand/mud/cobble:** Native eelgrass is still relatively common between -10 and -20 feet MLLW; however, beyond 20 feet below, light is limited and eelgrass and macroalgae are less prevalent. Some varieties of hard-shell clams are also less abundant with increased depth, while the geoduck clam tends to be more abundant in deeper water. The substrate within this elevation can provide suitable habitat for Dungeness crab mating and egg brooding. The substrate and water column are also used for feeding by a variety of fish, including sub-adult and adult juvenile salmon. Portions of the Site consist of subtidal habitat with sand or mud bottom.
  - **Gravel/rocky shore:** Larger-sized fish and shellfish often occur in deeper waters. Greater than -20 feet MLLW, light reaching the sea floor limits the abundance and growth of macroalgae. In addition, the occurrence of some species such as oyster is rare. Rocky subtidal shorelines within the Site predominantly occur along the developed shorelines.

Portions of the Site area have been developed for navigation uses with infrastructure improvements. This infrastructure affects the types of habitat conditions that are present in these areas. Other than depth modifications (i.e., dredging), the main types of navigation infrastructure that exist in the Site area include bulkheads, armored slopes, and over-water structures. Habitat considerations associated with these features are described below:

- **Bulkheads:** The term bulkhead refers to constructed sheer vertical walls that stabilize the shoreline. Typically they are concrete or metal sheetpile, although many older bulkheads are constructed from treated timber. In I&J Waterway, two bulkheads exist along the southeastern perimeter of the Waterway. Each extends from above MHHW (+17 feet MLLW) to the structure design depth, which is below +1 foot MLLW. A bulkhead yields a habitat with no depth variability and no horizontal surfaces to support primary production, secondary production, or processing of detritus. While sessile organisms, including barnacles and some macroalgae, can attach to the vertical bulkheads, it is not suitable for producing epibenthic prey organisms for juvenile salmon. The vertical slope also means that juvenile salmon using the top 1 to 2 meters of the water column are in much deeper water during most or all tidal cycles, depending on the bottom elevation of the bulkhead, compared to a naturally sloping nearshore area. This may increase their susceptibility to predators. Juvenile salmon use waters adjacent to bulkheads and can forage on prey items derived from planktonic or neustonic sources. However, due to the lack of epibenthic organisms, overall prey resources are typically considered to be reduced relative to sloped habitat.
- **Armored Slopes:** Slopes armored with large stones (riprap) are present west of the USCG facility along the north shoreline, and to a lesser extent east of the USCG facility (only upper areas are armored, with smaller rock). These areas are typically 3H:1V and compress the horizontal habitat profile, yielding less habitat within the desired zones for juvenile salmonids than do more gently sloped habitats. Unlike bulkheads, the resulting habitat does have surfaces to support primary productions, secondary production, and processing of detritus. At elevations that are exposed to regular, significant wave energy, riprap has essentially no ability to retain water or organic material on its own, except in depressions in individual pieces. Exposed rock surfaces at these elevations eventually develop sessile biological matrices, including macroalgae and invertebrates, which reduce desiccation at small scales and allow for an assemblage including mobile invertebrates. At lower elevations that do not have significant wave exposure, riprap can provide a suitable substrate for many different species of macroalgae and also provides habitat areas in its interstices for invertebrates. A common means of improving the productivity of riprap slopes is to fill the interstices of the rock with a finer material (e.g., gravel) that can increase both

water and organic material retention, and increase the ability of the bulkhead slope to support an assemblage include juvenile salmon prey organisms. This method may not be appropriate in higher energy areas where substrate may not be retained at mid and higher elevations. The biological assemblages on riprap substrate are more comparable to that of a rocky nearshore area than beaches. While there are epibenthic prey available for juvenile salmon in these areas, habitat function is reduced compared to areas with smaller substrate. Juvenile salmon use waters adjacent to riprap and can forage on prey items derived from planktonic or neustonic sources, as well as the limited epibenthic prey.

- **Overwater Structures:** Intertidal and shallow subtidal shading has decreased light levels underneath and around overwater structures. Shading is of primary concern because it reduces light available for photosynthesis by aquatic vegetation. Reduced primary productivity has implications both in terms of habitat structure and complexity (reduction or loss of aquatic vegetation), and in terms of supporting productivity elsewhere in the food web, including juvenile salmon prey organisms. Shading impacts extend beyond the structural footprint of the structure as the sun's movement across the sky over a day or season results in a larger shaded area as it is oriented in different aspects. Small structures, such as narrow piers, shade relatively less area than large or wide structures such as pier aprons. Depending on the orientation of the narrow structure, direct sunlight can reach most of the shade footprint over the course of a day or season. The distance from the lighted edge to the center of the structure footprint is also relatively smaller than at a wider structure, resulting in higher levels of ambient light. In contrast with wide structures, large proportions of the shade footprint may never receive direct sunlight. Wider structures also decrease the ratio of lighted edge to shaded area, and increase the distance from the lighted edge to the center of the structure footprint. This results in less ambient light under wider structures and therefore more intense impacts associated with shading. This has implications for productivity and can reduce the habitat function of an area for juvenile salmon foraging. Nearshore habitat function may be reduced underneath and immediately adjacent to overwater structures. For juvenile salmon, this impact is relatively greater at the typically highly productive low to middle intertidal zone, although impacts on macroalgae in the shallow subtidal and salt tolerant plants in the supratidal splash zone also can affect productivity in these zones. As with bulkheads, foraging function around overwater structures may be reduced due to decreased productivity, but alternative food sources (e.g., plankton and neuston) are available. Those juvenile salmon that move into deeper water to avoid overwater structures may be more susceptible to deeper water predators, but this behavior is not always the response to encountering a structure.

3.2.2 Plant and Animal Species

The Bellingham Bay area is utilized by a wide range of plant and animal species. Documented uses for significant plant and animal species are summarized in Sections 3.2.2.1 through 3.2.2.3.

3.2.2.1 Fisheries and Invertebrate Resources

Documented fisheries resources for Bellingham Bay include the following:

- **Surf Smelt and Sand Lance:** Surf smelt and Pacific sand lance are common fish that spawn in the high intertidal portions of coarse sand and gravel beaches (WDFW 1992). Surveys by the Washington Department of Fish and Wildlife (WDFW) have documented spawning beaches in Bellingham Bay. However, no surf smelt or sand lance spawning has been documented in inner Bellingham Bay, presumably because suitable substrates are not available.
- **Pacific Herring:** Pacific herring spawn in inland marine waters of Puget Sound between January and June in specific locations. There is typically a 2-month peak within the overall spawning season. Herring, which deposit their eggs on marine vegetation such as eelgrass and algae in the shallow subtidal and intertidal zones between +1 foot and -5 feet MLLW, are known to congregate in the deeper water of Bellingham Bay. However, only relatively low-density spawning deposition occurs in the bay, and none of that has been documented in the vicinity of I&J Waterway.
- **Salmonids:** Bellingham Bay is used extensively by anadromous salmon species (Shea et al. 1981). Each of the streams flowing into Bellingham Bay is used by one or more of the economically important species listed in Table 3-1. The Nooksack River has the largest salmon runs in Bellingham Bay, followed by Squalicum and Whatcom creeks. Concentrations of chum (*Oncorhynchus keta*), coho (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) along the shoreline and in offshore

waters in Bellingham Bay peak annually about mid-May. Juvenile coho and Chinook salmon appear to have different migration habits. Coho remain in the bay for approximately 30 to 35 days, while Chinook salmon remain about 20 days. More recent studies on the distribution of Chinook salmon (Ballinger and Vanderhorst 1995) indicate relatively high numbers of juvenile Chinook salmon and average numbers of coho salmon use the area around Whatcom Waterway. It is less likely that juvenile salmonid use I&J Waterway than Whatcom Waterway, because of higher salinity conditions in I&J Waterway (Port of Bellingham 2008).

- **Groundfish:** Several species of groundfish occur in both shallow and deep waters in Bellingham Bay for part or all of their life. Detailed information on groundfish species and their timing and use of Bellingham Bay is not available. Key characteristics of groundfish occurring in northern Puget Sound are generally applicable to Bellingham Bay.

Bellingham Bay supports a variety of marine invertebrates, ranging from infauna (worms, clams, and small ghost shrimp that penetrate benthic sediments) to epibenthic plankters (organisms such as very small crustaceans that move off the substrate surface) to larger invertebrates such as oysters, crabs, and shrimp, as described below:

- **Clams, Geoduck, and Oysters:** The predominant bivalves in Bellingham Bay are intertidal and subtidal hard-shell clams. Intertidal shell clam types include butter, littleneck, horse, and soft-shell clams and cockles. Subtidal clam resources consist of butter, littleneck, and horse clams. Native oyster and Pacific geoduck are also known to occur in Bellingham Bay (Palm 1995; WDFW 1981, 1992; Webber 1974). Shellfish densities are relatively low along the eastern shore of Bellingham Bay and in the vicinity of Whatcom Waterway, although bivalves are the dominant benthic organism within the Waterway (Anchor Environmental 1999). Scattered oysters also occur along the shoreline of the Whatcom Creek estuary (Palm 1995). Geoduck, which is only present in a handful of locations in the bay, does not occur within I&J Waterway.
- **Shrimp:** Seven species of pandalid shrimp, including, pink (*Farfantepenaeus brevirostris*), coonstripe (*Pandalus hypsinotus*), dock (*Pandalus danae*), and spot shrimp (*Pandalus platyceros*), occur in nearshore and deeper waters of Bellingham Bay. For example, coonstripe shrimp have been observed in intertidal areas

immediately offshore of the Cornwall Avenue Landfill (just south of Whatcom Waterway), and this species is common around piers and floats. Shrimp densities in the areas surrounding I&J Waterway are assumed to be moderate when the bay is viewed as a whole.

- **Crab:** Crab trawls conducted for the Puget Sound Dredge Disposal Analysis (PSDDA) program investigations indicate that the predominant crab resources in Bellingham Bay are the non-edible purple or graceful crab (*Cancer gracilis*), the edible red rock crab (*Cancer productus*), and the edible Dungeness crab (*Cancer magister*). The highest densities of rock crab occur in relatively shallow water (-30 to -45 feet MLLW) in areas extending from the Lummi Peninsula to inner Bellingham Bay. Rock and Dungeness crab are likely to occur in shallower waters of Bellingham Bay not sampled as part of the PSDDA investigations. Dungeness crab is generally abundant in most areas of Bellingham Bay and has been documented in Whatcom Waterway (Ecology 2003). The northern and eastern shorelines of Bellingham Bay serve as nursery/rearing areas for juvenile Dungeness crab. A shell substrate is a preferred habitat for the first 8 to 10 weeks after larvae settle. However, other substrates, such as small cobbles and gravel, algae, and eelgrass, are also recognized as important rearing habitat for juvenile crab. Because I&J Waterway has relatively limited quantities of these habitats, its usefulness as a nursery/rearing area is likely limited.

3.2.2.2 Sea Birds and Marine Mammals

The greater Bellingham Bay area and its shallow estuarine habitats support a number of birds at all seasons. Although Bellingham Bay is not used extensively by large populations of waterfowl, wintering populations tend to be 10 to 15 times larger than summer populations for migratory species (Manual et al. 1979). The bay is located on the flight path between the Fraser River estuary and Skagit Bay, and is used as a stopover for seabirds and waterfowl migrating between these two areas. Waterfowl sighted in Bellingham Bay include brant, snow geese, mallard, widgeon, green-winged teal, and pintail. Bellingham Bay is also used as an over-wintering area for diving birds such as scoter and golden eye. A variety of both natural and man-made habitats provide protection from winter storms to migrant and wintering birds.

Glaucous-winged gulls use inner Bellingham Bay for resting and foraging. Pigeon guillemots use the shoreline area in and around Whatcom Waterway for nesting and foraging. The *Habitat Restoration Documentation Report* (PIE and Anchor Environmental 1999b) describes the individual bird species and their use of Bellingham Bay by season.

Limited information is available on the presence and residence time of marine mammals in Bellingham Bay (PTI 1989). Bay-wide, several species have been reported: the harbor seal (*Phoca vitulina*), sea lion (*Otariidae*), orca whale (*Orcinus orca*), gray whale (*Eschrichtius robustus*), and harbor porpoise (*Phocoena phocoena*). As described in the following sections, humpback whales (*Megaptera novaeangliae*), Steller sea lions (*Eumetopias jubatus*), and the local population of orca whale are listed as threatened or endangered under the Endangered Species Act (ESA). The other marine mammals are not threatened or endangered species under the ESA, but they are protected from hunting under the Marine Mammal Protection Act. Seals and sea lions have been noted using the Log Pond along Whatcom Waterway and portions of I&J Waterway for resting areas. Migrating gray whales have been noted to enter Bellingham Bay and to feed in subtidal areas of Puget Sound. Orca whales are occasionally observed in and near Bellingham Bay, though they are more typically observed in Rosario Strait and near the San Juan Islands.

3.2.2.3 Threatened, Endangered, Sensitive, and Candidate Species

Under the ESA, a species that is likely to become extinct is categorized as "endangered." A species likely to become endangered within the foreseeable future is categorized as "threatened." This section provides information on the occurrence of threatened and endangered fish, marine mammal, and bird species in Bellingham Bay. It also includes information on WDFW priority species and habitats in Bellingham Bay.

Puget Sound Chinook Salmon: Puget Sound Chinook salmon were listed as threatened on August 2, 1999 (NOAA 1999). The Puget Sound evolutionarily significant unit (ESU) of Chinook salmon includes all naturally spawned populations from rivers and streams flowing into Puget Sound, including the Strait of Juan de Fuca from the Elwha River eastward, and rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington, as well as 26 artificial propagation programs. The Nooksack River, which is located approximately 4 miles northwest of the Site, carries early-timed (spring) and late-timed (fall) stocks of Chinook salmon. Three additional Chinook salmon-bearing streams are located in the vicinity of the Site, including Squalicum Creek and Whatcom Creek to the northwest and Padden Creek (WDFW 2014a). These streams all carry fall stocks. Adult Chinook salmon use much of Puget Sound during their migration to and from the open ocean and their upriver spawning grounds. Adults are opportunistic pelagic feeders, and their diets consist of smaller forage fish such as herring, surf smelt, and sand lance as well as squid, larval crabs, and pelagic amphipods.

Adult Chinook could be present in the offshore waters near the Site mainly in the summer and fall (outside of the in-water work window) prior to their upriver migration, but are not expected in the nearshore. Juvenile Chinook salmon would be expected to use the nearshore areas of the Site as they migrate out of their natal streams and rivers. Designated ESA critical habitat for Chinook salmon in and around the Site includes freshwater, estuarine, nearshore, and offshore marine areas.

Puget Sound Steelhead (*Oncorhynchus mykiss*): Puget Sound Distinct Population Segment (DPS) steelhead were listed as threatened on May 11, 2007 (NOAA 2007). The Puget Sound DPS of steelhead includes all naturally spawned anadromous winter-run and summer-run populations, in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive), as well as the Green River natural and Hamma Hamma winter-run steelhead hatchery stocks. In addition to the Nooksack River, three steelhead-bearing streams are located in the vicinity of the proposed project including Squalicum Creek and Whatcom Creek approximately 1 and 1.5 miles (respectively) to the northwest, and Padden Creek, approximately 1 mile to the south (WDFW 2014a).

Puget Sound steelhead exhibit two life history types (winter-run and summer-run) that are defined based on the timing of adult returns to their natal spawning streams and by their degree of sexual development at the time they enter freshwater (NMFS 2005). The Puget Sound DPS, including the Nooksack River population, is primarily composed of winter-run steelhead stocks, but also includes several small stocks of summer-run steelhead occupying limited habitat. The three creeks noted above all carry winter-run stocks. Winter-run, or ocean-maturing, steelhead enter freshwater between November and April at an advanced stage of maturation and spawn shortly thereafter, usually from March through June. Summer-run, or stream-maturing, steelhead enter freshwater in a sexually immature stage, usually between May and October. These summer-run steelhead remain in freshwater for several months before reaching maturity and spawning between January and April. Juvenile steelhead out-migrate from freshwater between mid-March and early June. Juvenile steelhead enter marine waters at a much larger size and have a higher rate of survival than other salmonid species. The majority of steelhead smolts appear to migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al. 1992).

Naturally produced juvenile steelhead presence would be extremely rare in the Site during the expected in-water work window. Some hatchery smolts may be present, although they are released by WDFW typically later than the proposed in-water work window and other work window exemption (April and May). Adult steelhead could be present at any time of year. Designated ESA critical habitat for steelhead in and around the Site includes freshwater, estuarine, nearshore, and offshore marine areas.

Bull Trout (*Salvelinus confluentus*): The Coastal-Puget Sound DPS Bull Trout was listed as threatened by the U.S. Fish and Wildlife Service (USFWS) under the ESA on November 1, 1999 (DOI 1999). Bull trout were originally classified with Dolly Varden (*Salvelinus malma*) under a single scientific name. In 1991, the American Fisheries Society (AFS) supported the decision to separate them into two distinct species. Information on the distribution and life history of each species is not distinct because the species are biologically similar (Bonar et al. 1997). Thus, the two are often counted as the same in surveys, as in those discussed below. Typical bull trout timing for spawning is from August through November (McPhail and Murray 1979; Pratt 1992). Resident and juvenile bull trout prey on invertebrates and small fish, and adult migratory bull trout primarily eat fish.

In northern Puget Sound, bull trout occur in the Nooksack, Skagit, Stillaguamish, and Snohomish basins. Sub-adult and adult bull trout feed mostly on fish in marine/estuarine areas of northern Puget Sound (e.g., smelt, herring, and juvenile salmonids). The closest spawning populations to the Site occur in the North, Middle, and South Forks of the Nooksack River, which enters Bellingham Bay approximately 4 miles from the Site.

The Water Resource Inventory Area (WRIA) 1 salmonid Recovery Plan notes that out-migrating juvenile bull trout have been caught in the lower Nooksack River smolt trap from early April to late August (NNR et al. 2005). Juveniles have been caught in the lower mainstem Nooksack River from early April through mid-July (Ballenger 2000) and would be expected in nearshore marine areas in and near Bellingham Bay during that time frame. Adults in the Nooksack population spawn from August to October (NNR et al. 2005) and would be expected in offshore areas of the proposed project prior to their spawning migration. Bull trout have been documented as present in Whatcom Creek (COB 2011) but do not spawn there. Designated ESA critical habitat for bull trout in and around the Site includes freshwater, estuarine, nearshore, and offshore marine areas.

Bocaccio (*Sebastes paucispinis*), Yelloweye (*Sebastes ruberrimus*), and Canary Rockfish (*Sebastes pinniger*): Adult bocaccio are most commonly found at depths between 160 and 820 feet, but may be found as deep as 1,560 feet (Feder et al. 1974; Love et al. 2002). Juveniles and sub-adults are more common than adults in shallower water, and bocaccio are known to school in nearshore waters as juveniles (McCall and He 2002). Adults are generally associated with rocky areas and outcrops but may also be found in areas lacking hard substrate. Bocaccio rockfish are rare in the North Puget Sound, where the Site is located.

Yelloweye adult rockfish occur in waters 80 to 1,560 feet deep (Orr et al. 2000) but are most commonly found at depths between 300 and 590 feet (Love et al. 2002). They are typically associated with high relief zones with crevices and complex rock habitats (Love et al. 1991; Richards 1986). Juveniles are associated with rocky reef areas, kelp canopies, and artificial structures and may be more common than adults in shallower waters. Based on habitat requirements and life histories, yelloweye rockfish are considered highly unlikely to occur in the Site.

Canary rockfish most commonly inhabit waters 160 to 820 feet deep (Orr et al. 2000) but may be found in waters as deep as 1,400 feet (Boehlert 1980). They were once common in the greater Puget Sound area but are now rare. Similar to other rockfish, canary rockfish are live-bearers, and larvae are found in surface waters over a wide area (Moser 1996). Based on habitat requirements and life histories, canary rockfish are considered highly unlikely to occur in the Site.

Critical habitat for ESA-listed rockfish species has not been designated.

Orca Whales: On November 18, 2005, the National Marine Fisheries Service (NMFS) listed the Southern Resident DPS of killer whale (also known as orca whales) as endangered under the ESA (NOAA 2005). Killer whales in the eastern North Pacific region are categorized as resident, transient, or offshore whales. Residents in the North Pacific are further classified into Northern, Southern, Southern Alaska, and Western North Pacific groups. The Southern Resident killer whale group has been established as a DPS and a stock under the Marine Mammal Protection Act of 1972; this group contains the pods, or groups, of J pod, K pod, and L pod, and was estimated to include approximately 89 individuals as of December 2011 (Center for Whale Research 2012, pers. comm.).

Orca whales are not frequently spotted in Bellingham Bay due to the shallow tideflats that typify the marine environment. The Whale Museum in Friday Harbor, Washington, provides the most up-to-date verified scientific information on killer whale sightings in Puget Sound (Osborne 2009, pers. comm.). The museum has maintained a database of verified sightings by location "quads," and the database was last updated in 2010. No killer whales were sighted in any of the five quads surrounding the Site from 2008 to 2010. Based on their known distribution and the lack of recent sightings, it is highly unlikely that orca whales would occur in the shallow waters of the Site, but they could potentially occur in the offshore waters of Bellingham Bay, with a higher likelihood in the summertime. The proposed project lies within the Puget Sound area of orca whale critical habitat.

Marbled Murrelet (*Brachyramphus marmoratus*): Marbled murrelets are small seabirds that occur along the Pacific Coast from the Bering Sea to central California, with the largest population occurring in southeastern Alaska and northern British Columbia. In Washington, murrelet populations tend to be concentrated on the outer coast, along the northern coast of the Olympic Peninsula and in the northern portion of Puget Sound (McShane et al. 2004; MMEMM 2008).

Field observations of murrelets in Puget Sound have suggested that foraging distribution is linked to tidal patterns that increase prey availability for the birds (Speich and Wahl 1995). Murrelets forage year-round in waters generally less than 90 feet deep and are most frequently within 1,500 feet of protected shoreline waters. They typically feed on forage fish, small crustaceans, and invertebrates. Old-growth or mature forest stands appear to be crucial for breeding and foraging, and most nests are in conifers more than 150 years old, and in trees greater than 55 inches diameter at breast height.

Recent marbled murrelet distribution data indicate that marbled murrelets could occur in Bellingham Bay in low numbers. WDFW Priority Habitat and Species information for the Site vicinity indicates murrelet presence in Whatcom County (WDFW 2014b), and WDFW winter aerial surveys (on- and off-transect, and 2-minute grid cells) from 1993 to 2004 showed the presence of marbled murrelets in the grid cell between Eliza Island and Fairhaven to the south with animals estimated at less than two birds per square kilometer (WDFW 2004). Based on this information, murrelets are not likely to be frequently found immediately near the Site, but they could be present in nearby marine waters. Marbled murrelets could fly through nearby forested areas and use the marine areas near the Site for foraging and may fly over the Site while migrating between foraging and nesting areas.

In addition to the ESA-listed species in the project vicinity, the WDFW priority species that may occur in the vicinity of the proposed project include the following:

- Chum salmon
- Coho salmon
- Sea-run cutthroat trout (*O. clarkii clarkii*)
- Pink salmon (*O. gorbuscha*)
- Sockeye salmon (*O. nerka*)
- Caspian tern (*Sterna caspia*)

There is a documented Caspian tern breeding area at the former Georgia-Pacific (GP) West Site and two priority seabird colonies (glaucous-winged gull and pigeon guillemot) exist in

Bellingham Bay. Two priority harbor seal haul-outs are also present in Bellingham Bay. Documented priority Pacific herring (*Clupea harengus pallasi*) holding areas, Dungeness crab, and Pandalid shrimp (*Pandalidae spp.*) are all located within 1 mile of the Site. Priority aquatic vegetation and macroalgae species in the Site include eelgrass, and turf algae (*Endocladia muricata*) are also in the vicinity of the Site (WDFW 2014b; Ecology 2007).

3.3 Historic and Cultural Resources

Historic and cultural resources for this Site were evaluated by the Port as part of the Waterfront District redevelopment project and are presented in the Waterfront District EIS (Northwest Archaeological Associates 2007). The area that comprises the Site historically consisted of tide flats, with the shoreline generally corresponding with the bottom of the bluff area. Dating back from pre-history to the 19th century, the Bellingham waterfront was occupied by ancestors of the present-day Lummi Nation and Nooksack Indian Tribe. The settlement and subsistence of communities throughout this region were similar in many ways, primarily in the seasonal cycle of congregation at winter villages. Winter villages were usually located along protected coastlines, where activities such as shellfish gathering and fishing were pursued. European settlement took hold on Bellingham Bay during the 1850s, and the Bellingham waterfront has since been primarily a shipping and industrial area.

The Site is located within the usual and accustomed (U&A) harvest areas of the Lummi Nation and Nooksack Indian tribe. These U&A areas include all tidelands in Bellingham Bay. The Bornstein Seafoods dock was constructed in two phases, in 1947 and 1963. Properties 50 years or older may be considered historic if they retain their historic integrity and are considered significant. The Bornstein Seafoods dock is not currently included on the National Register of Historic Places, the Washington Heritage Register, or the Bellingham Local Registry (Port of Bellingham 2008).

3.4 Land and Navigation Uses

Land within the Site is owned by both public and private entities. Existing uses and use designations are currently changing and are the subject of an intense community planning effort. Anticipated future land use will include enhanced public access at the head of the

Waterway. Section 2.1 describes current property ownership within and adjacent to the Site. Section 3.4.1 provides an overview of current land use regulations and planning activities.

3.4.1 Overview of Land Use Planning Activities

I&J Waterway is located partially within and adjacent to the Waterfront District area, which is undergoing a transition from historical industrial land uses to mixed-use development. This section provides an overview of the land use planning activities that are shaping, and are being shaped by, this change in land use.

3.4.1.1 Bellingham Bay Comprehensive Strategy

As described in Section 2.1.2, the Bellingham Bay Comprehensive Strategy was developed by a cooperative partnership of agencies, tribes, local government, and businesses known collectively as the Pilot Work Group. The Comprehensive Strategy was intended to provide long-term guidance to decision-makers relating to implementation of sediment cleanup, source control, and habitat restoration actions in Bellingham Bay. The Comprehensive Strategy was finalized as a Final EIS in October 2000, and it preceded some of the significant land-use changes that have occurred since that time. Much of the work of the Pilot, especially regarding potential habitat restoration actions, remains relevant. While the Port and City are not bound by regulation to implement these potential restoration actions, many of the habitat restoration actions that were identified in Appendix A of the 2000 EIS as furthering Pilot goals have been either implemented or have been carried forward as part of community land use planning efforts since 2000. These habitat goals were reflected in the Waterfront Vision and Framework Plan (WFG 2004) and the Waterfront District Subarea Plan (Port of Bellingham and City of Bellingham 2013) and supporting EIS documents (Port of Bellingham 2010, 2012).

3.4.1.2 Shoreline Master Program Update

The City recently revised their state-mandated Shoreline Master Plan (SMP), which regulates and manages uses and activities within 200 feet of the shorelines of the City. The revised SMP was approved by Ecology in January 2013. The pocket beach at the head of I&J Waterway is categorized as an urban maritime recreational use subarea and is identified as an area where public access will be established or enhanced.

3.4.1.3 Port Land Use Planning Activities

The Port is responsible to the citizens of Whatcom County for providing shipping and marine cargo facilities, general boating, and maritime industry facilities, as well as assisting in maintaining and developing a healthy regional economy. The Port's main planning tools are area Master Plans and the Port's Comprehensive Scheme of Harbor Improvements. Over the past few decades, the Port has led and participated in extensive land use planning activities related to Bellingham's waterfront areas.

The Port has partnered with the City to participate in land use planning efforts for the redevelopment of the Waterfront District area, including development of the Draft Subarea Plan for the area of Bellingham's Waterfront. The Draft Subarea Plan is the culmination of a planning partnership effort between the City and the Port that has included input from the public and different agencies. The Draft Subarea Plan aims to provide a framework for long-term redevelopment in the Waterfront District that incorporates the vision and elements of the Waterfront Vision and Framework Plan (WFG 2004).

The Draft Subarea Plan includes a phased approach to completion and divides the Waterfront District into five development areas. I&J Waterway is located in the Marine trades development area. The redevelopment focus of this area is to accommodate marine-related jobs.

The completed redevelopment of I&J Waterway is anticipated to include restoration of beach habitat and the creation of a beach park at the head of the Waterway (Figure 3-6; Port of Bellingham and City of Bellingham 2013). Elements of the subarea plan underwent Washington State Environmental Policy Act (SEPA) review in the 2010 Final EIS (Port of Bellingham 2010) and the Final EIS Addendum (Port of Bellingham 2012). The Draft Subarea Plan has been approved by The Bellingham Planning Commission and is in the final stages of approval with the Bellingham City Council. I&J Waterway cleanup activities will be coordinated with redevelopment work to the extent feasible.

3.4.2 Area-specific Navigation and Land Use

I&J Waterway includes a federal navigation channel, with a width of 100 feet and an authorized depth of -18 feet MLLW. Berth areas adjacent to the federal channel include a mixture of state-owned and privately-owned lands with varying water depth needs.

Current navigation uses in the Waterway include commercial fishing vessels berthing at the Bornstein Seafoods processing facility and USCG vessels that dock at the USCG station on the north side of the Waterway. The outer portion of the I&J Waterway federal navigation channel has elevations around -15 feet MLLW and provides navigation access for vessels entering Squalicum Inner Harbor or visiting the Hilton Harbor facilities.

Figure 3-2 and Chart 3-2 show the locations and provide descriptions of five general operational areas that have been defined for I&J Waterway. Operational areas have been developed for I&J Waterway based on the type of vessel maneuvers that can occur in each area and the type of vessels that can operate within each area.

Chart 3-2
Operational Areas in I&J Waterway

Operational Area	Type of Maneuvers	Type of Vessels	Approximate Depth (ft MLLW)
A	Transit in Channel	ALL	-15
B	Docking	Recreational	-5 to -10
C	Transit in Channel, Turning and Docking	USCG and Bornstein	-10 to -15
D	Turning and Docking	USCG	-10 to -14
E	None	n/a	-5 to -15

Notes:
ft = feet
MLLW = mean lower low water
n/a = not applicable
USCG = U.S. Coast Guard

The shoreline of the area has been maintained with the requisite infrastructure to allow utilization of water depths in the federal navigation channel of -18 feet MLLW. Elevations at the Bornstein Seafoods dock are currently approximately -10 feet MLLW, which means some larger fishing vessels have the potential to ground at the lowest tidal elevations. Bornstein Seafoods seeks to maintain water depths within their berthing area that are compatible with the condition of the federal navigation channel to minimize the potential for grounding vessels.

USCG currently operates vessels with small drafts (less than 4 feet) and has no current or future needs for the full authorized depth of -18 feet MLLW in the federal navigation channel. At the head of the federal navigation channel, substantial shoaling has occurred, where elevations are as shallow as -10 feet MLLW. In addition, no navigational need has been identified for the vacant former Olivine property located east of Bornstein Seafoods. Based on these factors, future plans for the Waterway could include potential reconfiguration of the federal navigation channel. Any modification to the federal navigation channel would need to be consistent with future land use, which includes a plan for development of the head into a beach park and public access area. It is expected that maintenance dredging of a portion or all of the federally authorized channel will be performed periodically in the future by USACE in conjunction with the Port, which is the local sponsor for the federal channel, and other parties, as needed, to achieve the authorized navigation depth.

4 SITE SCREENING LEVELS

This section provides an overview of exposure pathways and receptors and, for each potential receptor, discusses screening levels applicable to the investigation and cleanup of the Site. These screening levels are used in Section 5 in the evaluation of the nature and extent of contamination, and in the FS to set the cleanup levels for remedial actions at the Site. Table 4-1 summarizes the screening levels established based on information in this section and in Appendix B.

The screening levels were developed to ensure protection of human health and the environment under the regulatory framework of MTCA and the SMS. The screening levels address protection of sensitive receptors under various potential exposure pathways. The subsequent text in this section discusses screening levels for all applicable exposure pathways, organized as follows:

- Section 4.1: Protection of human health as a result of seafood consumption and direct contact and incidental ingestion of sediment during beach play and clamming
- Section 4.2: Protection of the benthic community
- Section 4.3: Protection of higher trophic level species
- Section 4.4: Other screening levels, including upland cleanup levels and background concentrations
- Section 4.5: Selection of screening levels

For each exposure pathway, the SMS provide methods for calculating lower potential screening levels, or Sediment Cleanup Objective (SCO), and higher potential screening levels, or Cleanup Screening Level (CSL). The SCO is a criterion at which no adverse effects occur, including no acute or chronic adverse effects on biological resources and no significant health risk to humans. The CSL is a minor adverse effects level, which is the minimum level to be achieved in all cleanup actions under SMS.

Screening levels were determined by the following:

1. Identifying potential protective levels for each exposure pathway and appropriate chemicals (also called risk-based concentrations [RBCs])

2. Considering other potential screening levels such as background concentrations and practical quantitation limits (PQLs)
3. Selecting the appropriate screening level of the potential screening levels evaluated, consistent with SMS methods for each chemical

4.1 Protection of Human Health

Human health screening levels were developed for the adult seafood consumption exposure pathway and the adult clamming and child beach play sediment incidental ingestion and dermal contact pathways using methods described in the Draft Sediment Cleanup Users Manual II (SCUM II; Ecology 2013). Development of the human health screening levels is described in the following sections.

4.1.1 Seafood Consumption Exposure Pathway

As shown in Table 4-1, RBCs were developed for carcinogenic polycyclic aromatic hydrocarbons (cPAHs) for seafood consumption. The cPAH SCO RBC was developed protective of a $1x10^{-6}$ excess cancer risk, and the CSL RBC was developed protective of a $1x10^{-5}$ excess cancer risk. RBCs were not developed for other bioaccumulative chemicals because Site surface sediment concentrations of these chemicals are below the PQL or natural background, had low detection frequency, and/or were not associated with the Site.

As described in Appendix B, cPAH SCO and CSL RBCs were developed using a combination of the default input parameters presented in the SCUM II (Ecology 2013) and Site-specific input parameters. Site-specific input parameters included the Tulalip adult body weight (81.8 kilograms [kg]) and the Tulalip Tribe's 90th percentile clam, crab, and bottomfish consumption rates. Literature biota sediment accumulation factor (BSAF) and lipid content values were used because no Site-specific tissue data were available.

The spatial scale of application for the seafood consumption RBCs is the upper 12 cm of sediment, applied as an average concentration across the entire Site.

4.1.2 Sediment Direct Contact and Incidental Ingestion of Sediment Exposure Pathways

The direct contact and incidental ingestion exposure pathways are combined into a single calculation for calculating RBCs. For the purpose of this discussion, "direct contact" is assumed to include incidental ingestion of sediment unless noted otherwise. Two scenarios were evaluated for the direct contact exposure pathway: beach play (child) and clamming (adult).

Like the RBCs developed for the seafood ingestion pathway, the carcinogenic chemical direct contact and incidental ingestion SCO RBCs were developed for RBCs protective of a $1x10^{-6}$ excess cancer risk, and the CSL RBCs were developed for RBCs protective of a $1x10^{-5}$ excess cancer risk. For non-carcinogenic chemicals, both the SCO and the CSL are based on the RBC that results in a hazard quotient of 1. Direct contact RBCs were developed using the SCUM II default equations and input parameters (Ecology 2013), except for the clamming exposure frequency. Because of the limited Site clam habitat, a clamming exposure frequency of 74 days per year was used. Appendix B includes the equations and assumptions used to develop the direct contact RBCs.

The spatial scale of applicability of the beach play and clamming RBCs are assumed to be the upper 45 cm of sediment, applied as the average concentration over the entire intertidal area of the Site.

4.2 Protection of the Benthic Community

Under the SMS, the SCO and CSL have been established for chemical contaminants for protection of the benthic community (Table 4-1). These are identical to the numerical standards promulgated by the previous SMS regulations that were referred to as the sediment quality standards (SQS) and the CSL. SQS and SCO for protection of the benthic community may be used interchangeably in this document for consistency with historical documentation at the Site.

The vertical point of compliance for protection of the benthic community is the upper 12 cm of sediment throughout the Site. Because the home range of benthic invertebrates is small, the numeric criteria for protection of the benthic community are generally applied to all sample locations (rather than average concentrations).

4.2.1 SCO and CSL Numerical Criteria

SMS marine SCO chemical criteria are defined in WAC 173-204-562 and numerical values are presented in Table III under that section of the regulations. The chemical parameter criteria are defined on either a dry weight basis or on an organic carbon-normalized basis for certain organic compounds. To normalize to total organic carbon, the dry weight concentration for each parameter is divided by the decimal fraction representing the percent total organic carbon content of the sediment.

SMS marine sediment CSL chemical criteria are defined in WAC 173-240-562 and numerical values are presented in Table III under that section of the regulations. As with the SCO criteria, the values are defined on either a dry weight basis or on an organic carbon-normalized basis, depending on the properties of the chemical.

4.2.2 Lowest Adverse Effects Thresholds

The Puget Sound Estuary Program (PSEP) adverse effects threshold (AET) is the level above which adverse effects are expected to occur (PSEP 1988). The AETs are defined on a dry weight basis and were developed for amphipod, oyster, benthic, and microtox. I&J Waterway sediment samples with TOC greater than 3.5% were compared to the lowest apparent effects threshold (LAET) rather than carbon-normalized concentrations for the SCO and the second lowest apparent effects threshold (2LAET) rather than carbon-normalized concentrations for the CSL, based on the potential that bioavailability may not change with TOC for samples with very high TOC content.

4.2.3 Dredged Material Management Program Screening Levels

The DMMP, formerly known as the PSDDA program, provides a comprehensive program for characterizing materials for open-water disposal or beneficial reuse. The program includes chemical and biological testing protocols to address toxicity of contaminants to benthic organisms and risk-based screening levels for use in evaluating potential bioaccumulation risks. The DMMP contains screening level (SL), bioaccumulation trigger (BT), and maximum level (ML) criteria, which are specific to DMMP program evaluations to determine suitability for open-water disposal or beneficial reuse. Site subsurface sediment testing results from 2006 were previously compared to DMMP criteria. In addition, because no SMS criteria are available for nickel, all sediment results are screened against the former SL/BT for nickel (which was removed from the DMMP list in 2011).

4.2.4 Biological Criteria

SMS regulations define bioassay testing procedures and interpretive criteria that can be used to directly test sediments for benthic toxicity. Test methods and interpretive criteria have been developed and provide for definition of two different thresholds of effect. The more stringent SCO provide a regulatory goal by identifying levels below which surface sediments have no adverse effects on the benthic community. The CSL represents the level above which minor adverse effects may be observed.

Bioassays have been used to directly screen sediments in the Site area for the presence of elevated contaminant levels or combinations of contaminants or conditions suspected by Ecology to result in toxicity. Bioassays have also been used in a confirmatory role when chemical testing demonstrates the presence of elevated contaminant levels. The widespread use of whole-sediment bioassays as part of the RI/FS testing program ensures that any potential Site impacts to benthic organisms are measured. This includes effects of specific potential contaminant fractions not directly quantified, additive or synergistic effects associated with multiple contaminants, or effects of other contaminants not specifically included in the RI/FS chemical testing program.

Bioassay test methods that have been used at the Site are defined in current Ecology regulations and include tests performed with amphipods, larval organisms, and juvenile polychaete worms. Under SMS, the results of bioassay tests generally override screening level determinations based on chemical concentrations because they are a more direct measure of sediment toxicity.

4.3 Higher Trophic Level Species

As described in Appendix B, the cPAH RBCs developed for human health are anticipated to be protective of aquatic dependent wildlife that may be exposed to bioaccumulative chemicals (through foraging) at the Site. PAHs were the only chemicals identified as Site related bioaccumulative chemicals of potential concern. Other bioaccumulative chemicals were excluded from further ecological evaluation based on frequency of detection, temporal and spatial chemical concentration patterns, and knowledge of current and historical Site activities.

Table B-1 presents human and aquatic dependent life target tissue levels (TTLs), as summarized in SCUM II (Ecology 2013) and other documents. The individual PAH and other bioaccumulative chemicals with human and aquatic-dependent wildlife TTLs are generally several orders of magnitude lower for humans than for aquatic dependent wildlife, indicating that the sediment concentrations corresponding to the human TTL would be inclusively protective of aquatic-dependent wildlife. While no aquatic life dependent cPAH TTL is available to compare to the human TTL, Ecology has not identified cPAHs or benzo(a)pyrene (as a surrogate) as a chemical that may pose a risk to aquatic dependent receptors at levels lower than may present an unacceptable risk to human health (Ecology 2013). Elevated concentrations of non-carcinogenic PAHs and other bioaccumulative chemicals co-located with cPAHs in Site sediments will be addressed with remedies developed for cPAHs. For these reasons, it is anticipated that the cPAH RBC developed for the human health reasonable maximum exposure (RME) seafood consumption scenario will also be protective of exposure of aquatic dependent wildlife.

4.4 Other Potential Screening Levels

Specific evaluations performed as part of the RI/FS also included comparisons to other potential screening levels. These comparisons include the following:

- **Natural and Regional Background:** The updated SMS regulations provide for use of natural background concentrations as the SCO and regional background concentrations as the CSL if background levels are higher than RBCs, and following a review of technical possibility and net adverse environmental impact. The development of background concentrations is detailed in Appendix B. Regional background levels have not been established for Bellingham Bay by Ecology; however, for the purposes of completing this RI/FS, preliminary levels have been calculated in Appendix B for cPAHs and dioxin/furans based on existing data in the bay. Similar to RBCs for protection of human health, screening levels based on natural or regional background concentrations are compared to all sediment samples; however, compliance with cleanup levels for human health parameters would be applied on area-wide averages.

- **PQLs:** Similar to background concentrations, the PQLs may be used as screening levels when above RBCs. PQLs are presented in Table 4-1 based on specific reporting limits at the I&J Waterway Site and recommended PQLs in the SCUM II Guidance (Table 4-1 and Appendix F). Similar to RBCs for protection of human health, screening levels based on PQLs are compared to all sediment samples; however, compliance with cleanup levels for human health parameters would be applied on area-wide averages.

4.5 Screening Levels Determination

The SCO and CSL concentrations for each chemical are shown in Table 4-1, determined based on the comparison of RBCs for all exposure pathways with natural background and PQLs. The SCO and CSL concentrations are determined by identifying the highest of: a) the lowest of the appropriate RBCs, b) natural or regional background, and c) PQLs.

Consistent with SMS, the SCO concentrations are used for screening levels for I&J Waterway. Cleanup levels based on both the SCO and CSL are developed in Section 8.

4.6 Identification of Constituents of Concern

The series of initial Site sediment investigations performed for surface and subsurface sediments in 1997 (Hart Crowser 1997), 1999 (Anchor Environmental 1999), and 2001 (ThermoRetec 2001) provided information to define COCs for the Site. The COCs identified for surface sediments based on these older studies included mercury, nickel, bis(2-ethylhexyl)phthalate, PAHs[2], phenol, and dibenzofuran (RETEC 2005).

Data from the 2005/2006, 2012, and 2013 investigations have been used to reevaluate the COCs for I&J Waterway (Table 4-2) based on the presence of one or more detected exceedances of the SCO. Based on this evaluation, the list of COCs has been revised to include the following compounds: nickel, 2,4-dimethylphenol, 2-methylphenol (o-cresol), 4-methylphenol (p-cresol), 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzoic acid, benzyl alcohol, bis(2-ethylhexyl)phthalate, chrysene, total cPAH[3], dibenz(a,h)anthracene, dibenzofuran, dimethyl phthalate, fluoranthene, fluorene, n-nitrosodiphenylamine, phenanthrene, pyrene, total high-molecular-weight polycyclic aromatic hydrocarbons (HPAHs), and total low-molecular-weight polycyclic aromatic hydrocarbons (LPAHs). PCBs and mercury were not selected as COCs because they are not associated with known Site releases. Areas with elevated concentrations are co-located with Site COCs in subsurface sediment and will be addressed as part of Site remediation.

Dioxin/furan was not retained as a COC because congener profiles suggest no site-associated release/activity and Site sediments are similar to Bellingham Bay profiles. Areas with elevated dioxin/furan concentrations are co-located with Site COCs and will be addressed as part of Site remediation. As shown in Appendix E, dioxin/furan congener profiles from sediment at the Site are similar to sediment samples collected by USACE in 2012 that extend to the end of the I&J Waterway, up to approximately 2,000 feet from the Site into Bellingham Bay. Congener patterns in Site sediment resemble profiles associated with typical urban inputs, such as automobile and diesel emissions (Attachments 1 and 2 of Appendix E), which is typical in urban areas with stormwater runoff from commercial and industrial areas. Site sediment samples also have similar congener patterns to the stormwater solids sample (CB-002) but do not resemble profiles typical of combustion.

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[2] Acenaphthene, anthracene, fluorene, phenanthrene, total LPAH, chrysene, benzo(a)anthracene, fluoranthene, and total HPAH.

[3] Benzo(a)anthracene, chrysene, and dibenz(a,h)anthracene are also included in total cPAH. For the human health RBC development described in Appendix B, only cPAH toxics equivalent quotient (TEQ) were evaluated as bioaccumulative PAHs.

5 NATURE AND EXTENT OF CONTAMINATION

This section describes the nature and extent of contamination from investigations conducted in the past 10 years (2005/2006, 2012, and 2013). The nature and extent of contamination at the Site is defined by the exceedances of screening levels for Site COCs associated with Site-related releases/activities.

5.1 Current Surface Sediment Quality

Current sediment quality, both chemical and biological, at the Site was directly measured during sampling events in 2005/2006 and later in the supplemental investigation sampling performed in 2012 and chemical testing conducted in 2013. Sampling has demonstrated a reduction in surface sediment chemical concentrations and surface sediment toxicity as measured by bioassay testing compared to testing prior to 2005. Results for surface sediment chemical testing results and bioassay results are presented in Section 5.2.1 and shown in Figures 5-1 through 5-6.

5.1.1 Benthic Criteria

The 2005/2006, 2012, and 2013 surface sediments were tested for SMS constituents and nickel, and the 2012 and 2013 samples were also tested for dioxin/furans. Tables 5-1a, 5-1b, 5-2, and 5-3 present results of the 2005/2006, 2012, and 2013 surface sediment chemical and physical testing, respectively. Exceedances of SMS or DMMP SL (nickel) criteria for 2005/2006, 2012, and 2013 sampling locations are shown in Figure 5-1. Bioassay test results from 2005/2006 and 2012 are summarized in Tables 5-4 and 5-5, respectively, and in Figure 5-2 and Chart 5-2. A summary of sediment physical characteristics is included in Section 3.1.4. The Data Summary Memo (RETEC 2006a) and *Supplemental Investigation Memorandum* (Anchor QEA 2013b) contain detailed summaries of chemical testing results and validated laboratory data of the 2005/2006 and 2012 sampling results, respectively. Appendix A includes the validated laboratory data for the 2013 sampling. The area that exceeds benthic criteria considers both chemical concentrations and bioassay results, with bioassay results overriding the chemical results.

5.1.1.1 Benthic Sediment Management Standards Parameters

The 2005/2006, 2012, and 2013 site sediment samples were tested for benthic SMS constituents, including metals, semivolatile organic compounds (SVOCs), and total polychlorinated biphenyls (PCBs). In 2005/2006, benthic SMS chemical concentrations were below SCO criteria in all samples, except for sample IJW-SS-06. This sample had SCO exceedances for acenaphthene, dibenzo(a,h)anthracene, fluorene, phenanthrene, chrysene, fluoranthene, total HPAHs, and dibenzofuran, with bis(2-ethylhexyl)phthalate exceeding CSL (RETEC 2006a). Similarly, all 2012 samples were below benthic SMS criteria, except for sample IJ12-04, which had fluoranthene concentrations exceeding the SCO criteria (Anchor QEA 2013b). Fluoranthene was not above SCO in the 2005/2006 co-located sample (IJW-SS-12).

The 2013 parent and field duplicate samples (IJ13-SS-101 and IJ13-SS-151, respectively) located beneath the north/east end of the dock each contained 2,4-dimethylphenol concentrations exceeding CSL. Sample IJ13-SS-101 had benzyl alcohol exceeding the SCO and IJ13-SS-151 had bis(2-ethylhexyl)phthalate above the CSL. Sample IJ13-SS-102, located beneath the south/west end of the dock, had 2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, and benzoic acid exceeding CSL and benzyl alcohol exceeding the SCO. This sample also had bis(2-ethylhexylphthalate), dibenzofuran, dimethyl phthalate, n-nitrosodiphenylamine, and multiple PAH[4] concentrations exceeding the LAET.[5] Figure 5-1 shows the 2005/2006, 2012, and 2013 benthic SMS chemical exceedances.

5.1.1.2 Nickel

In the 2005/2006 investigation, samples IJW-SS-07 through IJW-SS-12 located in the vicinity of the head of the Waterway had nickel concentrations exceeding the former DMMP SL. Sample IJW-SS-10, located closest to the historical Olivine site, had a nickel concentration that exceeded the DMMP BT and ML. In the 2012 samples, nickel concentrations were equivalent to or below the former DMMP SL in all samples, except for samples IJ12-01

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[4] 2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, chrysene, fluoranthene, fluorene, phenanthrene, pyrene, total HPAH and total LPAH.

[5] Sample IJ13-SS-102 had TOC greater than 3.5%. For this sample, chemicals with organic normalized SMS criteria were alternatively screened against the marine LAET.

and -02. Sample IJ12-03 contained a nickel concentration equivalent to the former DMMP SL. The 2012 sediment samples with nickel SL exceedances are located within the Site Area Above SMS Criteria. The 2012 results generally indicated declining surface sediment nickel concentrations compared to the co-located 2005/2006 sample results, which is further discussed in Section 6.2.2. The 2013 samples did not have nickel concentrations greater than the former DMMP SL.

5.1.1.3 Bioassay Data

This section provides a summary of the 2005/2006 and 2012 bioassay test results. Sediment toxicity was evaluated using three of the following standard bioassays:

- 10-day Acute Toxicity Amphipod Test (*Eohaustorius estuarius* in 2005/2006; *Ampelisca abdita* in 2012)
- Larval Development Test (*Mytilus galloprovincialis* in 2005/2006 and 2012)
- 20-day Juvenile Polychaete Chronic Toxicity Test (*Neanthes arenaceodentata* in 2005/2006 and 2012)

Site biological testing results were compared to the results from a reference sample for comparison to SMS criteria. The 2006 Data Summary Memo (RETEC 2006a) and 2013 *Supplemental Investigation Memorandum* (Anchor QEA 2013b) contain a detailed summary of biological testing methods and results. Bioassay test results from 2005/2006 and 2012 are summarized in Tables 5-4 and 5-5, respectively, and in Figure 5-2 and Chart 5-1. Figure 5-2 shows that area above SMS benthic biological criteria.

In 2005/2006, bioassay testing was conducted for the seven samples with nickel and/or SMS chemical exceedances (IJW-SS-06 through IJW-SS-12) and two additional samples (IJW-SS-04 and IJW-SS-13) as required by Ecology (RETEC 2006a). Site samples IJW-SS-04, IJW-SS-06 through -10, and IJW-SS-13 failed CSL criteria for the larval development test and samples IJW-SS-06 and IJW-SS-12 failed the former SQS criteria for the juvenile polychaete test. IJW-SS-11 passed all bioassay tests.

In 2012, biological testing was required for two samples (IJ12-05 and -07) and the three additional sample stations (IJ12-01, -02, and -03) that had nickel concentrations equivalent to or greater than the former DMMP SL. Samples IJ12-01, -02, -03, and -05 failed SQS (SCO) biological criteria for the larval development test. Sample IJ12-07 passed all bioassay tests. All samples passed the amphipod and juvenile polychaete tests.

Chart 5-1
Surface Sediment Chemical Criteria Exceedances and Biological Testing Results

Station ID	Chemical Criteria Exceedances[1]	SQS/CSL Biological Criteria (Pass/Fail)[2]
2005/2006 Biological Testing		
IJW-SS-04	None	CSL Fail (larval)
IJW-SS-06	Acenaphthene, Fluorene, Phenanthrene, Dibenzo(a,h)anthracene, Chrysene, Fluoranthene, Total HPAH, Bis(2-ethylhexyl)phthalate, dibenzofuran	SQS Fail (juvenile polychaete)
IJW-SS-07	Nickel	CSL Fail (larval)
IJW-SS-08	Nickel	CSL Fail (larval)
IJW-SS-09	Nickel	CSL Fail (larval)
IJW-SS-10	Nickel	CSL Fail (larval)
IJW-SS-11	Nickel	Pass
IJW-SS-12	Nickel	SQS Fail (juvenile polychaete
IJW-SS-13	None	CSL Fail (larval)
2012 Biological Testing		
IJ12-01	Nickel	SQS Fail (larval)
IJ12-02	Nickel	SQS Fail (larval)
IJ12-03	Nickel	SQS Fail (larval)
IJ12-05	None	SQS Fail (larval)
IJ12-07	None	Pass

Notes:

1. Chemical criteria used were the SCO for chemicals with SMS benthic criteria, and the former DMMP SL for nickel.
2. Refer to text for a description of bioassay testing.

CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
HPAH = high-molecular-weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold (marine)
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
SQS = Sediment Quality Standard

The 2012 biological results generally indicate improved conditions compared to the 2005/2006 results for those sample stations co-located during the two sampling events. The 2005/2006 samples IJW-SS-07, -09, and -13 formerly failed CSL criteria for the larval development test, but each co-located 2012 sample (IJ12-03, -02, and -05, respectively) only failed SQS (SCO) criteria (but was below CSL).

5.1.2 Bioaccumulatives

This section discusses the nature and extent of bioaccumulative chemical contamination in surface sediment in I&J Waterway. cPAHs are the only bioaccumulative COC for I&J Waterway; dioxins/furans are also discussed in this section even though they are not COCs.

5.1.2.1 cPAHs

cPAHs were summed for surface sediment samples collected in 2005/2006, 2012, and 2013 per MTCA (WAC 173-340-708(e)) methods using the seven minimum PAHs presented in Table 708-2 and are expressed as benzo(a)pyrene toxic equivalents quotient (TEQs) with nondetects treated as one-half the detection level. Total cPAH TEQs are presented in Chart 5-2 and Tables 5-1a, 5-2, and 5-3. Figure 5-3 presents interpolated results of surface sediment cPAH concentrations. Figure 5-4 presents interpolated surface sediment cPAH concentrations at the Site and in Bellingham Bay; this dataset was used to calculate background concentrations for cPAHs as described in Appendix B. The procedures used for developing interpolated concentration plots are described in Appendix H. cPAH concentrations in I&J Waterway samples ranged between 45.8 micrograms per kilogram (µg/kg) TEQ and 2,475 µg/kg TEQ. As shown in Figure 5-3, the cPAH concentrations from samples located underneath and along structures and shoreline areas are higher than other parts of the Site. The highest cPAHs were found at the face of the Bornstein Seafoods dock (2,475 µg/kg TEQ at IJW-SS-06), underneath the Bornstein Seafoods dock (987 and 799 µg/kg at IJ13-SS-101 and duplicate sample IJ13-SS-151, respectively, and 1310 µg/kg at IJ13-SS-102), near the bulkhead along the former Olivine property (1,154 µg/kg TEQ at IJW-SS-10), near the Hilton outfall east of Bornstein Seafoods (705 µg/kg TEQ at IJ12-04), and near the Roeder Avenue outfall (504 µg/kg TEQ and 533 µg/kg TEQ at IJW-SS-11 and IJ12-01, respectively).

Chart 5-2
2005/2006, 2012, and 2013 Surface Sediment cPAH Testing Results

Station ID	Reported Concentrations (µg/kg as TEQ; ND = 1/2 RL)[1]
2005/2006 I&J Waterway Samples	
IJW-SS-01	59
IJW-SS-02	46
IJW-SS-03	245
IJW-SS-04	104
IJW-SS-05	100
IJW-SS-06	2475
IJW-SS-07	143
IJW-SS-08	232
IJW-SS-09	149
IJW-SS-10	1154
IJW-SS-11	504
IJW-SS-12	512
IJW-SS-13	62
2012 I&J Waterway Samples	
IJ12-01	533
IJ12-02[4]	89
IJ12-03	113
IJ12-04[5]	705
IJ12-05[6]	71
IJ12-06	57
IJ12-07	66
IJ12-08a[7]	92
IJ12-58a[2,7]	178
IJ12-11[3]	29
2013 I&J Waterway Samples	
IJ13-SS-101	987
IJ13-SS-151[8]	799
IJ13-SS-102	1310

Notes:

1. TEQs were calculated using MTCA (WAC 173-340-708(e)) methods and TEF values presented in Table 708-2.
2. Sample IJ12-58a is a field duplicate of sample IJ12-08a.
3. Sample collected to assess chemical composition at a station representative of Bellingham Bay.
4. Re-occupied 2005/2006 sample IJW-SS-09
5. Re-occupied 2005/2006 sample IJW-SS-12
6. Re-occupied 2005/2006 sample IJW-SS-13

7. Re-occupied 2005/2006 sample IJW-SS-03
8. Sample IJ13-SS-151 is a field duplicate of sample IJ13-SS-101.

µg/kg = microgram per kilogram
MTCA= Model Toxics Control Act
ND = non-detect
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient
WAC = Washington Administrative Code

5.1.2.2 Dioxin/Furans

As noted previously, dioxin/furan was not retained as a COC because congener profiles suggest no site-associated release/activity and Site sediments are similar to Bellingham Bay profiles. Elevated concentrations of dioxin/furan are present at the Site and throughout Bellingham Bay, but they will be addressed within the Site as part of remediation of Site COCs. Therefore, the nature and extent of dioxins/furans are discussed here only for the purposes of general information and consideration in the Feasibility Study dredged material disposal alternatives.

Dioxin/furans were tested in 2012 and 2013 and presented in Chart 5-3 and Table 5-2. Figure 5-5 presents results of surface and subsurface sediment dioxin/furan concentrations, Figure 5-6 presents interpolated surface sediment dioxin/furan concentrations, and Figure 5-7 presents interpolated Bellingham Bay dioxin/furan concentrations, which include calculated dioxin/furan TEQs acquired from EIM; this dataset was used to calculate background concentrations for dioxin/furan as described in Appendix B. The procedures used for developing interpolated concentration plots are described in Appendix H. Dioxin/furan concentrations in surface sediments ranged between 9.5 nanograms per kilogram (ng/kg) TEQ and 57.7 ng/kg TEQ. The highest concentration of 57.7 ng/kg TEQ (IJ13-SS-102) is located beneath the southwest portion of the Bornstein Seafoods dock.

Chart 5-3
2012 and 2013 Surface Sediment Dioxin/Furan Testing Results

Station ID	Reported Concentrations (ng/kg TEQ; ND = 1/2 RL)[1]
2012 I&J Waterway Samples	
IJ12-01	26
IJ12-02	21
IJ12-03	10

Station ID	Reported Concentrations (ng/kg TEQ; ND = 1/2 RL)[1]
IJ12-04	36
IJ12-05	20
IJ12-06	15
IJ12-07	12
IJ12-08a	33
IJ12-58a[2]	15
IJ12-11[3]	9.5
2013 I&J Waterway Results	
IJ13-SS-101	36
IJ13-SS-151[4]	39
IJ13-SS-102	58

Notes:

1. TEQs were calculated using the 2005 World Health Organization TEFs developed for mammalian receptors (WAC 173-340-708(8d) Table 708-1).
2. Sample IJ12-58a is a field duplicate of sample IJ12-08a.
3. Sample collected to assess chemical composition at a station representative of Bellingham Bay.
4. Sample IJ13-SS-151 is a field duplicate of sample IJ13-SS-101.

ND = non-detect
ng/kg = nanogram per kilogram
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient
WAC = Washington Administrative Code

5.2 Subsurface Sediment Quality

This section summarizes subsurface sediment samples collected and tested at the Site. The purpose of the SMS is to reduce and ultimately eliminate adverse effects on biological resources and significant health threats to humans from surface sediment contamination. Surface sediments are defined by the sediment bioactive zone, which for Bellingham Bay has been determined to be 12 cm. However, if subsurface sediment has the potential to become surface sediment, through natural processes or through anthropogenic influences, it also must be addressed. Some of the factors affecting sediment stability include wave-induced erosion, bioturbation, propeller wash, and anchor drag. These factors are discussed in Section 6 of this report. Area land use and navigation patterns and issues that have potential bearing on subsurface sediment exposure due to navigation dredging or land use actions are described in Section 3.4.

RI/FS subsurface samples were collected at the Site in 2005/2006, 2012, and 2013. One historical core located at the head of the Waterway near the former Olivine upland site was also collected in 1996 and is included in this RI/FS. These subsurface data were developed to assist in the evaluation of long-term sediment stability and also to support Site remedial alternatives evaluations in the FS. The maximum depth of contamination is bounded by the native clay layer shown in Figures 5-8, 5-9, and 5-10.

5.2.1 1996

The 1996 core collected as part of the Whatcom Waterway sediment investigation was sampled at the 0- to 4.5-foot depth and 4.7- to 7.1-foot depth and tested for SMS constituents. Subsurface sample depths are reported as depth below the mudline surface. The 0- to 4.5-foot depth sample was below SMS for all constituents except for mercury and 2,4-dimethylphenol, which exceeded CSL, and bis(2-ethylhexyl)phthalate, which exceeded SCO. The 4.7- to 7.1-foot depth sample was below SMS criteria for all constituents except for 2,4-dimethylphenol, 2-methylphenol, and 4-methylphenol, which were above CSL (RETEC 2005). A summary of the sediment core chemical testing results is included in Table 5-6. Trace wood chips were observed in both depth intervals sampled and are a probable contributor to the elevated concentrations of methylphenols in the core sediments.

5.2.2 2005/2006

In the 2005/2006 sediment investigation, composite core samples for five potential Dredged Material Management Units (DMMUs) were tested for DMMP constituents plus tributyltin and dioxin/furans to evaluate suitability for open-water disposal. Composite samples were collected for four surface DMMUs (3, 4A, 5, and 6) and one subsurface DMMU (4B, deeper than 4 feet). The samples comprising the composite surface and subsurface samples were collected from above the Z-layer (estimated post-dredge surface). Table 5-7 presents testing results, along with which sediment cores comprised each DMMU composite. DMMU composite samples were below SMS metal and the former DMMP nickel criteria, except for mercury concentrations in DMMU composites 4A and 4B (near the head of the Waterway), which exceeded SCO, and DMMUs 3, 5, and 6 (in central portions of the Waterway), which exceeded CSL. Nickel in the surface DMMU 4A also exceeded the former DMMP SL. Bis(2-ethylhexyl)phthalate exceeded the CSL and DMMP ML, 2,4-dimethylphenol exceeded the CSL and DMMP SL, and dimethyl phthalate exceed the DMMP SL in the composite DMMU 6 sample (located at the Bornstein Seafoods dock).

The DMMU samples were tested for dioxin/furan. The DMMU samples dioxin/furan concentrations ranged from 22.05 ng/kg TEQ (DMMU 4B) to 32.98 ng/kg TEQ (DMMU 6). DMMU composite samples were also tested for bioassays for evaluation of open-water disposal suitability, which are presented in the 2006 Data Summary Memo (RETEC 2006a).

5.2.3 2011

Sediment cores from I&J Waterway were collected as part of an investigation conducted by USACE in 2011 (Figure 3-3). Z-layer samples were collected to characterize the predicted post-dredge surface concentrations if maintenance dredging were to occur to the federally authorized channel limits with a 2-foot over-dredge (to -20 feet MLLW). Sample intervals were approximately from -20 feet MLLW to -22 feet MLLW. Samples I-1-Z and I-2-A-Z were tested for SMS constituents, nickel, and dioxin/furan. Dioxin/furan was also tested in sample I-Z-3, located outside the Site in the vicinity of the 2012 surface sample IJ12-11. The Z-layer was determined to be above the native Glacial Marine Drift (clay) layer, which represents recent sediment deposition since dredging of the original federal channel. Testing results are summarized in Table 5-8. Sample I-1-Z contained 2,4-dimethylphenol and 2-methylphenol above CSL, dimethyl phthalate and N-nitrosodiphenylamine above LAET, and total PCBs were equal to the LAET. In sample I-2-A-Z, mercury and 2,4-dimethylphenol exceeded CSL, and total PCBs exceeded LAET.

Samples I-1-Z, I-2-A-Z, and I-3-Z contained dioxin/furan concentrations of 29.4, 41.8, and 5.7 TEQ, respectively. At locations I-1 and I-3, samples were collected of potential dredge material from the sediment surface down to the top of the Z-layer (DM samples). Dioxin/furans in Z-samples were lower than the upper composite DM sample for both I-1 (I-1-DM was 38.2 TEQ) and I-3 (I-3-DM was 28.6 TEQ).

5.2.4 2013

Two sediment cores were collected from underneath the Bornstein Seafoods dock in 2013, including one core from under the northeast portion of the dock (IJ13-VC-101) and one from the southwest portion of the dock (IJ13-VC-102). The cores were collected from underneath the dock, approximately 11 feet and 12 feet from the dock face, respectively. The cores were driven to refusal and clay was present in the end of each core, indicating that the cores had been driven to the Glacial Marine Drift layer. Subsurface samples were collected from the 0- to 2-foot interval in both cores, from the 2- to 3.9-foot interval in core IJ13-VC-101, and from the 2- to 4-foot and 4- to 5.4-foot intervals in core IJ13-VC-102. Each sample collected from the 0- to 2-foot interval was archived. Samples collected from the 2- to 3.9-foot (IJ13-VC-101), 2- to 4-foot, and 4- to 5.4-foot intervals were tested for SMS constituents, nickel, dioxins/furans, and Atterberg limits. The 2013 sediment core logs are included in Appendix D. Testing results are summarized in Table 5-9.

All subsurface samples contained 2,4-dimethylphenol and 2-methylphenol concentrations exceeding CSL. Sample IJ13-VC-102-2-4 also had 4-methylphenol and benzoic acid concentrations above the CSL and phenol concentration exceeding the SCO. Sample IJ13-VC-2-4 had dibenzofuran, 2-methylnaphthalene, and naphthalene concentrations above the LAET, and both samples IJ13-VC-102-2-4 and IJ13-VC-102-4-5.4 had dimethyl phthalate concentrations above the LAET.

Dioxin/furan concentrations were 8.5, 31.6, and 10.3 ng/kg TEQ for samples IJ13-VC-101-2-3.9, IJ13-VC-102-2-4, and IJ13-VC-102-4-5.4, respectively.

6 CONTAMINANT FATE AND TRANSPORT

This section summarizes processes that may affect concentrations of sediment contaminants. The status of source control efforts within I&J Waterway is discussed. Also discussed are the processes that may improve Site sediment quality (e.g., sediment natural recovery) and those processes that can degrade sediment quality or trigger sediment recontamination. The contaminant fate and transport topics covered in this section include the following:

- Source Control Activities (Section 6.1)
- Natural Recovery Processes (Section 6.2)
- Other Factors Affecting Sediment Stability (Section 6.3)

6.1 Sediment Source Control Activities

Identification and control of sources of sediment contamination is a key objective of the SMS regulations. The various upland and sediment RI/FS projects and Bellingham Bay Pilot activities have included source control evaluations and corrective actions within Bellingham Bay. The Central Waterfront upland RI/FS is being conducted in parallel to ensure upland sources do not pose a risk of future sediment recontamination. A summary of the source control information is provided below.

6.1.1 Control of Historical Contaminant Sources

The primary sources of sediment contamination within the Site are historical in nature. These historical sources have been controlled through land use changes, changes in operational practices, and pollution control improvements, as described below:

- **Central Waterfront Olivine Subarea:** As described in Section 2.1, the former Olivine processing facility has been demolished and the area is currently vacant with no structures present. Potential sources of ongoing contamination to I&J Waterfront include surface soil erosion to stormwater and groundwater migration. These contaminant pathways are being addressed during the Central Waterfront RI/FS and ongoing monitoring.
- **Former Lumber Mills:** Prior to the Olivine processing facility, lumber mills were present along the south nearshore areas and head of I&J Waterway. All related structures have been demolished and no contaminant sources are present.

- **Bornstein Seafoods:** The Bornstein Seafoods fish processing facility has been in place since the 1950s. The potential contaminant source contributions from the Bornstein Seafoods facility include historical discharge of fish matter, historical diesel fueling for boats at its dock, activities associated with the fire at the facility in 1985, and stormwater discharges. Bornstein Seafoods currently carries a State Waste Discharge Permit (ST7304) for the discharge of screened seafood processing wastewater to the Bellingham Post Point waste water treatment plant. The warehouse fire was a discrete historical event, and diesel fueling occurred from approximately 1960 until the early 1980s. Additional discussion of stormwater inputs is presented in Section 6.1.2.
- **Georgia-Pacific West:** Former operations at the GP property have been terminated and the property is currently undergoing a RI/FS under an Ecology Agreed Order (No. DE6834). Former discharges from the GP facility have been discontinued and are no longer a potential source of contamination to I&J Waterway.
- **Stormwater:** Historical stormwater inputs from the City and Port stormwater systems may have contributed contamination. Additional discussion of stormwater inputs are presented in Section 6.1.2.

6.1.2 Stormwater

Stormwater discharges are a potential source of contamination to I&J Waterway and include inputs from the City, Port, and Bornstein Seafoods, which are described in this section. A total of five waterfront or surface water discharge source locations to I&J Waterway were identified (Figure 6-1). The potential sources included two Bornstein Seafoods National Pollutant Discharge Elimination System (NPDES) discharge outfalls, two Port stormwater outfalls, and one City stormwater outfall.

COCs above screening levels in surface sediment near these outfalls include nickel near the Roeder outfall and Hilton outfall and fluoranthene near the Hilton outfall. Higher concentrations of dioxin/furan were also measured in surface sediment near the Roeder outfall and Hilton outfall. City and Port stormwater permit requirements and associated maintenance and cleanout schedules are likely to address potential recontamination from stormwater. This will be further evaluated through post-cleanup sediment monitoring.

A summary of the main identified stormwater discharges is provided below:

- **City of Bellingham Stormwater System:** The City is regulated under Phase II of the federal NPDES Stormwater Program, the City of Bellingham stormwater program, and other permitted discharges described in the Inner Bellingham Bay Contaminated Sediments Total Maximum Daily Load (TMDL) program (Ecology 2001). The City has one stormwater outfall located at the head of the Waterway (Roeder outfall). The City originally developed a local stormwater program and submitted it to Ecology in 1999. It included an extensive source cleanup program, which incorporated removal of solids from stormwater catch basins using vactor trucks. After review of the program, Ecology recommended that the City concentrate on improvements in two areas: 1) coordinate the stormwater program with the planned sediment cleanup in Bellingham Bay; and 2) improve the stormwater plan requirements for redevelopment. The City was in full compliance with all catch basin maintenance requirements during the 2007 to 2013 NPDES permit period, which in general included catch basin inspection and maintenance every 2 years.
- **Port of Bellingham Stormwater Program:** The Port has one outfall along the southern shoreline that drains stormwater from Hilton Avenue (Hilton outfall) and one outfall along the northern shoreline (Bellwether outfall). The Port recently cleaned the Hilton catch basins 001 and 002 on April 22, 2014. The Port inspects and maintains their catch basins annually, including the Bellwether catch basins. The Hilton catch basins will also be inspected and maintained annually going forward. The Port leads environmental protection efforts at its properties around Bellingham Bay, in part through its Stormwater Management Program (Port of Bellingham 2013). The Program conforms to the City's stormwater requirements, as well as Ecology's Puget Sound Stormwater Technical Manual for all development and redevelopment activities near Bellingham Bay, including the uplands surrounding the I&J Waterway Site. The Stormwater Management Program includes reference to a series of operational and structural best management practices (BMPs) and treatment alternatives to reduce or eliminate adverse impacts from Port activities on stormwater and receiving waters.
- **Bornstein Seafoods:** Bornstein Seafoods has an Industrial Stormwater General Permit (WAR000679) for discharge from two outfalls (Outfall 001 and 002) that are subject to quarterly monitoring. Bornstein Seafoods cleans its catch basins and oil-water

separators at least once per year, or more frequently as needed. Both outfalls discharge roof and parking lot runoff after passing through an oil-water separator near each outfall. Bornstein Seafoods has been working with Ecology to reduce discharged copper concentrations. No other elevated concentrations were observed during regular monitoring.

6.1.3 Storm Solids Inspection and Sampling

During the 2012 supplemental investigation, a reconnaissance survey was conducted to identify the presence of stormwater solids within catch basins for each storm drainage outfall for the Site. Storm drain locations are shown in Figure 6-1. Information collected during the survey included the total depth below ground surface, depth to the base of the outflow pipe, depth to water, time measurement (to determine tidal influence), presence of and orientations of connection pipes, and approximated thickness of storm drains solids, if present, as documented in the *Supplemental Investigation Memorandum* (Anchor QEA 2013b). Two Port catch basins (Figure 6-1) were identified within Port of Bellingham Outfall 002 that contained sufficient solids material to sample (greater than or equal to 2.5 inches of material). These catch basins are part of a small storm drain basin that drains the area immediately adjacent to these basins along Hilton Avenue and discharges northeast of, and adjacent to, the Bornstein Seafoods building. Port of Bellingham Catch Basin-2 (CB-002) was selected for solids sampling due to its location nearest to the outfall. Other catch basins did not contain sufficient solids accumulation for sample collection.

A grab sample was collected from the CB-002 storm drain maintenance hole and tested for SMS constituents, nickel, and dioxin/furan compounds. The storm drain solids chemical testing results are included in Table 6-1. All SMS constituents were below criteria, except for butylbenzylphthalate, which exceeded SQS (SCO). Nickel exceeded the former DMMP SL and BT/ML. Storm drain solids contained a dioxin/furan concentration of 13.2 ng/kg TEQ. The Port performed maintenance of the area around catch basin 001 in 2011 to expose the catch basin, which had been buried as a result of recent construction and grading activity. The elevated butylbenzylphthalate and nickel in the storm drain solids sample are likely related to erosion from surrounding surface soil. The Port cleaned this catch basin and removed storm drain solids and will continue to implement BMPs to prevent further erosion into the storm drain.

6.1.4 Adjacent Cleanup Sites

Ecology and the Port are conducting cleanup activities at the Central Waterfront site located adjacent to the I&J Waterway Site. The Central Waterfront site includes four former cleanup sites that have been combined into a single site to comprehensively manage commingled groundwater contamination. The site includes properties formerly known as the Roeder Avenue Landfill, the Chevron Bulk Fuels Facility, The Boat Yard at Colony Wharf, and the Olivine Uplands site (Ecology 2004). The Roeder Avenue Landfill was a bermed municipal landfill that operated between 1965 and 1974. The Chevron Bulk Fuels Facility is located along C Street and is an area where soils and groundwater are impacted by petroleum hydrocarbons associated with historical fuel handling practices. This has been purchased by the Port. The Boat Yard at Colony Wharf is an operational boatyard. Soils and groundwater at the site are impacted by low levels of metals contamination, principally copper. Petroleum has also been detected in soil and groundwater.

The former Olivine Uplands area is adjacent to the I&J Waterway Site along the southeastern shoreline. The Olivine Uplands site was formerly used by previous Port tenants for operation of a lumber mill, and later for operation of a rock crushing plant. Contaminants identified at the site include petroleum hydrocarbons, PAHs, and low levels of heavy metals, principally nickel. The Port is conducting the cleanup of the Central Waterfront site in coordination with Ecology and ongoing RI/FS activities are underway consistent with an Agreed Order with Ecology. Potential ongoing contaminant sources to the I&J Waterway Site from the Central Waterfront site, including soil erosion to stormwater and groundwater migration, are being addressed as part of the Central Waterfront RI/FS (Anchor QEA 2013a).

6.2 Natural Recovery Processes

Natural recovery of aquatic sediments can occur through physical processes, biological processes, and chemical processes. Natural recovery is defined as the effects of natural processes that permanently reduce risks from contaminants in surface sediments (Apitz et al. 2002) and effectively reduces or isolates contaminant toxicity, mobility, or volume. At the

Whatcom Waterway site, within which the I&J Waterway Site is located, natural recovery through the physical process of sediment deposition has been highly effective at restoring sediment quality in the bioactive zone.

The potential for natural recovery of sediment is determined through multiple lines of evidence. A thorough assessment of natural recovery within the areas of Bellingham Bay was performed as part of the RI/FS and remedial design for the Whatcom Waterway site (Figure 6-2). That work is summarized below, including measurements of sediment profiles, estimates of deposition rates, and the findings of natural recovery modeling. In addition, as discussed in Section 6.2.2, natural recovery is occurring at the I&J Waterway Site as shown by the decrease in surface sediment chemical concentrations throughout most of the site between the late 1990s, 2000, 2005/2006, and 2012 sediment monitoring events.

6.2.1 Sedimentation Rates

An empirical estimation of sedimentation rates is one line of evidence to support the occurrence of natural recovery within I&J Waterway. Sedimentation studies for areas within Bellingham Bay were completed as part of the Whatcom Waterway 1996 remedial investigation activities, as summarized in the 2000 Whatcom Waterway RI/FS (Anchor Environmental and Hart Crowser 2000) and Supplemental Whatcom Waterway RI/FS (RETEC 2006b).

6.2.1.1 Sedimentation Rate Studies

As part of the Whatcom Waterway RI/FS sampling effort, three natural recovery cores (HC-NR-100, HC-NR-101, and HC-NR-102) were collected and two sediment traps (HC-ST-100 and HC-ST-101) were deployed and sampled within the study area. Sediment traps HC-ST-100 and HC-ST-101 were co-located with natural recovery cores HC-NR-100 and HC-NR-101, respectively; the traps were deployed for three periods, each approximately 4 months in duration. These sampling locations are shown in the 2006 Supplemental Whatcom Waterway RI/FS, Figure 3-4 (RETEC 2006b).

The natural recovery cores were sectioned in approximately 2-cm increments as described in the approved Sampling and Analysis Plan (SAP; Hart Crowser 1996). Selected subsamples were submitted for isotopic analysis of lead-210 (Pb-210), and cesium-137 (Cs-137), and chemical analysis of total mercury (chemical tracer based on known mercury discharges), and total solids. Data from the natural recovery cores were used to estimate the net sedimentation rates in the study area and to evaluate mercury concentration trends through time (Tables 6-3 through 6-5).

Sediment traps were deployed, retrieved, and sampled to characterize settling particulates. Settled particulate matter (SPM) that had accumulated in the traps was analyzed for total mercury, phenols, TOC, and total solids. Data from the sediment trap study were used to estimate gross sedimentation rates, and to characterize the chemical and physical properties of SPM in the study area. In addition, comparison of gross sedimentation rates in sediment traps with net sedimentation rates in co-located, radio-dated cores provides an estimate of resuspension rates.

The gross sedimentation rate (settling rate; see Table 6-4) was estimated from sediment trap data and provides a measurement of the flux of suspended solids through the water column. The net sedimentation rate (Table 6-4) was estimated from sediment cores dated with radioisotopes (Cs-137 or Pb-210) or chemical tracers that can be correlated with specific historical events (i.e., mercury in Bellingham Bay). Net sedimentation describes the rate at which sediments are permanently incorporated into the seabed. The difference between gross sedimentation rates and net sedimentation rates provides information on the rate at which bottom sediments are resuspended to the overlying water column where they may be subject to horizontal advection or resettling.

Sediment in the natural recovery cores has been subjected to both coring-induced compaction (an artifact of the sampling process) and burial-induced compaction (the natural consolidation of sediments). The effect of sampling-induced compaction was removed from the data, and actual sampling depths were reconstructed based on the ratio of core penetration to core recovery.

Sedimentation rates are often presented in mass-based accumulation units of grams per square centimeter per year (g/cm^2-yr) to implicitly account for burial-induced compaction and porosity reduction with depth in the sediment. However, the density gradients in the natural recovery cores are slight; therefore, sedimentation rate calculations were performed using length-based units in centimeters per year (cm/yr) without introducing significant errors. Length-based units were preferred for the following reasons:

1. The point of compliance for biological effects is defined on the basis of length, not mass, and is the depth of the biological mixing zone (12 cm).
2. Length-based sedimentation rates are simpler, more intuitive, and more easily compared to geologic events in the sediment stratigraphy.

6.2.1.2 Net Sedimentation Rates

6.2.1.2.1 Geochronology Cores

Net sedimentation rates can be calculated from Pb-210 activity based on a model of constant and uniform sediment accumulation (Battelle 1995). Sediment accumulation rates, however, are affected by seasonal variations in sedimentation resulting from river discharges, vessel traffic, and biological activities, as well as long-term variations resulting from changing land use patterns in the watersheds. Therefore, the interpretation of Pb-210 profiles is often subject to model assumption violations, particularly in shallow urban waterways such as inner Bellingham Bay. Non-uniform sedimentation probably accounts for much of the observed scatter in the profiles, although radioisotope counting errors also contribute to the uncertainty.

The supported Pb-210 activity for the natural recovery cores was estimated to be 0.75 disintegrations per minute per gram (dpm/g). This estimate is based on the range of published, supported Pb-210 values (0.5 to 1 dpm/g) typical for Puget Sound sediments (Battelle 1995). The value for the supported Pb-210 activity was estimated because a baseline Pb-210 value could not be established with certainty in the lower sections of the cores. The estimated supported value of 0.75 dpm/g is believed to be representative of Bellingham Bay conditions. Uncertainty associated with the supported Pb-210 values has very little effect on the calculation output because the slope of the regression analysis drives the output.

The net sedimentation rate was calculated from the slope of natural logarithm of excess Pb-210 activity versus depth below the mixing layer. The slope was statistically determined using linear regression techniques. The estimated Pb-210 sedimentation rates ranged from

1.4 to 2.07 cm/yr. These rates are generally consistent with sedimentation rates estimated using Cs-137 or mercury, as described in the following paragraphs.

Cs-137 has entered the oceans over the last 63 years as the result of nuclear weapons testing. The peak in Cs-137 profiles is believed to reflect the major global input of Cs-137 to the Earth's atmosphere during the period of active bomb testing and is correlated with a date of 1962. An additional index depth is the point where Cs-137 concentrations begin to increase sharply from a background or non-detectable concentrations to measurable concentrations. This point can be time labeled because Cs-137 is anthropogenic in origin and no background concentrations occurred in sediments prior to the nuclear weapon testing. The depth representing the onset of the introduction of Cs-137 to the sediments is correlated with 1950.

The sedimentation rates calculated from the Cs-137 profiles using both of the time indices (i.e., the onset and the peak of atmospheric fallout) were generally consistent between the natural recovery cores and ranged from 1.52 to 1.99 cm/yr based on the introduction of Cs-137 activity, and from 1.43 to 1.52 cm/yr based on the peak of Cs-137 activity. These sedimentation rates are generally consistent with the estimates derived using Pb-210 or mercury profiles. Modern sedimentation rates appear to be relatively stable, based on consistency across different datums, and thus are appropriate for use in future projections.

Selected subsamples from each natural recovery core were analyzed for total mercury. Mercury was selected as a chemical tracer because it is a primary COC in Bellingham Bay and the period of maximum discharge to the bay is well-documented. Maximum discharges of mercury to Bellingham Bay occurred between 1965 and 1970 (Bothner et al. 1980). Sediment mercury accumulations likely reached their maximum in approximately 1970, allowing a few years of lag time for mercury to flux through the water column and become incorporated in the sediment. Estimated sedimentation rates based on the mercury profiles are generally consistent among the natural recovery cores and range from 1.54 to 1.98 cm/yr. These sedimentation rates are also consistent with estimates based on radioisotopic dating methods.

In summary, the average net sedimentation rates were calculated using the mean of the four estimation methods:

1. Onset of Cs-137 activity
2. Peak of Cs-137 activity
3. Pb-210 decay
4. Peak mercury concentration

Average sedimentation rates calculated for inner Bellingham Bay are generally consistent among the three natural recovery cores and range from 1.52 cm/yr at HC-NR-100 and HC-NR-101 to 1.77 cm/yr at HC-NR-102. The uncertainty in the sedimentation rate estimates is about 0.5 cm/yr.

6.2.1.2.2 Bathymetric Comparison

Net sedimentation was also estimated by comparing bathymetry surveys conducted on April 4, 2012, and October 11, 2005. Sediment thickness was estimated for the site by subtracting each sediment surface in computer aided design to develop a net sediment accumulation rate over approximately 6.5 years. The analysis indicated an average net sedimentation rate of 0.2 foot per year (ft/yr), or 6 cm/yr. However, this analysis is limited by the accuracy and survey methods of each survey, which could affect the precision of this evaluation. Nevertheless, the survey comparison suggests accumulation of sediment is occurring throughout the entire site, likely at rates higher than estimated by the geochronology cores discussed previously.

6.2.1.3 Gross Sedimentation Rates

Gross sedimentation, or particle settling rate, is the sum of the net sedimentation and sediment resuspension. Gross sedimentation rates were determined by measuring the flux of particulate matter into sediment traps deployed about 1 meter above the seabed. Gross sedimentation rates are often higher than net sedimentation rates, because only a fraction of the particles settling through the water column are permanently incorporated into the seabed.

As part of the Whatcom Waterway RI sampling program, two sediment traps (HC-ST-100 and HC–ST-101) were deployed in inner Bellingham Bay for three periods, each approximately 4 months in duration. The entire deployment period spanned from October

1996 to September 1997; however, sediment trap HC-ST-101 tipped over during the second deployment period and no sample was recovered.

Particle mass accumulation rates were generally consistent between the two sediment trap locations. Mass accumulation rates ranged from 3.69 to 9.59 g/cm^2-yr, and from 3.55 to 9.16 g/cm^2-yr at locations HC-ST-100 and HC-ST-101, respectively. Surface sediment dry densities in co-located natural recovery cores were used to convert from mass-based accumulation units (g/cm^2-yr) to length-based units (cm/yr). The dry density of surface sediments at the sediment trap locations is 0.47 g/cm^3 at HC-NR-100 and 0.42 g/cm^3 at HC-NR-101. Thus, estimated gross sedimentation rates ranged from 7.85 to 20.4 cm/yr and from 8.45 to 21.8 cm/yr at locations HC-ST-100 and HC-ST-101, respectively.

Gross sedimentation rates varied by almost a factor of 3 between the fall/winter and summer deployment periods. Higher settling rates in summer may be caused by a more direct influence from Nooksack River runoff, which is carried to the site in clockwise, fair-weather circulation patterns that are more typical of summer months. Settling of suspended sediments from the turbid river plume is apparently enhanced during this time period. During winter months, prevailing counter-clockwise circulation patterns deflect the river plume toward Lummi Peninsula and away from the site, resulting in lower settling rates.

6.2.1.4 Resuspension Rates and Mixed-Layer Thicknesses

Resuspension rates were estimated by the difference between gross sedimentation rates measured in sediment traps and net sedimentation rates measured in dated cores (Resuspension = [Gross SR – Net SR]/Gross SR) (Baker et al. 1991). Resuspension describes the continuous exchange of sediments between the seabed and water column. The average of the net sedimentation rates estimated using the four different dating techniques was used in the resuspension rate calculations. Resuspension rates ranged from 81% to 93% throughout the year, averaging about 90% at both locations.

Mixing within the sediment column is a result of bioturbation, tidal wave-induced, or propeller-induced currents. The thickness of the surface mixed layer was interpreted from plots of the natural logarithm of excess Pb-210 activity with depth. The depth at which the

Pb-210 activity indicates steady-state decay behavior (constant decrease with depth in the log activity) corresponds to the bottom of the mixed layer; within the mixed layer, Pb-210 activity is theoretically constant. In these cores, however, Pb-210 activity in the mixed layer is erratic, and may be complicated by propeller wash, anchor drag, construction events, and other bottom disturbances. Based on the Pb-210 profiles the base of the mixed-layer was estimated to range between 24 cm (core HC-NR-100) and 11 cm (core HC-NR-102). These values are in general agreement with studies conducted in other Puget Sound embayments (Battelle 1995).

6.2.2 Temporal Surface Sediment Chemical Trends

Temporal trends of surface sediment chemical and biological testing indicates that contaminant conditions at the site are improving. Table 6-2 summarizes the temporal trends in seven co-located surface sediment samples for key COCs, including nickel, bis(2-ethylhexyl)phthalate, and phenol. Appendix C includes a figure from the Work Plan (RETEC 2005) summarizing the previous surface sediment exceedances. At the three 2005/2006 stations with nickel above the former DMMP SL, the 2012 nickel concentrations declined to below the former DMMP SL at IJ12-04, to equal the former DMMP SL at IJ12-03, and just above the former DMMP SL at IJ12-02. Four stations exceeded SQS (SCO) or CSL for bis(2-ethylhexyl)phthalate prior to 2005/2006 but attenuated to below SQS (SCO) at three of these stations in 2005/2006 (IJW-SS-03, IJW-SS-12, and IJW-SS-13). The fourth station was above CSL in 2005/2006 but was not resampled in 2012 (IJW-SS-06). Phenol concentrations also exceeded SQS (SCO) or CSL at two locations in 1996 but have since attenuated to below SQS (SCO).

COCs that exceeded chemical criteria in the 2005/2006 and 2012 subsurface samples included mercury, bis(2-ethylhexyl)phthalate, 2,4-dimethylphenol, 2-methylphenol, 4-methylphenol, dimethylphthalate, and N-nitrosodiphenylamine. None of these COCs were measured above SMS or LAET criteria in 2005/2006 or 2012 surface samples, except for bis(2-ethylhexyl)phthalate in the 2005/2006 sample IJW-SS-06 collected adjacent to the Bornstein Seafoods dock.

A comparison of surface and subsurface concentrations in the 2013 samples collected beneath the Bornstein Seafoods dock suggest some parameters are lower in surface sediment than subsurface sediment, but other parameters are higher at the surface. Methylphenols are lower in surface sediment than at each of the corresponding subsurface locations; however, each of the three methylphenols is above SMS criteria at one or more location in surface sediment. For phthalates, bis(2-ethylhexyl)phthalate is higher in surface sediment than at each corresponding subsurface sediment sample, but dimethylphthalate is lower in surface sediment for each location. Other parameters are higher in surface sediment than subsurface sediment at location IJ-SS-102, such as dibenzofuran, N-nitrosodiphenylamine, and most PAHs. The contaminant patterns are, however, not entirely consistent between the underpier core samples, indicating that the potential sources of the contamination are variable.

As described in Section 5.2.2, the 2012 biological test results generally indicate improved conditions compared to the 2005/2006 results for those sample stations co-located during the two sampling events. CSL failures in 2005/2006 were SQS (SCO) failures in 2012 at stations IJ12-02, IJ12-03, and IJ12-05.

Besides samples located beneath the Bornstein Seafoods dock and in the berthing area for the Bornstein Seafoods dock, surface sediment trends and comparison of existing surface sediment to subsurface sediment suggests natural recovery processes are attenuating the surface sediment chemical concentrations.

6.3 Other Factors Affecting Sediment Stability

Additional information on factors that could influence future sediment stability was developed for evaluation of the effects of rare, extreme event conditions on contaminant and sediment mobility. Evaluation of future bed stability can be conducted in a number of ways, including inference from empirical evaluation of historical data (e.g., core profiles), and prediction based on assessments of extreme event stresses and potential sediment mixing/transport conditions.

Sediments within the Site have already been subjected to a range of bioturbation and hydrodynamic events, including mixing of sediments by benthos, periodic storm surges, and propeller wash. Despite these events, the stability of sediments located in deep-water depositional areas is reflected in the progressive reduction of surface sediment concentrations and toxicity as cleaner sediments have continued to deposit in these areas (Table 6-2). However, sediment stability in localized areas can differ depending on local conditions. Factors affecting sediment stability are discussed in the following sections.

6.3.1 Bioturbation

Bioturbation (sediment mixing) caused by the natural activities of aquatic organisms (e.g., benthos) can affect sediment stability concern in certain situations. At some locations, organisms may be capable of mixing underlying contaminated sediments to the surface, potentially affecting effective long-term isolation of underlying contaminants. In Bellingham Bay, the depth of the biologically mixed (bioturbation) zone has been established as the top 12 cm of sediment.

6.3.2 Wind and Wave Activity

I&J Waterway is subject to impact from large waves produced in Bellingham Bay due to high wind events. Waves produced in the bay can propagate into I&J Waterway and break in shallow areas and along the shoreline of the Waterway. These waves can induce both surface and near-bottom current velocities in the Waterway that are larger than those due to tidal circulation and have the potential to suspend bottom sediments. Wave-induced near-bed velocities are proportional to the wave height and length, which are in turn influenced by wind direction, fetch distance, storm duration, and local topography and bathymetry.

At the Site, winds and waves from the southwest have the potential to impact the site due to the orientation of the Waterway and the frequency of occurrence of high winds from the southwest. Empirical wave data or numerical modeling of wave heights specifically developed in I&J Waterway are not available. However, wind-wave hindcasting and wave modeling completed for the Whatcom Waterway site, which included I&J Waterway within the modeling domain (Anchor QEA 2013c), can be used to estimate potential wave heights in I&J Waterway due to particular storm events.

Extreme wind speeds from the southwest, evaluated for the Whatcom Waterway project, range from 25 miles per hour based on a 2-year recurrence interval to approximately

48 miles per hour based on a 100-year recurrence interval. Wave modeling was conducted for the Whatcom Waterway site (including I&J Waterway[6]) based on a 25-, 50- and 100-year recurrence interval wind event from the southwest. Wave heights estimated in I&J Waterway ranged from approximately 3 feet at the mouth of the Waterway to about 1.5 feet at the back end of the Waterway during these storm events.

In addition to storm waves, wakes generated by vessels moving just offshore of I&J Waterway or within the Waterway itself can be equal to or greater in height than the predicted wind-waves. The height of vessel-induced waves (wakes) is highly variable depending on the type and speed of vessel movement and the location of the vessel relative to shoreline areas. Vessel operations are described in more detail in the following section.

Both wind- and vessel-induced waves have the ability to impact long-term stability of bottom sediments in I&J Waterway. They can also have implications for design of capping or shoreline armoring as required by the proposed remedial design alternatives. These issues will be discussed directly as part of the FS and the evaluation of remedial alternatives for the Site. Remedial design activities for the final cleanup action will also include additional evaluations of the impacts of wave disturbances on sediment stability.

6.3.3 Propeller Wash

Propeller wash from vessels can produce increased bottom velocities and in some cases localized sediment resuspension. The propeller wash effects are generally proportionate to the size, draft, and power of vessels, with larger, deeper, and more powerful vessels exhibiting propeller wash effects to greater depths. However, propeller wash effects are influenced by propeller type, orientation, water depth, and duration of maneuver.

When the bottom velocities created by propeller wash conditions exceed the stability threshold of the sediments present in the affected area, the surface sediments of the bed may begin to erode. The depth to which the erosion will occur varies with the velocity, the

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[6] The I&J Waterway Site was included in the model domain for the Whatcom Waterway modeling effort. However, the model was not refined nor calibrated within the I&J Waterway area as part of this effort.

sediment type, the duration, and the repetition of the event. Detailed propeller wash scour modeling and tracking performed at other similar sites in Puget Sound (Ecology 1995; PIE 1998; WSF 1999) shows that the maximum depth of potential propeller wash scour can vary from shallow effects (i.e., less than 10 cm) to worst-case scour depths of approximately 90 cm. The greatest scour depths are observed when all factors are aligned, resulting in high bottom velocities in the same location and orientation and occurring repeatedly (e.g., repeated moderate to high power, localized propeller wash occurring at ferry terminals). Scour depths are generally much lower where propeller wash events are transient and in inconsistent orientations (e.g., in offshore areas where vessel traffic patterns are variable).

Chart 6-1 outlines representative vessel types used in I&J Waterway. USCG has a facility in the Waterway and is expected to dock both small and medium response vessels at that location. Bornstein Seafoods also has a dock with various fishing vessels that use that facility. Recreational vehicles also access the boat haul-out and dock just west of the Bornstein Seafoods facility.

Chart 6-1
Vessel Specifications for I&J Waterway Use

Owner/ Operator	Representative Design Vessel	Vessel Length (ft)	Vessel Draft (ft)	Prop Type	# of Props	Props Ducted?	Prop Diameter (ft)	Power per Prop (hp)
USCG	Small Response Boat	25	3.25	Conventional	2	no	1	225
USCG	Medium Response Boat	45	3.33	Waterjet	n/a	n/a	n/a	825
Bornstein Supplier	Large Fishing Vessel	80	12	Conventional	4	no	5.5	156
Public	Recreational-Sea Ray	38	3.1	Conventional	2	no	1	370

Notes:
ft = feet
hp = horsepower
n/a = not applicable
USCG = U.S. Coast Guard

Operational areas shown in Figure 3-2 provide the locations and descriptions of five operational areas that have been defined for I&J Waterway. This information will be used as part of the FS to estimate near-bottom propeller wash velocities, shear stresses, and scour depths for each operational area. This information will be used to inform the evaluation of alternatives.

6.3.4 Seismic Influences on Sediment Stability

The I&J Waterway Site is located within the Puget Sound Basin, an area of active seismicity. The Site could be affected by earthquakes from three primary sources: shallow crustal faults, deep intraslab earthquakes, and interpolate (subduction) earthquakes. The contribution of each of these sources to ground shaking hazards has been evaluated by the U.S. Geological Survey (USGS; http://geohazards.cr.usgs.gov).

USGS disaggregation analyses indicate that the hazard in Bellingham is controlled predominantly by shallow crustal earthquakes at distances of less than 25 kilometers at a return period of 2,475 years. The relative contribution of crustal sources is expected to be even larger at the 475-year return period level.

Liquefaction can be observed in loose, saturated, cohesionless soils subjected to strong earthquake shaking. Cohesive soils, such as plastic silts and clays, are not susceptible to liquefaction, though sensitive clays may exhibit similar behavior. The potential for liquefaction to occur therefore varies from location to location with area lithology, and can affect certain site sediments, and upland soils adjacent to certain site sediment areas.

The primary effects of liquefaction are flow sliding or lateral spreading. Flow sliding occurs when the residual shear strength of a liquefied soil is lower than the shear stresses required to maintain static equilibrium. While it occurs relatively rarely, flow sliding can lead to large lateral soil movements, either during or following earthquake shaking. Lateral spreading can also produce horizontal soil movements during strong ground motion. The displacements produced by lateral spreading typically develop during earthquake shaking and are complete by the time earthquake shaking has ended.

Seismic stability analyses are typically incorporated into the design and permitting for implementation of cleanup actions, and for other types of construction. For example, the Engineering Design Report for the Log Pond Interim Remedial Action (Anchor Environmental 2000) assessed quantitatively the potential for flow sliding and lateral spreading at the Log Pond cap area. Such analyses will be performed as part of the design of any remedial action at the I&J Waterway Site.

Based on site lithology, and the generalized seismic information for the site, seismic issues are unlikely to significantly affect sediment conditions within most of the deep-water site areas. These areas are relatively flat, and lateral spreading and flow sliding are unlikely to occur. The potential for significant sediment movement increases for steep shoreline areas and bulkheaded waterfront areas, due to the lower stability of these steeper slopes. Engineering analyses during remedial design for Site cleanup will address measures to mitigate potential seismic stability concerns in these areas.

7 CONCEPTUAL SITE MODEL

This section summarizes the results of the RI and provides a CSM for the I&J Waterway Site. The CSM provides a concise summary of the information developed in the RI process. The key elements of the CSM include the following:

- Contaminants and Sources (Section 7.1)
- Nature and Extent of Contamination (Section 7.2)
- Contaminant Fate and Transport Processes (Section 7.3)
- Exposure Pathways and Receptors (Section 7.4)

Graphical illustrations of the CSM are included in Figures 7-1 and 7-2. The CSM is provided to assist the reader in review of site information, and in evaluating the appropriateness of potential remedial strategies discussed in the following FS sections. The reader should refer to previous sections of this report for the detailed information on which the CSM is based.

7.1 Contaminants and Sources

As measured by relative concentration and frequency of detection, the principal contaminants in the site surface sediments include nickel and PAHs, and localized areas near the Bornstein Seafoods dock with bis(2-ethylhexyl)phthalate, dimethyl phthalate, N-nitrosophenylamine, dibenzofuran, benzoic acid, and benzyl alcohol. The key contaminants in subsurface sediments include mercury, bis(2-ethylhexyl)phthalate, and 2,4-methylphenol, and localized areas along the southern edge and the head of I&J Waterway with benzoic acid, dibenzofuran, dimethyl phthalate, phenol, and PAHs. As discussed in Section 5.2, dioxin/furans are also present in surface and subsurface sediment at the Site and throughout much of Bellingham Bay. Section 6.1 contains a more detailed discussion of the site source control status. Contaminants and sources are further described below:

- **Nickel Contamination is from Historical Sources:** The primary source of nickel within I&J Waterway Site surface sediments is historical activities at the Olivine Corporation facility, which operated a rock crushing plant for the mineral olivine. Nickel is a constituent within olivine ore and was periodically released to the Waterway through dust and wastewater. The Olivine Corporation ceased operation in 1992. Potential surface soil erosion to stormwater or the Waterway is being addressed as part of the Central Waterfront RI/FS.

- **Bis(2-ethylhexyl)phthalate is from Historical Sources:** Potential sources of phthalate contamination previously investigated include stormwater outfalls, leachate from the Roeder Avenue landfill, and compressor oil that may have leaked from a compressor on the Bornstein Seafoods dock, but the latter two were previously determined not to be major contributors of bis(2-ethylhexyl)phthalate to the Waterway. Sediment concentrations continue to decrease in most areas of the Waterway, indicating that there are no ongoing significant sources of bis(2-ethylhexyl)phthalate.
- **PAHs are Predominantly from Historical Sources:** Elevated PAHs are localized adjacent to the Bornstein Seafoods dock and along bulkhead/shoreline areas. Historical sources of PAHs are likely related to stormwater discharges to the Waterway, the diesel fueling facility for boats at the Bornstein dock between 1960 and the early 1980s, and existing creosoted piles and bulkhead structures located throughout the Waterway.
- **Subsurface Mercury and Phenol Contamination is Predominantly from Historical Sources:** The primary source of mercury within the I&J Waterway Site subsurface sediments are related to the Whatcom Waterway site and include the discharge of mercury-containing wastewaters from the Chlor-Alkali Plant between 1965 and the 1970s. This historical 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 cleanup of the Log Pond area in 2000 and 2001 controlled the secondary source of mercury by capping contaminated sediments in this area. Some regional and natural sources of mercury continue to exist, but these sources are not expected to result in exceedances of Site screening levels. Mercury was not present above criteria values in either the 2005/2006, 2012, or 2013 surface sediment samples.

  The primary sources of methyl-phenolic compounds within the I&J Waterway Site sediments include historical log rafting, wood products handling as part of lumber company/mill activities that historically operated at the Site, and potential lesser contributions from historical stormwater and wastewater discharges. These sources have been controlled. Log rafting and wood handling activities no longer occur in I&J Waterway.

- **Other COCs are localized in the vicinity of the Bornstein Seafoods Dock and the historical source is not known:** Other COCs, including benzyl alcohol, benzoic acid, dimethylphthalate, and N-nitrosodiphenylamine are present in one sample beneath the Bornstein Seafoods dock (IJ13-SS-102). Dibenzofuran is elevated in two samples beneath/near the Bornstein Seafoods dock (IJ13-SS-102 and IJW-SS-06). Elevated concentrations are present of these COCs in subsurface sediment at IJ13-VC-102, but not in other areas of the Site, suggesting that there is no ongoing source of these contaminants to the Site. Sediment resuspension associated with propeller wash mixing near the Bornstein Seafoods dock could be contributing to slower sediment quality recovery than in other parts of the Site.
- **Dioxin/Furan is a Bay-wide issue:** Dioxin/furan is present at elevated levels in surface and subsurface sediments, which tend to be present in higher concentrations throughout Bellingham Bay and in urban areas in Puget Sound. Historical dioxin/furan sources include activities associated with the GP mill and stormwater discharges. Other sources to Bellingham Bay may also include historical controlled and uncontrolled combustion sources (such as hog fuel burners and/or other fires). Ecology will continue to work with the City and Port to review permitted and unpermitted discharges to reduce dioxin/furan loading to Bellingham Bay.

Because primary contamination sources for COCs have been controlled, the main focus of the Site cleanup actions will be to address residual contamination in sediments at the Site. Other contaminated sites located in the vicinity of the I&J Waterway Site are being addressed by Ecology, including the Whatcom Waterway and Central Waterfront sites. Additionally, stormwater management practices have changed over the past several decades, reducing the contaminant load to the Waterway from stormwater. Port, City, and Bornstein Seafoods stormwater system upgrades, maintenance, and BMPs are intended to reduce incoming sediments and associated chemical concentrations to the Waterway. Like all nearshore areas of Bellingham Bay, however, urban activities will continue to contribute stormwater that could contain contaminants, including cPAHs and dioxin/furan. The Port, City, and Bornstein Seafoods will continue to administer current programs to identify and reduce contaminants into I&J Waterway. In addition, post-construction sediment evaluations will provide information on these source control efforts.

7.2 Nature and Extent of Contamination

The nature and extent of sediment contamination impacts within the Site have been delineated through investigations in 2005/2006, 2012, and 2013 and are generally depicted in Figures 5-1 through 5-6. These studies provide an understanding 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 and are summarized in the following bulleted list. These findings are graphically displayed as a CSM in Figures 7-1 and 7-2.

- **Head of Waterway Sediments:** The head of the Waterway is a gradual sloping beach to an elevation of approximately -5 feet MLLW where the slope steepens down to the toe of the federal navigation channel. Sediments near the head of the Waterway contain the highest level of nickel concentrations at the Site, which is adjacent to the former upland Olivine processing facility. As described in Section 5, nickel concentrations have declined over time and biological testing over time has improved from CSL exceedances to SQS (SCO) exceedances or passed SMS criteria. Surface sediment nickel concentrations are continuing to improve as a result of deposition of clean sediments. Higher cPAH concentrations are also present along the bulkhead and shoreline areas and concentrations elevated above regional background generally correspond to the Area Above SMS Criteria. Dioxin/furan concentrations are also present in surface sediment in this area with concentrations elevated above regional background. Subsurface sediments in this area contain nickel and mercury concentrations elevated above benthic criteria and dioxin/furan concentrations elevated above regional background.
- **Navigation Channel Sediments:** Navigation channel sediments include the federal navigation channel and areas immediately adjacent to the channel, including the area by the USCG facility. Sediments generally consist of a layer of soft, silty contaminated sediments. Sediments in the navigation channel contain elevated nickel and also failed biological SMS criteria in several locations, including areas without exceedances of screening levels. Subsurface sediments contain elevated

nickel, mercury, and dioxin/furan. The elevation and thickness of the impacted layer varies with location, but is generally between 3 and 7 feet in thickness. The vertical extent of contamination was delineated based on the presence of the glacial marine drift (clay) layer in the navigation channel, which was exposed as a result of historical dredging activities. The impacted navigation channel sediments are subject to natural recovery by ongoing deposition of clean sediments, which is expected to continue.

- **Nearshore Bulkhead and Dock Sediments:** The southern shoreline of the Site consists of marine trade infrastructure, including the east and west bulkheads and the Bornstein Seafoods dock. Figure 7-2 presents a longitudinal view of the nearshore bulkhead and dock areas. The slope from the bulkheads to the toe of the navigation channel is generally at or steeper than a 2H:1V slope. Chemical and biological impacts have been identified in the nearshore area, which are consistent with historical sources to the Waterway. Surface sediment in this area contain elevated nickel, PAHs (including cPAHs), and dioxin/furans, with elevated bis(2-ethylhexyl)phthalate, dibenzofuran, phenols, benzoic acid, benzyl alcohol, dimethylphthalate, and N-nitrosodiphenylamine present near the dock. Subsurface sediment contains elevated nickel, mercury, bis(2-ethylhexyl)phthalate, phenols, and dioxin/furans, along with localized areas near the dock with elevated benzoic acid, dibenzofuran, dimethylphthalate, 2-methylnaphthalene, and naphthalene.

7.3 Contaminant Fate and Transport Processes

Sediments within the 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 observed within the Site and have also been extensively documented in Bellingham Bay as part of the Whatcom Waterway cleanup investigations. Most areas of the Site are stable and depositional, and clean sediments continually deposit on top of the sediment surface. RI investigations for Whatcom Waterway and bathymetry comparisons for I&J Waterway have documented depositional rates and have verified that patterns of deposition and natural recovery are consistent throughout most site areas. One potential exception to this general observation is in nearshore, underpier, and berth areas near the Bornstein Seafoods dock, where recovery rates may be reduced by the resuspension of fine-grained sediments from propeller wash or wave activity. In all other areas of the Site, cleaner sediments are consistently observed on top of impacted sediments throughout most areas, and generally improved at co-located stations between 2005/2006 and 2012. Quantitative estimates of natural recovery rates and temporal surface sediment trends are presented in Sections 6.2.1 and 6.2.2.

- **Wind and Wave Processes:** The effects of wind/wave erosional forces represent the principal natural process affecting sediment stability. High-energy, nearshore areas like at the head of the Waterway may have slower natural deposition of fine-grained sediments than other areas. In these areas, fine-grained sediments can be resuspended, mixed, 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 that represent the majority of the 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 marine trade infrastructure has been a prominent feature of the Site and has shaped the current site lithology. The RI/FS includes extensive discussion of historical and future navigation and infrastructure issues that could affect site sediments. The FS incorporates potential future dredging activities as part of the evaluation of the long-term effectiveness of the remedial alternatives. The FS also assesses the inter-relationships between site cleanup decisions and community land use and habitat enhancement objectives, consistent with the goals of the Pilot.
- **Other Erosional or Sediment Disturbing Processes:** As part of the evaluation of sediment stability, the RI included a discussion of bioturbation and propeller wash. 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. Propeller wash in particular will affect sediment stability in near-shore navigation areas. These factors are incorporated into the FS analysis of remedial alternatives.

7.4 Exposure Pathways and Receptors

Section 4 discusses the principal environmental receptors and exposure pathways applicable to the Site. That section also discusses the site screening levels that are used to evaluate protection of these receptors. Exposure pathways and receptors are summarized in the following bulleted list and illustrated in Figure 7-2:

- **Protection of Benthic Organisms:** The primary environmental receptors applicable to the 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 toxic effects. Chemical and biological standards specified under SMS are used to screen for such effects. The whole-sediment bioassays provide an ability to test for potential synergistic effects between multiple chemicals, and to test for potential impacts associated with parameters not measured as part of chemical testing.
- **Protection of Human and Ecological Health:** cPAHs have been retained as bioaccumulative COCs based on levels protective of human health for beach play, clamming, and seafood consumption. Concentrations of other bioaccumulatives, including arsenic, mercury, and pentachlorophenol are below screening levels.

  cPAHs are present at concentrations elevated above regional background along the bulkhead and shoreline areas, with elevated concentrations generally corresponding to the Area Above SMS Criteria. cPAH concentrations outside the Area Above SMS Criteria are lower and similar to Bellingham Bay concentrations. It is anticipated that Site sediments with elevated cPAH concentrations will be addressed as part of the Site remediation for SMS constituents and nickel. cPAHs will be evaluated for protection of human health as part of remedial alternative evaluation in the FS.

  Dioxin/furans are not a COC for the Site, but the distribution is noted for completeness. Dioxin/furans are present at levels above natural background throughout Bellingham Bay and in urban areas in Puget Sound. Higher dioxin/furans at the Site tend to co-occur with other COCs in I&J Waterway sediments. It is anticipated that Site sediments with elevated dioxin/furan concentrations will be addressed as part of the Site remediation for SMS constituents and nickel.

Dioxin/furans will be evaluated for protection of human health as part of remedial alternative evaluation in the FS.

7.5 RI Conclusions

In summary, the nature and extent of contamination at the I&J Waterway Site has been defined. Primary contaminant sources have been controlled, and sufficient information is available to define protective cleanup levels for final site cleanup. The final site cleanup will address areas of sediment contamination and will protect human health and environmental receptors by terminating exposure pathways. The data collected in the RI are sufficient for development of the site FS. The CSM provides a summary of significant factors that must be addressed by the remedial alternatives evaluated in the FS.

8 CLEANUP REQUIREMENTS

This section presents applicable regulatory requirements for the cleanup action, develops cleanup standards for the site based on these regulatory requirements, and develops a remediation footprint to achieve those cleanup standards.

8.1 Regulatory Framework

This section presents applicable regulatory requirements for the cleanup action, including the SMS, the MTCA, and other potentially applicable regulations.

8.1.1 Sediment Management Standards and Model Toxics Control Act

The primary law that governs the cleanup of contaminated sites in the State of Washington is MTCA (WAC 173-340), with sediment cleanup sites primarily governed under the state SMS (WAC 173-204). The SMS were developed to establish cleanup standards for marine, low salinity, and freshwater environments for the purpose of reducing and/or eliminating adverse effects on biological resources and significant health threats to humans from surface sediment contamination. Both SMS and MTCA regulations require that cleanup actions must protect human health and the environment, meet the environmental standards of other applicable laws, and provide monitoring to confirm compliance with cleanup levels. Chart 8-1 provides a list of potentially applicable laws for setting cleanup levels.

The key SMS decision-making document for cleanup actions is the RI/FS. In the RI/FS, the nature and extent of contamination and the associated risks at a site are evaluated, and potential alternatives for conducting a site cleanup action are identified. The cleanup action alternatives are then evaluated against SMS remedy selection criteria, and one or more preferred alternatives are selected. After reviewing the RI/FS, and after consideration of public comment, Ecology then selects a cleanup action for the site and documents the selection in a CAP. Following public review of the CAP, the site cleanup process typically moves forward into design, permitting, construction, and long-term monitoring.

This FS report was prepared consistent with the requirements of the SMS and MTCA.

8.1.2 Project Permitting and Implementation

Chart 8-2 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 the procedural requirements of most state and local permits. 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 National Environmental Policy Act (NEPA) regulations. The SEPA review for the cleanup of the I&J Waterway Site will be completed by Ecology in the future, concurrent with development of the Consent Decree/CAP. NEPA review will be completed in the future at the time of project permitting by USACE.

As described in Section 3.4.1.3, the Port has partnered with the City to participate in land use planning efforts for the redevelopment of the Waterfront District area, including development of the Subarea Plan for the area of Bellingham's Waterfront. 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.

As part of future remedial design activities, a request will be made to the City and WDFW for a written description of their substantive permit requirements. This information will be included in the Engineering Design Report.

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, including impacts to the federal navigation channel. It is anticipated that the cleanup of the I&J Waterway Site will be performed using a Federal 404 permit, either as an individual permit or a Nationwide 38 Permit for cleanup activities.

Chart 8-1

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 8.2, cleanup levels apply to the sediment bioactive zone and are developed for protection of human health, the benthic community, and higher order species.
Surface Water	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.

Notes:

RCW = Revised Code of Washington

WAC = Washington Administrative Code

Chart 8-2

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 USC 4321 et seq.)	The SEPA review will be completed by Ecology in the future, concurrent with development of the Consent Decree/CAP. 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 (RCW 90.58; WAC 173-18; WAC 173-20), City of Bellingham – Shoreline Master Program (BMC Title 22); Critical Areas Regulations (BMC Chapter 16.55) Coastal Zone Management Act (16 USC 1451 et seq.)	All of the project alternatives are consistent with the Bellingham Bay SMP. Construction activities requiring federal approval must be consistent with the state's Coastal Zone Management Program.

Location/ Activity	Requirement/ Prerequisite	Citation	Comments and Substantive Requirements
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) Rivers and Harbors Appropriation Act (33 USC 401, 40 CFR 230, 33 CFR 320, 322, 323, 325)	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 WDFW 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. USACE 404 permit (Individual or Nationwide permit) to be used for project implementation. Project implementation includes USACE 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 USACE.	Port-WDNR Memorandum of Understanding (December 2005) and Port Resolution 1230 Taking possession of, use of, or injury to harbor and river improvements (33 USC 408)	Any change in the channel authorization will include coordination between the Port, WDNR, and the Washington State Congressional Delegation. No changes to channel authorization are currently expected to be required for the alternatives presented. USACE will conduct a 408 review to evaluate the impacts of the remedy on the federal navigation channel concurrent with the USACE 404 permitting process.

Location/ Activity	Requirement/ Prerequisite	Citation	Comments and Substantive Requirements
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) USEPA Wetland Actions Plan (January 1989, Office of Wetlands and Water Protection)	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) Native American Graves Protection and Repatriation Act (25 USC Chapter 32 §3001 through 3113; 43 CFR Part 10) Protection of Indian Graves (RCW 27.44) Archaeological Sites and Resources (RCW 27.53) Archaeological Resources Protection Act (16 USC 470aa et seq.; 43 CFR Part 7) National Historic Preservation Act (16 USC 470 et seq.; 36 CFR Parts 60, 63, and 800)	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.

Location/ Activity	Requirement/ Prerequisite	Citation	Comments and Substantive Requirements
Endangered and Threatened Species	Actions must be performed so as to conserve endangered or threatened species, including consultation with DOI.	Endangered Species Act of 1973 (16 USC 1531 et seq.) (50 CFR Part 17) (50 CFR Part 402) (Title 77 or 79 RCW)	Chinook salmon, bull trout, steelhead, several rockfish, orca whales, and marbled murrelet have been listed as threatened species. Federal agencies must confer with NOAA Fisheries and USFWS 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 and 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 no net loss 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.

Location/ Activity	Requirement/ Prerequisite	Citation	Comments and Substantive Requirements
		Washington Department of Fish and Wildlife Regulations regarding salmon, steelhead, and Puget Sound bull trout recovery and management (RCW 77.85 and 110) Fish and Wildlife Habitat Conservation (WAC 365-190-130; RCW 90.72; RCW 36.70A.050 and 36.70A.190) Growth Management Act (RCW 36.70a) Magnuson-Stevens Act (16 USC § 1801 et seq.) Migratory Bird Treaty Act (16 USC 703-712.) Bald Eagle Protection Act (16 USC 668 et seq.)	

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) Health and Safety for Hazardous Waste Operations and Emergency Response (WAC 296-62; and Health and Safety 29 CFR 1901.120) Occupational Safety and Health Standards (29 CFR 1910) Washington Industrial Safety and Health Regulations (WAC 296-62, WAC 296-155, WAC 296-800)	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.

Notes:

BMC = Bellingham Municipal Code
CAP = Cleanup Action Plan
CFR = Code of Federal Regulations
CWA = Clean Water Act
DOI = Department of the Interior
Ecology = Washington State Department of Ecology
EPA = Environmental Protection Act
ESA= Endangered Species Act
HPA= Hydraulic Project Approval
MTCA = Model Toxics Control Act
NEPA = National Environmental Policy Act
NOAA = National Oceanic and Atmospheric Administration
OSHA/WISHA = Occupational Safety and Health Administration/ Washington State Department of Labor and Industries
RCW = Revised Code of Washington
RI/FS = Remedial Investigation/Feasibility Study
SEPA = Washington State Environmental Policy Act
SMP = Shoreline Master Plan
USACE = U.S. Army Corps of Engineers
USC = U.S. Code
USEPA = U.S. Environmental Protection Agency
USFWS = U.S. Fish and Wildlife Service
WAC = Washington Administrative Code
WDNR = Washington Department of Natural Resources
WDFW = Washington State Department of Fish and Wildlife

Chart 8-3

Potentially Applicable Laws: Treatment and Disposal

Activity	Requirement	Citation	Comments and Substantive Requirements
In-Water Sediment Capping and Dredging	USACE 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 and 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 USACE 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 WDFW 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.
	Rules for management of state-owned aquatic lands	State Aquatic Lands Management Laws (RCW 79.90 through 79.96; WAC 332-30) State Constitution (Articles XV, XVII, XXVII) Public Trust Doctrine	Sediment capping on state-owned lands, if performed as part of the remedy, will comply with rules for management of state-owned aquatic lands.

Activity	Requirement	Citation	Comments and Substantive Requirements
	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 Disposal of Dredged Sediments	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 upland handling. 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.

Activity	Requirement	Citation	Comments and Substantive Requirements
	Permitting and treatment requirements for direct discharges into surface water	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.
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 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 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.

Activity	Requirement	Citation	Comments and Substantive Requirements
Wastewater	Permitting and treatment requirements for direct discharges into surface water	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.

Notes:
CFR = Code of Federal Regulations
HPA= Hydraulic Project Approval
NPDES =National Pollutant Discharge Elimination System
NWAPA = Northwest Air Pollution Authority Regulation
RCW = Revised Code of Washington
RI/FS = Remedial Investigation/Feasibility Study
USACE = U.S. Army Corps of Engineers
WAC = Washington Administrative Code
WDFW = Washington Department of Fish and Wildlife

8.1.3 Containment, Treatment, Handling and Disposal

Chart 8-3 summarizes regulatory requirements potentially applicable to sediment containment or disposal alternatives.

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

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.

Sediments that are dredged and transferred to upland management may be subject to additional profiling requirements and/or other requirements under federal Resource Conservation and Recovery Act regulations and under Washington State Dangerous Waste regulations. However, state-only toxicity designations and federal toxicity characteristic leaching procedure and listing criteria are not anticipated to affect I&J 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), which is defined as "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 dredged 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.

8.1.4 Solid and Hazardous Waste Management

The Washington Hazardous Waste Management Act (Revised Code of Washington [RCW] 70.105) and the implementing regulations, the Dangerous Waste Regulations (Chapter 173-303 WAC), would apply if dangerous wastes are generated during the cleanup action. There is no indication of dangerous wastes being generated or disposed of at I&J Waterway. Related regulations include state and federal requirements for solid waste handling and disposal facilities (40 Code of Federal Regulations [CFR] 241, 257; Chapter 173-350 and -351 WAC) and land disposal restrictions (40 CFR 268; WAC 173-303-340).

8.1.5 Dredged Material Management Program

In Puget Sound, the open-water disposal of sediments is managed under the DMMP. This program is administered jointly by USACE, EPA, WDNR, and Ecology. The DMMP developed the dredged material evaluation and disposal procedures, which include testing requirements to characterize whether dredged sediments are appropriate for open-water disposal. The results of this characterization are formalized in a written suitability determination from the Dredged Material Management Office.

The DMMP has also designated disposal sites throughout Puget Sound. This FS assumes that sediments dredged for remediation would not qualify for open-water disposal. However, dredged material could be considered for open-water disposal at the time of remedial design. Use of DMMP facilities would need to comply with other DMMP requirements including material approval, disposal requirements, and payment of disposal site fees.

8.1.6 Washington State Environmental Policy Act

SEPA (RCW 43.21C; WAC 197-11) and SEPA procedures (WAC 173-802) are intended to ensure that state and local government officials consider environmental values when making decisions. The SEPA process begins when an application for a permit is submitted to an agency, or when an agency proposes to take some official action such as implementing a MTCA CAP. Prior to taking any action on a proposal, agencies must follow specific procedures to ensure that appropriate consideration has been given to the environment. The severity of potential environmental impacts associated with a project determines whether an Environmental Impact Statement is required. A SEPA checklist would be required prior to initiating remedial construction activities. Because the site cleanup action will be performed under a Consent Decree, the SEPA and MTCA processes will be integrated.

8.1.7 Shoreline Management Act

The Shoreline Management Act (RCW 90.58) and its implementing regulations establish requirements for substantial developments occurring within water areas of the state or within 200 feet of the shoreline. Local shoreline management master programs are adopted under state regulations, creating an enforceable state law. Because the site cleanup action will be performed under a Consent Decree, compliance with substantive requirements would be necessary, but a shoreline permit would not be required.

8.1.8 Washington Hydraulics Code

The Washington Hydraulics Code (WAC 220-110) establishes regulations for the construction of any hydraulic project or the performance of any work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh water of the state. The code also includes a program requiring Hydraulic Project Approval (HPA) permits for any activities that could adversely affect fisheries and water resources. Timing restrictions and technical requirements under the hydraulics code are applicable to dredging, construction of sediment caps, and placement of post-dredge residual covers if necessary. For the reasons stated above, the procedural requirements of an HPA permit would not be required, but the cleanup action must still meet the substantive requirements of an HPA.

The FS has been prepared using durations that recognize potential fish closure periods, during which time dredging and any in-water work will not be permitted. Exact in-water closure periods will be determined during the remedial design phase through agency and tribal consultation.

8.1.9 Water Management

8.1.9.1 Clean Water Act

The CWA is the primary federal law for protecting water quality from pollution. The CWA regulations provide requirements for the discharge of dredged or fill material to waters of the United States and are applicable to any in-water work. The CWA regulations also prescribe permitting requirements for point source and non-point source discharges. Acute marine criteria are relevant and appropriate requirements for discharges to marine surface water during sediment dredging, as well as for return flows (if necessary) to surface waters from dewatering operations.

Section 404 of the CWA requires permits from USACE for discharges of dredged or fill material into waters of the United States, including wetlands. Section 404 permits depend on suitability determinations (described previously) according to DMMP guidelines. Section 404(b)(1) requires an alternatives analysis as part of the permitting process. Requirements for all known, available, and reasonable technologies for treating waste water prior to discharge to state waters are applicable to any dewatering of marine sediment prior to upland disposal. Section 401 of the CWA requires the state to certify that federal permits are consistent with water quality standards. The substantive requirements of a certification determination are applicable.

Ecology has promulgated statewide water quality standards under the Washington Water Pollution Control Act (RCW 90.48). Under these standards, all surface waters of the state are divided into classes (Extraordinary, Excellent, Good, and Fair) based on the aquatic life uses of the water bodies. Water quality criteria are defined for different types of pollutants and the characteristic uses for each class of surface water. The standards for marine waters will be applicable to discharges to surface water during sediment dredging, and return flows (if necessary) to surface waters from dewatering operations.

8.1.9.2 Construction Stormwater General Permit

Onshore construction activities that disturb 1 acre or more of land need to comply with the provisions of construction stormwater regulations. Ecology has determined that a construction stormwater general permit is not covered under the permit exemption provisions of MTCA, and thus a project-specific construction stormwater permit would be required if land disturbance greater than 1 acre is necessary. It is anticipated that, if required, the construction stormwater general permit would be obtained during the remedial design phase, and a Construction Quality Assurance Project Plan would also be prepared as part of the remedial design process, supplemented as appropriate by the remedial contractor.

8.1.10 Other Applicable Regulatory Requirements

The following is a list of other applicable regulations for the cleanup action:

- **Health and Safety:** Site cleanup-related construction activities will be performed in accordance with the requirements of the Washington Industrial Safety and Health Act (RCW 49.17) and the federal Occupational Safety and Health Act (29 CFR 1910, 1926). These applicable regulations require that workers are protected from exposure to contaminants.
- **Archaeological and Historic Preservation:** The National Historic Preservation Act and associated amendments will apply if any subject materials are discovered during site cleanup activities.

These requirements are not specifically addressed in the detailed analysis of cleanup action alternatives because they apply to all active cleanup measures.

8.2 Cleanup Standards and Cleanup Footprint

This section discusses the development of cleanup standards and cleanup footprint for I&J Waterway, consistent with SMS. The following subjects are discussed:

- Statement of remedial action objectives. Narrative statements that describe the goals of cleanup.
- Summary of the exposure pathways, screening levels, and COCs developed in Section 4 of the RI.
- Selection of cleanup standards for COCs. Under SMS, the cleanup standards consist of a cleanup level (i.e., a concentration goal for remediation) and an appropriate point of compliance for achieving that cleanup level (i.e., depth of compliance).
- Identification of cleanup footprint and action levels for remediation. Action levels are contaminant-specific, point-based sediment concentrations that trigger the need for remediation. They may be equivalent to the cleanup level, or higher than the cleanup level (e.g., point-based concentration designed to achieve area-average based cleanup levels).

8.2.1 Remedial Action Objectives

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

- **Surface Sediments:** Use appropriate technologies including active and/or passive measures to ensure compliance with site cleanup levels as defined in Section 8.2.2 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 8.2.2.
- **Applicable Laws:** Ensure that implementation of the remedial action complies with other applicable laws.

8.2.2 Summary of Exposure Pathways, Screening Levels, and Constituents of Concern

Section 4 developed screening levels for potential COCs for multiple exposure pathways, consistent with WAC 173-204-560, as summarized in the following list:

- Protection of human health, consistent with WAC 173-204-561, for the following exposure scenarios:
  - Seafood consumption
  - Direct contact and incidental ingestion of sediment
    - Beach play
    - Clamming
- Protection of the benthic community, consistent with WAC 173-204-562
- Protection of higher trophic level species, consistent with WAC 173-204-563

Note that screening levels to reduce risks to human health also reduce risks to below the regulatory thresholds for higher trophic level species.

For each exposure pathway, the SMS provide methods for calculating lower potential screening levels, the SCO, and higher potential screening levels, the CSL. The SCO is a criterion at which no adverse effects occur, including no acute or chronic adverse effects on biological resources and no significant health risk to humans. The CSL is a minor adverse effects level, which is the minimum level to be achieved in cleanup actions under SMS. The SCO and CSL values for these exposure pathways are presented in Table 4-1. The assumptions and calculations are presented in Appendix B.

In addition to the potential screening levels based on exposure pathways, the SMS also consider other potential screening levels such as background concentrations and PQLs. These were compared to the risk-based screening levels to identify a SCO and CSL for each chemical (Table 4-1).

Finally, COCs were identified by comparing existing sediment concentrations in I&J Waterway to the SCO and CSL. Chemicals with one or more SCO exceedances were retained as COCs. Co-occurring contaminants will also be addressed as part of the Site remediation, including dioxins/furans, total PCBs, and mercury. Dioxins/furans were not retained as a COC because congener profiles suggest no site-associated release/activity and Site sediments are similar to Bellingham Bay profiles (Appendix E). Total PCBs and mercury are also not associated with Site releases and were not retained as COCs. The Site remediation will reduce concentrations of these co-occurring contaminants to meet regulatory goals. The COCs are listed in Table 8-1.

8.2.3 Selection of Cleanup Standards for Constituents of Concern

Under SMS, the cleanup standards consist of a cleanup level (i.e., a concentration goal for remediation) and an appropriate point of compliance for achieving that cleanup level (i.e., depth of compliance). The SMS state that cleanup levels are initially set at the SCO, but may be adjusted upward as high as the CSL based on site-specific evaluation of technical possibility, and net adverse environmental impact. For I&J Waterway, it is technically possible to achieve the SCO for all retained COCs in a reasonable restoration time frame, except for cPAHs. The SCO is selected as the cleanup level for all COCs (Table 8-1).

The SCO of 61 µg/kg is unlikely to be achievable for cPAHs in I&J Waterway due to loading from diffuse stormwater inputs, consistent with other urban areas throughout the Puget Sound region. For I&J Waterway, preliminary regional background (70 µg/kg) represents an estimate of the contribution of cPAH contamination from diffuse sources such as stormwater. Therefore, remediated sediments will equilibrate to concentrations approximately equal to regional background. Although it may be technically possible to remediate to concentrations less than regional background in the short term, it is not technically possible to maintain those concentrations over the long term. Furthermore, repeated attempts to achieve SCO concentrations (e.g., through additional rounds of dredging or capping) would result in net adverse environmental impacts to the benthic community without additional benefit. For these reasons, the cleanup level was adjusted upward to the preliminary regional background value.

Cleanup levels are applied at different vertical and horizontal spatial scales depending on the exposure pathway they were developed to protect. The site-wide cleanup level for total cPAHs was developed to protect human health from seafood consumption; therefore, the cleanup level must be met on an area-weighted average basis in the upper 12 cm of sediment (the biological active zone that could transfer contaminants up the food chain). The relevant exposure area depends on the species, which includes crab and fish (subtidal home range of approximately 10 km^2) and clam (potentially harvested from the intertidal portion of the site). The intertidal cleanup level for cPAHs was developed to protect human health from direct contact; therefore, the cleanup level must be met on an area-weighted average basis in the upper 45 cm of sediment (the approximate depth of potential exposure) in intertidal areas that are accessible to the public. All other cleanup levels were developed to protect the health of the benthic community and therefore must be met for individual points in the upper 12 cm of the site.

8.2.4 Action Levels and Cleanup Footprint

Action levels are the contaminant-specific, point-based sediment concentrations that trigger the need for remediation. The following action levels were used to determine the cleanup footprint that would achieve all cleanup standards:

- Based on protection of the benthic community, all COCs (except cPAHs) with point concentrations above the SCO were incorporated into the remedial footprint.
- Based on protection of the benthic community, all SCO exceedances of biological effects criteria were incorporated into the remedial footprint.
- Based on protection of human health (and higher trophic level species), cPAH point concentrations above 610 μg TEQ/kg dry weight were incorporated into the remedial footprint. This achieves the preliminary regional background cleanup level on an area-weighted basis when combined with the action levels for other COCs. cPAHs west of the Site boundary are not associated with releases from the Site. Methods to estimate the area-weighted concentrations are presented in Appendix H.

The cleanup footprint totals 3.1 acres, as shown in Figure 8-1. As noted above, dioxins/furans were not retained as a COC and no action level was developed. However, post-cleanup concentrations are predicted to achieve preliminary regional background concentrations for dioxins/furans in I&J Waterway.

The following section divides the cleanup footprint into site units based on consideration of site use, physical conditions, and chemical conditions.

9 SEDIMENT SITE UNITS

Different areas of the I&J Waterway Site have different uses, contributions to site risk, and chemical and physical conditions. The division of the Site into different areas or "sediment site units" is performed in this section consistent with the SMS; these units are based on unique physical characteristics, site use considerations, natural resources, and contaminant distribution.

This section describes the sediment site units (site units) that are used for this FS and discusses the characteristics of each of those units. These characteristics are described in four of the following groups:

- **Physical Factors** including bathymetry, sediment particle size and texture, the characteristics of overwater structures, and 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 9-1 shows the I&J Waterway Site units used in this FS. Characteristics of the site units are listed in Table 9-1 and summarized in the following sections.

9.1 Navigation Channel Units

The navigation channel units consist of the Navigation Channel West and the Navigation Channel East site units.

9.1.1 Physical Factors

Navigation Channel West unit water depths vary from approximately -12 feet MLLW toward the east end of the unit to -16 feet MLLW toward the western end of the unit. The Navigation Channel East unit water depths are shallower than the Navigation Channel West unit, varying from MLLW near the east end of the unit to -14 feet MLLW near the western portion of the unit. These depths are the result of historical dredging activities in the federal navigation channel and subsequent sedimentation. Federal dredging was completed in 1966 to the authorized channel elevation of -18 feet MLLW. Selected areas in each of these units were dredged by USACE to the authorized elevation in 1992. The outer portion of the federal navigation channel to the west of these site units is generally shallower than -15 feet MLLW.

Sediments in these site units are dominated by fine particle size distributions (silts and clays), with a total fines content generally greater than 80%. Fish matter was observed in cores IJ-21 and IJ-24 in the Navigation Channel West unit, and IJ-20 and IJ-25 in the Navigation Channel East unit. The USCG dock is adjacent to these units to the north.

9.1.2 Land Use and Navigation

The Navigation Channel West unit is used by USCG vessels and vessels visiting Bornstein Seafoods. These vessels dock in other waterway units, but vessel propeller wash is associated with transiting and berthing activities. Unlike the Navigation Channel West unit, the Navigation Channel East unit is used only by the USCG. Propeller wash influence from vessel traffic is expected to be significantly less for this site unit than the Navigation Channel West unit because USCG vessels have relatively shallow drafts (Appendix G). Water depths in the Navigation Channel West unit are adequate for vessels visiting Bornstein Seafoods and for USCG vessels (including in the Navigation Channel East unit).

These site units are within the federal navigation channel. Federal navigation channels represent a conditional agreement between USACE 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 navigation channel, the project depth is defined as -18 feet MLLW.

9.1.3 Natural Resources

These site units are composed of navigation and subtidal aquatic areas. No areas of existing high-function 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 site unit.

9.1.4 Contaminant Distribution

Surface sediments concentrations within the Navigation Channel West unit are above action levels, with two CSL bioassay exceedances from 2005/2006 and a SCO bioassay exceedance from 2012 indicating that sediment quality causes minor adverse effects. A portion of this unit contains surface sediment concentrations above the cPAH action level based on interpolation of samples in the adjacent berthing area. Surface sediment concentrations within the Navigation Channel East unit exceed action levels for nickel, and two CSL bioassay exceedances from 2005/2006 and a SCO bioassay exceedance from 2012 indicate that sediment quality causes minor adverse effects.

Subsurface sediment concentrations in the Navigation Channel units are based primarily on historical composite samples, indicating potential SCO exceedances for mercury, 2,4-dimethylphenol, 2-methylphenol, phthalates, and n-nitrosodiphenylamine.

9.2 Coast Guard and Coast Guard Bank Units

The Coast Guard unit consists of the area near the USCG dock structure. The Coast Guard Bank unit is the portion of the Bellwether shoreline adjacent to the Coast Guard site unit.

9.2.1 Physical Factors

Water depths in the Coast Guard unit are slightly shallower than the Navigation Channel East unit, with depths from MLLW to -13 feet MLLW. These depths are largely the result of historical dredging activities in the Waterway, most recently conducted to -18 feet MLLW in 1992, and subsequent sedimentation. The Coast Guard unit consists of a fixed boathouse on piles and a floating pile-supported dock.

The Coast Guard Bank grades from MLLW to approximately -10 feet MLLW at the Coast Guard unit. The slope is approximately 2.4H:1V. Soft surface sediment extends up to approximately 0 foot MLLW with rubble and riprap present at higher elevations. There are no structures in the Coast Guard Bank unit.

Sediments in the Coast Guard unit are dominated by fine particle size distributions (silts and clays). Fish matter was observed in core IJ-31 in the Coast Guard unit. The Coast Guard Bank Unit consists of sediment and rubble with riprap in the shallow portion.

9.2.2 Land Use and Navigation

The Coast Guard unit is used only by USCG shallow draft vessels for berthing. Propeller wash from vessels are expected to be significantly less than in the Navigation Channel West unit due to the shallow drafts (Appendix B). Part of the Coast Guard unit is in the federal navigation channel.

9.2.3 Natural Resources

The areas of the Coast Guard unit are composed of navigation and subtidal aquatic areas. The Coast Guard Bank unit includes shallow water depths considered 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). The Coast Guard Bank unit also has intertidal area that is accessible to the public from the Head of Waterway site unit, but consists of riprap and is not considered to contribute to clamming or beach play exposure scenarios.

9.2.4 Contaminant Distribution

Surface sediment concentrations within the Coast Guard unit exceed action levels for nickel, and one CSL bioassay exceedance from 2005/2006 and one SCO bioassay exceedance from 2012 indicate that sediment quality causes minor adverse effects. No locations were sampled in the Coast Guard Bank unit. Surface sediment concentrations are assumed to be similar to the adjacent Coast Guard and Head of Waterway site units.

Subsurface sediment concentrations in the site unit are based primarily on historical composite samples, indicating potential SCO exceedances for mercury, 2,4-dimethylphenol, 2-methylphenol, phthalates, and n-nitrosodiphenylamine.

9.3 Berthing Area Unit

The Berthing Area unit is located between the Navigation Channel West unit and the Dock units.

9.3.1 Physical Factors

The Berthing Area unit water depths vary from approximately -16 feet MLLW adjacent to the navigation channel to -10 feet MLLW at the dock face. These depths are the result of historical dredging activities in the Waterway in 1966 (to -18 feet MLLW), again in 1992 along the western portion of the dock (to -18 feet MLLW), and subsequent sedimentation.

Sediments in the Berthing Area unit are dominated by fine particle size distributions (clays and silts) and tend to have higher organic carbon content in subsurface sediments, including fish matter present above the native clay (glacial marine drift layer) present at approximately -20 feet MLLW in this area. Fish matter was observed in cores IJ-23 and IJ-27 in the Berthing Area unit.

Remediation of this site unit must consider the structural integrity of the adjacent dock structure.

9.3.2 Land Use and Navigation

This site unit is primarily used by commercial seafood vessels visiting Bornstein Seafoods for navigation and berthing. The appropriate berthing elevations for commercial seafood vessels that frequent the Bornstein Dock would be consistent with the elevations in the navigation channel, but no shallower than -15 feet MLLW. Propeller wash effects from vessel traffic are potentially significant from vessel berthing activities (Appendix G).

9.3.3 Natural Resources

The Berthing Area unit is composed of navigation and subtidal aquatic areas. No areas of existing high-function nearshore aquatic habitat are located in the site unit.

9.3.4 Contaminant Distribution

Surface sediment concentrations within the Berthing Area unit exceed action levels for total cPAHs, bis(2-ethylhexyl)phthalate, dibenzofuran, and a CSL bioassay exceedance from 2005/2006.

No discrete core samples were analyzed in the berthing area, but subsurface sediment concentrations based on historical composite samples (DMMUs 5 and 6 from 2005), indicate SCO exceedances for mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol.

9.4 Dock Units

The Dock units consist of the Dock unit and the Floating Dock unit situated between the Berthing Area unit and the adjacent upland bulkhead.

9.4.1 Physical Factors

The water depths vary from approximately -10 feet MLLW adjacent to the navigation channel to +1 foot MLLW at the upland bulkhead. Slopes are not armored and have a grade of approximately 2.5H:1V, although debris and rubble is present in the intertidal area. Fish matter was observed in cores IJ-26 and IJ13-VC-101 in the Dock unit.

Dock support piles rows have 10-foot spacing, except under the eastern portion, where spacing is 5 feet. The floating dock is moored by four dolphins that consist of three piles each. A gangway extends down to the floating dock from the upland area. An upland bulkhead is present, which supports the upland property that is at an approximate elevation of +17 feet MLLW.

9.4.2 Land Use and Navigation

Commercial seafood vessels berth adjacent to the Dock units. The Bornstein Seafoods Dock is owned by Bornstein Seafoods and supports their seafood processing activities. The appropriate berthing elevations for commercial seafood vessels that frequent the Bornstein Dock would be consistent with the elevations in the navigation channel, but no shallower than -15 feet MLLW. The Port owns the adjacent upland areas.

Propeller wash effects on the surface sediments in this unit from vessel traffic (specifically, berthing activities) are likely (Appendix B).

9.4.3 Natural Resources

The Dock units consist of shallow-water habitat with appropriate elevation, substrate, wave energy, and other characteristics to maximize the benefits of the habitat to juvenile salmonids.

9.4.4 Contaminant Distribution

Surface sediment concentrations within the Dock unit exceed action levels for total cPAHs, 2,4-dimethylphenol, benzyl alcohol, bis(2-ethylhexyl)phthalate, and dibenzofuran.

Subsurface sediment in the Dock unit has exceedances for a number of chemicals, including elevated mercury, phthalates, methylphenols, phenol, benzoic acid, dibenzofuran, and PAHs.

Surface sediment concentrations in the Floating Dock unit exceed action levels for nickel, total cPAHs, and a SCO bioassay exceedance from 2005/2006.

Subsurface sediment in the Floating Dock unit has exceedances for mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol. Fish matter was observed in core IJ-28 in the Floating Dock unit.

9.5 South Bank Unit

The South Bank unit is adjacent to the Floating Dock unit, the Navigation Channel East unit, and the Head of Waterway unit.

9.5.1 Physical Factors

The water depths vary from approximately -10 feet MLLW adjacent to the navigation channel to +1 foot MLLW at the upland bulkhead. Slopes are not armored and have a grade of approximately 3H:1V.

9.5.2 *Land Use and Navigation*

This site unit does not support navigation as a result of shallower water depths. An upland bulkhead is present to the south. No activities are currently present in the upland area.

9.5.3 *Natural Resources*

The South Bank unit consists of shallow-water habitat with appropriate elevation, substrate, wave energy and other characteristics to maximize the benefits of the habitat to juvenile salmonids.

9.5.4 *Contaminant Distribution*

Surface sediment concentrations within the South Bank unit exceed action levels for nickel, total cPAHs, and a bioassay CSL exceedance from 2005/2006.

Subsurface sediment has exceedances for mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol.

9.6 Head of Waterway Unit

The Head of Waterway unit includes the eastern shore of the Waterway grading down to the navigation channel to the west. It is bordered by constructed banks to the north and an upland bulkhead to the south.

9.6.1 *Physical Factors*

The water depths within the Head of Waterway unit range from MLLW up to intertidal areas to the north, east, and south. Riprap and rubble is present along the north intertidal area, and an upland bulkhead is present to the south. Large riprap boulders and logs/driftwood are present near the high water line at the eastern end of the unit. A City stormwater outfall is present near high water at the upper end of this unit.

Sediment texture in the Head of Waterway unit is generally dominated by coarser sediments associated with higher energy shallow subtidal and intertidal areas. The grain size distribution grades to finer sediments at deeper elevations. Wood fragments have generally been observed in surface and subsurface sediments in this unit.

9.6.2 Land Use and Navigation

Existing site uses and designations are in the process of changing as part of a community planning effort. As described in Section 3.4.1, the 2012 Port of Bellingham Waterfront District *Draft Sub-Area Plan* provides a framework for long-term redevelopment in the Waterfront District (Port of Bellingham 2012). This document includes the restoration of beach habitat and the creation of a beach park at the head of I&J Waterway, which may include a public kayak launch area. The intertidal portion of the Head of Waterway unit is the only area of the site with potential future clamming and beach play exposure scenarios.

In the upland areas adjacent to the Head of Waterway unit, no land use activities are present to the south and east, but the USCG facility is present in the area to the north.

9.6.3 Natural Resources

The Head of Waterway unit includes intertidal areas of emergent shallow water habitat. These areas, along with portions of its sides, are valuable forage and refuge areas as part of migration corridors for juvenile salmonids. Eelgrass is not known to be present in this area, but the fine-grained substrate mud at higher elevations (+8 feet to +11 feet MLLW) could potentially provide spawning habitat for sand lance and surf smelt. The preservation and enhancement of these shallow subtidal and intertidal areas was identified as a priority action under the 2012 Waterfront District Draft Sub-Area Plan.

9.6.4 Contaminant Distribution

Surface sediment concentrations within the Head of Waterway unit exceed action levels for nickel, total cPAHs, and a bioassay SCO exceedance from 2012.

Subsurface sediment has exceedances for mercury, nickel, bis(2-ethylhexyl)phthalate, and methylphenols.

10 SCREENING OF REMEDIAL TECHNOLOGIES

This section presents the screening evaluation of remedial technologies for cleanup of the I&J Waterway Site. The remedial technologies in this section are screened for general applicability, and then screened for applicability in the specific site units presented in Section 9. This screening forms the basis for the remedial alternatives in Section 11. The remedial technologies identified for screening are the following:

- Institutional Controls (Section 10.1)
- Natural Recovery (Section 10.2)
- Containment (Capping) (Section 10.3)
- Removal (Section 10.4)
- Sediment Disposal and Reuse Options (Section 10.4.1)
- Ex situ Treatment (Section 10.5)
- In situ Treatment (Section 10.6)

Sections 10.1 through 10.6 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 10.7.

10.1 Institutional Controls

Institutional controls (ICs) are non-engineered measures and mechanisms for ensuring the long-term performance and protectiveness of cleanup actions. They are applicable to most remedies where contamination is anticipated to remain following active remediation, but they may also be selected as the primary remedial or response action where it is not technically possible to implement a more permanent cleanup action.

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

Additional ICs may be implemented as appropriate, depending on the cleanup action ultimately selected by Ecology. Such additional controls could include use authorizations of aquatic lands, and/or notification and documentation of the site remedial action in County property records, USACE and regulatory agency permit records, and/or records maintained by the State of Washington. For example, ICs would be necessary for monitored natural recovery (MNR) or enhanced natural recovery (ENR) scenarios in the federal navigation channel to ensure that future navigation maintenance dredging would be performed so as to not increase site risk. In this case, the Port will coordinate with the federal government to work towards reauthorizing the dimensions of the federal navigation channel in a manner that is consistent with current and anticipated uses, subject to USACE and/or congressional approval.

ICs can be effective, implementable, and cost beneficial when the remedial action for which the ICs are implemented is consistent with land and navigation uses. In particular, coordination between the Port, tenants of the Port, USACE, and Ecology will be needed to ensure protectiveness for all future site uses. While the use of ICs is not carried forward as an independent action for detailed evaluation, the use of appropriate ICs is part of all of the remedial alternatives.

10.2 Natural Recovery

Natural recovery of sediments within the I&J Waterway Site has been well documented, as evidenced by declining surface concentrations of nickel and other contaminants at co-located locations (Table 6-2). Section 6.2 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:

- Physical processes, such as sedimentation/deposition and mixing
- Biological degradation processes that cause reductions in the mass, volume, and/or toxicity of contaminants through biodegradation or biotransformation
- Chemical processes, including oxidation/reduction and sorption

As discussed in Section 6.2, natural recovery primarily through the physical process of sediment deposition has been effective at restoring sediment quality in the bioactive zone throughout much of the Site. As indicated in that section, estimates of sedimentation rates range from about 1.4 cm/yr to approximately 6 cm/yr. In addition, reoccupied surface sediment stations indicated declining surface sediment concentrations (Table 6-2 and Figure 5-1), and bioassay results indicate declining sediment toxicity from above the CSL in 2005/2006 to above the SCO in 2012 (Figure 5-2).

In additional to physical processes, biological and chemical processes may also contribute to restoring sediment quality at the Site over the long term. Biological processes may degrade or transform organic chemicals into less toxic forms, or they may produce long-term reductions of organic constituents (such as phenolic compounds). Although metals concentrations would not be expected to decrease through biological processes, the natural production of sulfides may result in the formation of metal-sulfide complexes, thereby limiting the bioavailability of certain metals (EPA 2000). Chemical processes include the preferential sorption of organic compounds to naturally occurring carbon and humic sources within the sediments. Also included are changes in redox potential and chemical precipitation reactions that chemically bind contaminants to sediments and reduce their toxicity, such as metal compounds forming stable precipitates with hydrogen sulfides in sediments.

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

10.2.1 Monitored Natural Recovery

The MNR remedy relies on natural recovery processes to reduce risks to acceptable levels following source control, while monitoring recovery over time to measure remedy success (Magar et al. 2009). Monitoring is a fundamental component of the MNR remedy and consists of data collection (physical, chemical, and biological testing) to assess the remedy performance and effectiveness. In the event that MNR does not meet or progress sufficiently toward achieving cleanup levels, contingency actions such as source control, ENR, capping, or dredging may be used. An adaptive management framework is essential in establishing decision rules with target endpoints and time frames for the performance of MNR in the long term (Magar et al. 2009).

Based on the evidence of natural recovery of the I&J Waterway Site, MNR is a retained remedial technology. In particular, the deeper areas of the Site have empirical evidence for high sedimentation rates and declining chemical concentrations. MNR is retained for the following site units:

- **Navigation Channels East and West:** Retained due to evidence of natural recovery and low surface sediment concentrations. These areas would require ICs to limit future dredging, or have contingency plans in place if maintenance dredging becomes necessary.
- **Coast Guard and Coast Guard Bank:** Retained due to evidence of natural recovery and low surface sediment concentrations. These areas would require ICs to limit future dredging, or have contingency actions in place if maintenance dredging becomes necessary.
- **South Bank:** Retained due to minimal impacts from vessel scour, and relatively low surface sediment concentrations.

MNR is eliminated from the following site units:

- **Berthing Area:** Eliminated due to need for maintenance dredging, potential for scour from fishing vessels, and relatively high surface sediment concentrations.
- **Dock and Floating Dock:** Eliminated due to relatively high surface sediment concentrations.
- **Head of Waterway:** Eliminated due to human health risks from clamming and beach play.

10.2.2 Enhanced Natural Recovery

ENR involves active measures, such as the placement of a thin layer of suitable sand or sediment, to accelerate the natural recovery process. ENR is often applied in areas with moderate chemical concentrations where natural recovery processes appear to be occurring, yet the rate of sedimentation or other natural processes is insufficient to reduce concentrations within an acceptable time frame (EPA 2005). The acceleration of natural recovery most often occurs due to burial and/or incorporation and mixing of the clean material into the contaminated surface sediments through bioturbation and physical mixing processes. ENR is usually applied in areas that are stable and not subject to scour; however, engineered aggregate mixes or engineered synthetic products may be used to ensure stability (Palermo et al. 1998). Placement of ENR materials is different than capping because it is not designed to provide long-term isolation of contaminants. As with MNR, ENR includes both monitoring and contingency plan components to verify that recovery is occurring as expected, and to respond accordingly. ENR has been highly effective in managing residual sediment remaining following dredging, referred to as residuals management cover, as discussed in conjunction with dredging in Section 10.4.

Based on the evidence of natural recovery of the I&J Waterway Site, ENR is a retained remedial technology. However, site use, particularly vessel scour from navigation, future maintenance dredging, and beach-related activities (i.e., clamming and beach play) limit the effectiveness of ENR in some areas of the Waterway. For this reason, ENR is incorporated into the remedial alternatives in certain bank areas. ENR is retained for the following site units:

- **South Bank**: Retained as a potentially effective remedial technology due to minimal impacts from vessel scour and relatively low surface sediment concentrations. ENR is assumed to be a sand/gravel mix for stability.

ENR is eliminated from the following site units:

- **Navigation Channels East and West:** Eliminated in Navigation Channel West unit due to potential scour from fishing vessels. ENR could be effective in the Navigation Channel East unit but could require reauthorization of the navigation channel or partial dredging prior to placement.
- **Berthing Area:** Eliminated due to need for maintenance dredging and vessel scour from fishing vessels.
- **Dock and Floating Dock:** Eliminated due to relatively high surface sediment concentrations, potential for scour from fishing vessels, and slope stability considerations.
- **Coast Guard and Coast Guard Bank:** ENR could be effective in these units but could require reauthorization of the navigation channel or partial dredging prior to placement.

- **Head of Waterway:** Eliminated due to human health risks from clamming and beach play.

10.3 Containment (Capping)

Capping is a well-developed and documented in situ remedial technology for sediment that contains and isolates contaminants. A cap should be designed with the objective of reducing risk through three main mechanisms (EPA 2005): 1) physical isolation of the contaminated sediment sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the cap surface; 2) stabilization of contaminated sediment and erosion protection of the sediment and cap, sufficient to reduce resuspension and transport of contaminants into the water column; and 3) chemical isolation that prevents transport of contaminants through the cap and into the water column.

In situ caps are generally constructed using granular material, such as clean sediment, sand, or gravel. Erosion resistance of a sediment cap could be improved as necessary by armoring stone (specifying minimum grain size on the surface of the cap), or by a layer of engineered concrete (e.g., grout mat). Chemical isolation could be improved as necessary with material specifications of the isolation layer, such as the addition of contaminant-sorbing or blocking materials (reactive caps). The additives are selected based on their ability to adsorb or react with contaminants migrating through the cap thickness; examples of reactive amendment materials that have been applied in caps are activated carbon (AC), bentonite, apatite, AquaBlok™, and coke.

In situ capping may be considered as a sole remedy or may be used in combination with other technologies (e.g., removal and MNR). In particular, removal to a specified depth may be required to meet elevation requirements in some areas, including no net loss of aquatic area, navigation depths, or authorized channel elevations. Caps placed within the federal navigation channels above the authorized elevation typically require reauthorization to a different authorized elevation. Capping on state-owned aquatic land may be subject to WDNR approval and a site use authorization.

Various equipment types and placement methods have been used for capping projects, including traditional mechanical equipment, hydraulic systems, conveyors, and hopper barges at larger sites. 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 I&J Waterway Site. Capping materials can be placed from barges or from the shoreline using conventional equipment, such as clamshells. Conveyors have also been used at sites throughout Puget Sound to broadcast capping materials where access is limited, such as under docks and piers.

Based on the proven effectiveness of sediment capping at other remediation projects, capping is a retained remedial technology in this FS. However, site use, such as vessel navigation needs, anticipated future maintenance dredging needs, and presence of an authorized federal navigation channel, limits the practicability of capping. For this reason, capping is only incorporated into the remedial alternatives under the dock and in the intertidal area at the head of the Waterway, with different assumptions for cap construction.

Capping is retained for the following site units:

- **Dock and Floating Dock:** Retained in conjunction with a sheetpile toe wall for cap stability.
- **Head of Waterway:** Retained for protection of human health for direct contact.

Capping is eliminated from the following site units:

- **Navigation Channels East and West:** Eliminated due to navigation elevation constraints and presence of federal navigation channel.
- **Coast Guard and Coast Guard Bank:** Eliminated due to presence of federal navigation channel.
- **South Bank:** Eliminated due to restrictions of capping near federal navigation channel (in Navigation Channel East unit).
- **Berthing Area:** Eliminated due to navigation elevation constraints.

For this FS, the cap beneath the Bornstein Seafoods dock would conceptually consist of a minimum thickness of 4 feet, including a 2-foot isolation layer (sand), 1-foot filter layer (gravel), and 1-foot armor layer (rock; see Appendix G). This cap would have a maximum slope of 3H:1V and increase in thickness toward the sheetpile toe wall at the face of the dock to achieve the appropriate slope. Capping material would be designed to withstand propeller wash forces from fishing vessels but also to allow for placement using a conveyor or other placement method from beside the dock. The toe of the cap would be supported by a sheetpile toe wall to maintain appropriate water depth in the adjacent berthing area, as shown in Figure 10-1. The conceptual design of the intertidal cap at the head of the Waterway would consist primarily of sand with a 3-foot minimum thickness that would be designed to withstand wave action, and appropriate scour protection in front of outfalls, if required. Placement of a cap in the intertidal area would be conducted in such a manner to result in no net loss of the aquatic environment, which could require excavation of limited upland areas near the high water line. Final cap designs would be developed during the future remedial design phase of the cleanup project.

10.4 Removal

Removal is a common and frequently implemented technology for remediation of contaminated sediment, either while it is submerged (dredging) or after water has been diverted or drained (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 routinely used for both maintenance of navigation channels and removal of contaminated sediments. While the objective of navigational dredging is to remove sediment as efficiently and economically as possible to maintain waterways for recreational, national defense, and commercial purposes, environmental dredging is intended to remove sediment contaminated above certain action levels while minimizing the spread of contaminants to the surrounding environment during dredging.

Removal consists of two major process options: dredging and excavation. 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.

There are two major types of dredges, mechanical and hydraulic. While 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 by 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. 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 dredging area, 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 2005). For this FS, it is assumed that I&J Waterway would be dredged and excavated with traditional mechanical methods. Areas with limited access, such as underpier areas, were considered for mechanical dredging using a barge-mounted excavator and for diver-assisted hydraulic dredging. However, either of these options would require some structural modifications to ensure stability. Diver-assisted hydraulic dredging was also eliminated in underpier areas due to the presence of debris and limited access associated with the piling density.

Prior to re-handling, transport, and disposal, the dredged sediment may require dewatering to reduce the sediment water content. Dewatering technologies may be used to reduce the amount of water in dredged sediment and to prepare the sediment for on-site consolidation or upland transport and off-site disposal. This FS assumes that sediment would be dewatered by gravity through natural drainage of sediment porewater to reduce the dredged sediment water content. Water generated during dewatering is typically discharged to receiving waters directly after a level of filtration. Passive dewatering typically requires little or no treatability testing, although characteristics of the sediment such as grain size, plasticity, settling characteristics, and contaminant content are typically considered to determine specific dewatering methods, to determine the size of the dewatering area, and to estimate the time frame required for implementation.

Experience at other sediment cleanup projects shows that resuspension of contaminated sediment and release of contaminants occurs during dredging, and that contaminated dredging residuals can remain following operations. Even after decades of sediment remediation project experience, there are still substantial uncertainties in our understanding of the cause-effect relationships relating dredging processes to risk reduction (EPA 2005; Bridges et al. 2008; Bridges et al. 2010). This FS assumes that dredging residuals would be managed by placement of a thin layer of material (such as 6 inches of sand) similar to ENR, which would provide a clean sediment surface following construction.

Based on the proven effectiveness of removal on other remediation projects, removal is a retained remedial technology for all areas of the Site. However, structural considerations such as docks and bulkheads limit the amount of sediments that can be removed without modifying or removing and replacing existing structures to ensure structural stability.

Removal is retained for all site units with the following assumptions:

- **Berthing Area:** Remove sediment to the native clay layer. Assume structural modifications to the dock and floating dock would be required to achieve full removal (considering stable side slopes).
- **Coast Guard and Coast Guard Bank:** Remove sediment to the native clay layer. Assume dock floats would be moved during construction.
- **Dock:** Remove sediment to the native clay layer. Assume structural modifications would be required for the dock and bulkhead.
- **Floating Dock:** Remove sediment to the native clay layer. Assume dock would be moved during construction and bulkhead would require structural modifications.
- **Head of Waterway:** Remove sediment to the native clay layer.
- **Navigation Channels East and West:** Remove sediment to the native clay layer.
- **South Bank:** Remove sediment to the native clay layer. Assume structural modifications would be required for the bulkhead.

For the purpose of completing this FS, the removal depth is to the native clay layer. However, specific removal depths will be determined during remedial design.

10.4.1 Sediment Disposal and Reuse Options

Options for disposal of marine sediments removed through dredging include landfill disposal, beneficial reuse, open-water disposal, nearshore confined disposal facility (NCDF), and Confined Aquatic Disposal (CAD).

Dredged material could be placed in an upland disposal facility at a permitted municipal or private landfill (e.g., construction debris landfill or Subtitle D landfill). Sediments excavated using water-based equipment could be delivered to a landfill by barge, truck, and/or rail depending on the landfill selected. Upland landfill is the only disposal option retained for this FS.

Where chemistry results allow for potential beneficial reuse, alternative methods for managing dredged material may be available. Based on chemical concentrations and project experience, beneficial reuse of contaminated sediment is not retained in this FS.

Sediments that are determined by the DMMP to be suitable for open-water disposal may be transported by bottom-dump barge for disposal at an unconfined open-water disposal site. Based on preliminary DMMP characterization of sediments at the site (Table 5-7; RETEC 2006a), sediments removed from I&J Waterway would not qualify for open-water disposal, and therefore this option is not retained for further analysis.

A NCDF facility, or a nearshore fill, is an engineered containment structure that allows for dewatering and permanent storage of dredged sediments. NCDFs feature both solids separation and landfill characteristics (EPA 1994), and containment of contaminated sediments in these facilities is generally viewed as a cost-effective remedial option at Superfund sites (EPA 1996). Interest in NCDFs for disposal of contaminated dredged sediment has led both USACE and EPA to develop detailed guidance documents for their construction and management (USACE 1987, 2000; EPA 1996; Averett et al. 1988; Brannon et al. 1990). NCDF facilities involve creation of a sediment containment area that has a final filled surface located above tidal elevations. NCDFs are commonly known as nearshore fills because they involve filling of aquatic areas and conversion of those areas to upland use. At this time, there are no known NCDF options near I&J Waterway without significantly reducing (and mitigating for) aquatic area; therefore, the NCDF option has not been carried forward in this FS.

CAD facilities are similar to NCDFs, as they are constructed in in-water areas and are used to contain sediment dredged from other areas. However, the top surface of the CAD facility must be constructed so that its final elevation retains overlying aquatic uses and must be positioned below the authorized channel depth to allow for maintenance dredging. In some cases, the CAD surface is designed with a surface that provides enhanced habitat conditions. Due to navigation depth requirements, a CAD facility would not be possible to implement and is not retained for further consideration as part of this FS.

10.5 Ex Situ Treatment

Ex situ treatment refers to the process of transforming, destroying, or detoxifying contaminants in dredged sediments. While ex situ treatment of sediment is the subject of considerable interest nationwide, these technologies generally have limited feasibility at full-scale for application to contaminated sediments. Use of ex situ treatment technologies can be challenging, as treatment needs to accommodate beneficial reuse of the material, and upland and in-water disposal remedies are usually much less expensive. Because of large up-front infrastructure costs (i.e., construction of the treatment facility), ex situ treatment is more practicable for larger sites where economies of scale can be leveraged.

Potential ex situ treatment options include acid extraction, phytoremediation, soil/sediment washing, thermal desorption, light weight aggregate production, plasma vitrification, and solidification. None of these options are sufficiently implementable or cost effective for this project and therefore, the technology is not retained for the remedial alternatives.

10.6 In Situ Treatment

In situ treatment entails the direct application or placement of amendments into the sediment and/or mixing reagents with sediment cap substrate to reduce the bioavailability of certain contaminants. Typical application involves the placement of AC or other types of reagents that bind certain organic and/or metal contaminants. In situ treatment has been applied at sediment cleanup sites using one of five process options at the field pilot scale, including the following:

- Mechanical mixing of amendments into shallow sediment
- Slurry placement of the amendments onto the sediment surface
- Mixing amendments with sand and placing the blended materials using methods similar to the ENR or containment technology discussed above
- Sequentially placing amendments under a thin sand cover
- Broadcast application of amendments in a pelletized form to improve settling characteristics (e.g., SediMite™); the pellet matrix subsequently degrades, allowing the AC to slowly mix into surface sediments through bioturbation

Of the amendments available, AC has undergone more testing and evaluation than organoclays, particularly with respect to sediment remediation, because the sorption capacities for PAHs, dioxin/furans, and other chemicals in AC are at least an order of magnitude higher than other sorbents.

While application of in situ treatment has been demonstrated to be effective and implementable at other sediment sites, I&J Waterway Site COCs such as nickel have not been demonstrated on a large scale. Thus, in situ treatment was not retained for further consideration.

10.7 Summary of Retained Technologies

As described in Sections 10.2 through 10.6 and summarized in Table 10-1, the following remedial technologies were considered sufficiently effective, implementable, and cost-effective for use in the development of remedial alternatives:

- **Institutional Controls:** ICs are effective, implementable, and cost-effective and are an aspect of all remedial alternatives.
- **Monitored Natural Recovery:** The effectiveness of natural recovery at reducing surface concentrations of nickel and other COCs within the site has been demonstrated. The use of MNR as part of a remedial strategy for the site is considered effective and implementable. MNR is retained for use in the development of remedial alternatives in subtidal areas with relatively low contaminant concentrations. MNR

would not require deauthorization or reauthorization of the federal navigation channel, but would require ICs to limit future dredging, or have contingency actions in place if maintenance dredging becomes necessary.

- **Enhanced Natural Recovery:** The effectiveness of natural recovery at reducing surface concentrations of nickel and other COCs within the site has been demonstrated. The use of ENR as part of a remedial strategy for the site is considered effective and implementable. ENR is retained for use in the development of remedial alternatives in bank areas with sufficient navigation depths, but not areas within the federal navigation channel that would trigger the need for deauthorization or reauthorization.
- **Containment by Capping:** Capping is effective, implementable, and cost-effective, and is retained for use in the development of remedial alternatives. Land use, navigation needs, and physical factors will be considered in the discussion of capping feasibility for specific site areas. Capping is retained for use in the development of remedial alternatives in intertidal and underdock areas.
- **Removal by Mechanical Dredging:** Mechanical dredging using appropriate equipment is retained for use in the development of remedial alternatives. Mechanical dredging is the most common form of dredging, and appropriate equipment and skilled operators are available from within the region. Removal is retained for use in the development of remedial alternatives in all areas.
- **Landfill Disposal:** Contaminated sediments may be disposed of at a disposal facility permitted to accept contaminated sediment disposal. This disposal option is retained for use in the development of remedial alternatives.

11 DESCRIPTION OF REMEDIAL ALTERNATIVES

This section combines the retained remedial alternatives for each site unit into site-wide remedial alternatives. Six remedial alternatives have been developed to capture the range of potential remedial actions. All remedial alternatives are designed to achieve significant risk reduction following construction, and achieve cleanup standards either following construction or within 10 years following construction. Stepping from Alternative 1 to Alternative 6, the remedial alternatives generally increase in reliance on removal and decrease in reliance on natural recovery (Table 11-1).

11.1 Common Assumptions for the Remedial Alternatives

All alternatives include some sediment removal, significant placement of residuals management cover, slope protection, or capping, and extensive work in the vicinity of the Bornstein Seafoods Dock. In addition to construction items, all alternatives include costs for permitting and design, mobilization and demobilization, staging, transloading, monitoring, ICs, and oversight. Many construction items are common to the remedial alternatives and the costs and construction time frames were estimated using the same assumptions for all alternatives. The common assumptions for cost estimation are documented in Appendix F. The costs and engineering assumptions are based on experience with other remediation sites in the Puget Sound region and represent a best estimate with an accuracy of approximately +50% to -30%.

All alternatives are consistent with land use plans at the head of the Waterway, which include a park and public access area, and continued operation of the Coast Guard and Bornstein facilities. None of the alternatives would require reauthorization or deauthorization of the federal navigation channel, but some would require ICs and additional coordination between the Port, Ecology, and USACE for alternatives that incorporate MNR in the federal navigation channel.

11.2 Alternative 1

Alternative 1 generally consists of capping and dredging areas with the highest contribution to site risk, and MNR in areas with lower contribution to site risk. As shown in Table 11-1 and Figure 11-1, Alternative 1 includes the following technologies:

- The Head of Waterway unit is capped to isolate contamination from clamming and beach play.
- The Dock and Floating Dock units are capped to immediately reduce surface sediment concentrations. A sheetpile toe wall will be installed at the dock face to support the cap.
- The Berthing Area unit is dredged to the native clay layer to immediately reduce surface and subsurface sediment concentrations and because other remedial technologies do not provide adequate berthing elevations.
- MNR is assigned to the rest of the site units, including the Navigation Channel, Coast Guard, Coast Guard Bank, and South Bank units. These are generally subtidal areas that have lower contaminant concentrations, higher sedimentation rates, and evidence of natural recovery.

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 1 consists of removal of 0.2 acre, capping of 1.0 acre, and MNR of 1.9 acres. The total removal volume is approximately 5,600 cy and the total placement volume is approximately 5,800 cy. Capping of the Dock and Floating Dock area would require the installation of a 330-foot-long sheetpile toe wall at the face of the dock and floating dock, with a freeboard height (differential elevation on inside and outside of the wall) of approximately 12 feet (Figure 10-1). Cleanup would cost approximately $5.4 million and take approximately 36 days.

The under-dock cap would require placement of capping material from beside the dock, using a conveyor or other placement method. Repairs to the dock may be required to account for vibrations from pile installation and/or damage during material placement (these are not included in the costs). The toe wall and required fender system would be offset 3 to 4 feet from the existing pier face (e.g., placed further into the channel) to accommodate driving the sheetpile and minimizing the potential damage to the dock. Costs have been included for installation of a fender system that is similar to what is currently present at the dock; however, additional coordination would be needed during design to ensure no loss in function for Bornstein operations at the dock as a result of the fender offset.

This alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. MNR in the Navigation Channel and Coast Guard units would not restrict current waterway usage, as the current water depth in those areas is adequate for current navigation needs. Sand/gravel/armor is included in the Berthing Area unit to provide support for the sheetpile toe wall. For costing purposes, placement of residuals management cover material is included in other portions of the Berthing Area unit to address presence of elevated dredging residuals concentrations. However, placement of residuals management cover material will be contingent on post-dredge concentrations.

This alternative would require ICs that require coordination between the Port, Ecology, and USACE in the event that maintenance dredging becomes necessary, based on navigation needs of the authorized depth of -18 feet MLLW or as a result of sediment deposition that affects navigation of waterway users. Any maintenance dredging action in the future would need to comply with conditions established by Ecology that would adequately address dredging/disposal and exposure of subsurface contaminated sediment, such as placement of an ENR or residual management cover layer following dredging to meet cleanup standards.

11.3 Alternative 2

Similar to Alternative 1, Alternative 2 generally consists of capping and dredging site units with the highest contribution to site risk, and MNR in areas with lower contribution to site risk. Alternative 2 differs from Alternative 1 in that it includes additional ENR in the South Bank unit to further reduce risks following construction (Table 11-1 and Figure 11-2).

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 2 consists of removal for 0.2 acre, capping for 1.0 acre, ENR for 0.3 acre, and MNR for 1.6 acres. The total removal volume is approximately 5,600 cy, and the total placement volume is approximately 6,400 cy. Capping of the Dock area would require the installation of a 330-foot-long sheetpile toe wall at the face of the dock and floating dock with a free board height of 12 feet (Figure 10-1). Cleanup would cost approximately $5.5 million and would take approximately 38 days.

Similar to Alternative 1, this alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. MNR in the Navigation Channel and Coast Guard units would not restrict current waterway usage, and the current water depth in those areas is adequate for current navigation needs. This alternative would require ICs that require coordination between the Port, Ecology, and USACE in the event that maintenance dredging becomes necessary, based on navigation needs of the authorized depth of -18 feet MLLW or as a result of sediment deposition that affects navigation of waterway users. Any maintenance dredging action in the future would need to comply with conditions established by Ecology that would adequately address dredging/disposal and exposure of subsurface contaminated sediment, such as placement of an ENR or residual management cover layer following dredging to meet cleanup standards.

11.4 Alternative 3

Alternative 3 is similar to Alternative 2, but with dredging to the native clay layer in the Navigation Channel West unit to immediately reduce surface and subsurface sediment concentrations (Table 11-1 and Figure 11-3).

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 3 consists of removal of 1.0 acre, capping for 1.0 acre, ENR for 0.3 acre, and MNR for 0.8 acre. The total removal volume is approximately 15,000 cy, and the total placement volume is approximately 7,500 cy. Capping of the Dock area would require the installation of a 330-foot-long sheetpile toe wall at the face of the dock and floating dock with a free board height of 12 feet (Figure 10-1). Cleanup would cost approximately $7.7 million and would take approximately 52 days.

Similar to the other alternatives, this alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. MNR in the Navigation Channel and Coast Guard units would not restrict current waterway usage, and the current water depth in those areas is adequate for current navigation needs. This alternative would require ICs that require coordination between the Port, Ecology, and USACE in the event that maintenance dredging becomes necessary, based on navigation needs of the authorized depth of -18 feet MLLW or as a result of sediment deposition that affects navigation of waterway users. Any maintenance dredging action in the future would need to comply with conditions established by Ecology that would adequately address dredging/disposal and exposure of subsurface contaminated sediment, such as placement of an ENR or residual management cover layer following dredging to meet cleanup standards.

11.5 Alternative 4

Alternative 4 is similar to Alternative 3, but with dredging to the native clay layer in the Dock unit and Floating Dock unit to immediately reduce surface and subsurface sediment concentrations instead of capping (Table 11-1 and Figure 11-4). Removal of contaminated sediment would require that the Bornstein dock in the Dock unit and the adjacent bulkhead be removed and replaced as part of cleanup because the existing dock and bulkhead would be destabilized as a result of dredging. The dock in the Floating Dock unit is assumed to be temporarily relocated and restored to its original position following remediation.

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 4 consists of removal of 1.3 acres, capping for 0.7 acre, ENR for 0.3 acre, and MNR for 0.8 acre. The total removal volume is approximately 18,000 cy, and the total placement volume is approximately 7,000 cy. Cleanup would cost approximately $12.6 million and would take approximately 68 days.

Similar to the other alternatives, this alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. MNR in the Navigation Channel and Coast Guard units would not restrict current waterway usage, and the current water depth in those areas is adequate for current navigation needs. This alternative would require ICs that require coordination between the Port, Ecology, and USACE in the event that maintenance dredging becomes necessary, based on navigation needs of the authorized depth of -18 feet MLLW or as a result of sediment deposition that affects navigation of waterway users. Any maintenance dredging action in the future would need to comply with conditions established by Ecology that would adequately address dredging/disposal and exposure of subsurface contaminated sediment, such as placement of an ENR or residual management cover layer following dredging to meet cleanup standards.

11.6 Alternative 5

Alternative 5 is similar to Alternative 3, but does not rely on ENR or MNR. Instead of ENR, this alternative relies on dredging to the native clay layer in the Navigation Channel East, Coast Guard, Coast Guard Bank, and South Bank site units. Like Alternatives 1 through 3, Alternative 5 caps contaminated sediment in the Dock unit and includes a subtidal sheetpile toe wall to provide cap stability and maintain berthing depths (Table 11-1 and Figure 11-5). Removal of contaminated sediment adjacent to the South Bank unit would require that the adjacent bulkhead be removed and replaced as part of cleanup because the bulkhead would be destabilized as a result of dredging.

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 5 consists of removal for 2.1 acres and capping for 1.0 acre. The total removal volume is approximately 30,000 cy and the total placement volume is approximately 8,900 cy. Capping of the Dock area would require the installation of a 330-foot-long sheetpile toe wall at the face of the dock and floating dock with a free board height of 12 feet (Figure 10-1). Cleanup would cost approximately $13.5 million and would take approximately 84 days.

Similar to the other alternatives, this alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. Because dredging is performed in the Navigation Channel and Coast Guard units, this alternative would not restrict potential future maintenance dredging needs.

11.7 Alternative 6

Alternative 6 is the full removal alternative and features dredging to the native clay layer in all locations. The alternative is shown in Table 11-1 and Figure 11-6.

The total estimated areas, volumes, costs, and construction time frames are provided in Table 11-2. Alternative 6 consists of removal for 3.1 acres. The total removal volume is approximately 39,000 cy, and the total placement volume is approximately 6,000 cy. This alternative requires removal and replacement of the Bornstein dock and the entire bulkhead adjacent to the Dock, Floating Dock, South Bank, and Head of Waterway units. Structures in the Floating Dock and Coast Guard units are assumed to be temporarily relocated and restored to their original positions following remediation. Cleanup would cost approximately $20.6 million and would take approximately 110 days.

Similar to the other alternatives, this alternative would not significantly alter intertidal or shallow subtidal area considered valuable habitat, or current usage of I&J Waterway. Because dredging is performed in the Navigation Channel and Coast Guard units, this alternative would not require ICs for future maintenance dredging.

12 DETAILED EVALUATION OF ALTERNATIVES

Remedy selection criteria under the SMS regulations are similar to those required under MTCA. The SMS evaluation criteria are specified in WAC 173-204-570. This section describes the requirements for cleanup action evaluations under the SMS.

12.1 Minimum Requirements

Cleanup actions performed under the SMS must comply with 11 minimum requirements under WAC 173-204-570(3). Alternatives that do not comply with these criteria would typically not be considered suitable cleanup actions under the SMS. This section discusses the achievement of the SMS minimum requirements.

12.1.1 Compliance with Cleanup Standards

Under SMS, compliance with cleanup standards represents the measure of whether and when an alternative has reduced risk sufficiently to protect human health and the environment. The cleanup standards were developed to protect human health, the health of the benthic community, and the health of higher trophic level species under WAC 173-204-560 through 563. Therefore, compliance with cleanup standards is used to evaluate the minimum requirements of "protection of human health and the environment" (WAC 173-204-570(3)(a)), "compliance with cleanup standards" (WAC 173-204-570(3)(c)), and to "provide for a reasonable restoration time frame" (WAC 173-204-570(3)(d)). Compliance with cleanup standards is discussed in additional detail under Protectiveness in Section 12.2.1.

Table 12-1 presents the estimated performance of the remedial alternatives relative to human health cleanup standards. As discussed for each alternative, all alternatives are expected to meet cleanup standards either following construction, or within 10 years following construction.[7] Consistent with WAC 173-204-570(5)(a), all alternatives are considered to have a reasonable restoration time frame and meet these three minimum requirements.

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[7] Concentrations of co-occurring contaminants, including dioxins/furans, mercury, and total PCBs, will achieve SMS requirements following construction.

12.1.2 Other Minimum Requirements

The achievement of other minimum requirements is discussed in the following list:

- All alternatives comply with all applicable laws as listed in Section 8 of this FS (WAC 173-204-570(3)(b)).
- All alternatives include source control elements for the purpose of achieving cleanup standards (WAC 173-204-570(3)(f)). The degree to which alternatives control sources is discussed in the context of the disproportionate cost analysis (DCA) (Section 12.2).
- A sediment recovery zone is not expected to be necessary for any of the remedial alternatives ((WAC 173-204-570(3)(g)) because cleanup standards are achieved within 10 years following construction.
- None of the remedial alternatives exclusively rely on monitored natural recovery or ICs (WAC 173-204-570(3)(h)).
- Under any alternative, the RI/FS and Cleanup Action Plan will undergo appropriate public review and comment by affected landowners and the general public (WAC 173-204-570(3)(i)), and a periodic review will be performed under WAC 173-204-570(3)(k).
- All alternatives include adequate monitoring to ensure effectiveness of the cleanup action WAC 173-204-570(3)(j).

The DCA is discussed in the next section and addresses the minimum requirement of "using permanent solutions to the maximum extent practicable" (WAC 173-204-570(3)(d)).

12.2 Disproportionate Cost Analysis

SMS specifies that preference shall be given to actions that are permanent solutions to the maximum extent practicable. Identifying an alternative that is permanent to the maximum extent practicable requires weighing the costs and benefits of each. SMS uses the MTCA DCA (WAC 173-340-360(3)(e)) as the tool for comparing each remedial alternative's incremental environmental benefits with its incremental costs. The DCA is the primary method by which the alternatives are systematically compared to each other in this FS. According to WAC 173-340-360(3)(e)(i), costs are considered disproportionate to benefits when the incremental costs of the alternative exceed the incremental benefits achieved by the alternative compared to that achieved by other lower-cost alternatives.

Seven criteria, which are defined under WAC 173-340-360(3)(f), are used to evaluate and compare remedial alternatives when conducting the DCA. Each of the criteria is not considered equal in DCA evaluation, and therefore, each is assigned a relative weight. The first six criteria are weighted and assigned a score for total benefits; these total benefits are then compared with costs across all alternatives.

- Protectiveness (30% of total benefit score)
- Permanence (20% of total benefit score)
- Effectiveness over the long term (20% of total benefit score)
- Management of short-term risks (10% of total benefit score)
- Technical and administrative implementability (10% of total benefit score)
- Consideration of public concerns (10% of total benefit score)
- Cost (compared to total benefits)

The following sections describe the methodology and rationale for evaluating alternatives under each criterion.

12.2.1 Protectiveness

MTCA defines protectiveness as follows:

> *Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality (173-340-360)(3)(f)(i).*

Consistent with DCAs used by Ecology at other Puget Sound sediment cleanup sites, the protectiveness of each remedial alternative was scored based on two considerations:

1. Overall protection of human health, considering anticipated human health risk reductions during and following remedial actions
2. Overall protection of the environment, considering the reduction in risk to the benthic community

Table 12-2 summarizes these considerations. All alternatives protect human health by reducing concentrations to protective levels in appropriate exposure areas (i.e., fish and crab contaminant accumulation from the site, as a portion of their home range [approximately 2,500 acres for these species] and beach areas for direct contact and clam consumption). Within the I&J Waterway Site, which is approximately 3 acres, Alternatives 1 and 2 are expected to achieve cleanup standards within 10 years following construction, and Alternatives 3 through 6 achieve cleanup standards immediately following construction (Table 12-1).

For the health of the benthic community, Alternatives 1 through 4 are predicted to meet benthic criteria following construction for all chemicals except nickel and potentially toxicity testing, which are expected to be met 10 years following construction. Alternatives 5 and 6 are predicted to meet all benthic criteria immediately following construction.

Protectiveness also considers impacts during construction. In particular, dredging and capping disrupt the existing benthic community, and dredging results in releases of contamination into the water column through resuspension of contaminated sediment. However, for this evaluation, the alternatives were not scored on the basis of impacts during construction for protectiveness because each alternative is expected to be constructed within a single construction season.

All alternatives score relatively high for protectiveness because they are all designed to reduce risk to the regulatory goals within 10 years. Alternatives 1 and 2 score lower for protectiveness due to some reliance on natural recovery to achieve cleanup goals; Alternatives 3 and 4 score in the middle due to less reliance on natural recovery to achieve cleanup goals; and Alternatives 4 and 5 score highest for this criterion due to no reliance on natural recovery to achieve cleanup goals.

12.2.2 Permanence

MTCA defines permanence as follows:

> *The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated (173-340-360)(3)(f)(ii).*

For I&J Waterway, permanence is scored based on the certainty and reliability the alternative will not result in future releases to the biological active zone. In particular, the alternatives are scored based on two considerations:

1. The degree of removal of contaminated sediments in areas with potential vessel scour
2. The removal of potential ongoing sources (e.g., creosote piles)

For the first consideration, the alternatives score higher with more dredging (e.g., Alternative 6 scores highest). Alternatives with removal from likely disturbance areas are scored higher, such as in the Berthing Area unit (all alternatives) and the Navigation Channel West unit (Alternatives 3, 4, 5, and 6). Alternatives 1, 2, 3, and 5 may be subject to concerns about long-term stability of the under-dock cap, as a result of the long-term viability of the sheetpile toe-wall and potential recontamination associated with future repairs and modifications of the Port's bulkhead or the Bornstein Seafoods dock. For the second consideration, the alternatives score with a similar trend; however, Alternative 5 scores lower than Alternative 4 because Alternative 5 does not include removal of the creosote-treated dock and west bulkhead. None of the alternatives score a 5 because urban stormwater inputs are expected to continue with any alternative.

12.2.3 Effectiveness Over the Long Term

As part of effectiveness over the long term, the SMS provides a preferential hierarchy of remedial technologies, which replaces a similar upland-oriented list in MTCA, as follows:

> *When assessing the relative degree of long-term effectiveness of cleanup action components, the following types of components may be used as a guide, in descending order, in place of the components listed in WAC 173-340-360 (3)(f)(iv):*
>
> *(i) Source controls in combination with other cleanup technologies;*

> *(ii) Beneficial reuse of the sediments;*
> *(iii) Treatment to immobilize, destroy, or detoxify contaminants;*
> *(iv) Dredging and disposal in an upland engineered facility that minimizes subsequent releases and exposures to contaminants;*
> *(v) Dredging and disposal in a nearshore, in-water, confined aquatic disposal facility;*
> *(vi) Containment of contaminated sediments in-place with an engineered cap;*
> *(vii) Dredging and disposal at an open water disposal site approved by applicable state and federal agencies;*
> *(viii) Enhanced natural recovery;*
> *(ix) Monitored natural recovery; and*
> *(x) Institutional controls and monitoring (WAC 173-204-570(4)(b)).*

Alternatives score higher for effectiveness over the long term if they are less likely to have future releases to the biological active zone. Similar to permanence, the alternatives are scored based on:

1. Where the more robust remedial technologies (e.g., dredging and capping) are applied
2. The extent of source control

As shown in Table 12-2, the alternatives score higher for Alternatives 4 and 6, consistent with the increased amount of dredging. Alternatives 3 and 5 score lower than Alternative 4 because Alternatives 3 and 5 use capping in likely disturbance areas, and this cap relies on a sheetpile toe wall, which may require maintenance in the future. Similarly, Alternatives 1, 2, 3, and 5 do not include removal of the creosote treated dock and west bulkhead. None of the alternatives score a 5 for source control because urban stormwater inputs are expected to continue with any alternative.

12.2.4 Management of Short-term Risk

MTCA defines management of short-term risk as follows:

> *The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks (173-340-360)(3)(f)(v).*

Management of short-term risk considers impacts during construction, and the risks remaining on site during the restoration time frame.

During construction, dredging and capping disrupt the existing benthic community, and dredging results in releases of contamination into the water column through resuspension of contaminated sediment. Table 12-2 presents the construction time frame for the remedial alternatives as a metric for assessing the magnitude of impacts to human health and the environment during construction. The construction time for the alternatives increases from approximately 36 days to approximately 110 days from Alternative 1 through Alternative 6.

The restoration time frame for the alternatives vary from within 10 years following construction (Alternatives 1 through 4) to immediately following construction (Alternatives 5 and 6).

The summary scores for management of short term risk are similar for all alternatives because the two considerations tend to balance with each other (e.g., the lower numbered alternatives score higher for risks during construction and lower for restoration time frame).

12.2.5 Technical and Administrative Implementability

MTCA defines technical and administrative implementability as follows:

> *Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions (173-340-360)(3)(f)(vi).*

For cleanup of I&J Waterway, three primary considerations include:

1. Technical feasibility to implement
2. Feasibility to maintain over the long term
3. Permitting and regulatory implementability

For “technical feasibility to implement,” the alternatives that include capping the underdock area are considered less technically implementable because of structural concerns during installation of the sheetpile toe-wall and underpier cap beneath the existing dock structure (Alternatives 1, 2, 3, and 5). The vibrations associated with driving the sheetpile and ability to place capping material in the underdock area via conveyor contributes to the risk of damage to the existing dock (piles, cross bracing, and other features) and/or contractor claims. Removal and replacement of the dock and bulkhead are technically challenging but use standard construction methods and are more certain (Alternatives 4 and 6).

“Feasibility to maintain over the long term” considers routine maintenance that will be required of the remedial alternatives. Capping the underdock area is considered more difficult to maintain because performance monitoring may indicate that the cap requires repair from the effects of propeller wash or the sheetpile toe wall may require maintenance or replacement. In addition, the dock will likely require maintenance in the future, which could include installation of new piles to replace piles that are of declining quality, thus requiring further maintenance to the underpier cap. Removal and replacement of the dock and bulkhead will require less long-term maintenance. Capping the head of the Waterway will require performance monitoring and potential contingency actions for all alternatives except Alternative 6.

“Permitting and regulatory implementability” addresses the challenges to permitting or gaining regulatory acceptance for the alternatives. All alternatives could be permitted; however, some would present more permitting challenges than others. Alternatives 1 and 2 score the lowest because they use MNR to remediate the Navigation Channel West unit, which would require additional ICs. Alternatives 3 and 5 score slightly higher than Alternatives 1 and 2 because they do not use MNR in the Navigation Channel West area. Alternatives 1, 2, 3, and 5 also score lower than Alternatives 4 and 6 because the sheetpile toe wall to support the under-dock cap would be a new structure on state-owned aquatic lands, with uncertainty related to permitting. The sheetpile toe wall and required fender system would be offset from the existing pierface (e.g., placed further into the channel), which may present permit concerns from WDNR, USCG, and USACE. These alternatives would also require additional regulatory approvals and requirements for long-term maintenance of the underpier cap associated with propeller wash, dock maintenance, or sheetpile toe wall repair/replacement. Alternatives 4 and 6 score highest because they have the fewest permitting and regulatory hurdles.

12.2.6 Consideration of Public Concerns

MTCA defines consideration of public concerns as follows:

> *Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site (173-340-360)(3)(f)(vii).*

Although the RI/FS has not been reviewed by the public, public concerns can be preliminarily scored based on input at other sediment cleanup sites in the area. Generally, public concerns may include maintaining consistency with City/Port land use plans, ensuring the cleanup protects users of the Site, implementing the most permanent cleanup, and restoring habitat. All alternatives are consistent with land use plans, protect users, and restore habitat. However, there are some differences in the permanence of the alternatives. Alternatives with more removal of contaminated sediment are scored higher, and alternatives that include removal of potential ongoing sources of contamination, such as the Bornstein dock and bulkhead, are scored higher. Alternatives 1, 2, and 3 score the lowest for this criterion because they rely in part on MNR, do not remove as much contaminated sediment as the other alternatives, and do not remove potential sources of contamination associated with the Bornstein dock and bulkhead. Alternatives 4 and 5 score higher than Alternatives 1, 2, and 3 because they remove more contaminated sediment. Alternative 4 also scores higher because it removes potential ongoing sources of contamination associated with the Bornstein dock and bulkhead. Alternative 6 ranks highest because it removes all contaminated sediment from the Site and potential ongoing sources associated with the Bornstein dock and bulkhead.

12.2.7 Total Benefits and Costs

Total benefit scores and costs are shown in Table 12-2 and plotted in Figures 12-1 and 12-2. The total weighted benefits range from 2.4 for Alternative 1 to 4.4 for Alternative 6, and costs range from $5.4 million to $20.6 million. For Alternatives 1 through Alternative 4, the alternatives increase in both costs and benefits. Alternative 5 has higher costs than Alternative 4 but does not have increased benefits. Alternative 6 has the highest benefits and the highest costs.

MTCA states that "costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower alternative exceed the incremental degree of benefits achieved by the alternative over that of the lower cost alternative" (WAC 173-340-360(3)(e)(i)). By weighing both the costs and the benefits of the alternatives, Alternatives 5 and 6 are considered disproportionately costly compared to the benefits; Alternative 4 has the highest benefits of the other alternatives.

13 SUMMARY AND CONCLUSIONS

The FS portion of this RI/FS presents a comprehensive analysis of cleanup requirements applicable to the I&J Waterway cleanup Site. After establishing site units and screening potentially applicable cleanup technologies, six comprehensive cleanup alternatives were evaluated and ranked for compliance with regulatory requirements. The alternatives are described in detail in Section 11. The evaluation of alternatives under MTCA and SMS regulations is included in Section 12.

13.1 Description of the Preferred Alternative

Based on the analysis described in Section 12, Alternative 4 provides the most benefits that are not disproportionately costly. Under this alternative, contaminated sediments are remediated using both active and passive remedial technologies, including removal of sediments to the native clay layer in the Dock, Floating Dock, Berthing Area, and Navigation Channel West site units, capping in the Head of Waterway unit, ENR in the South Bank unit, and MNR in the Coast Guard and Navigation Channel East units. Removal of contaminated sediment in the Dock and Floating Dock units will require the removal and rebuild of the Bornstein Seafoods Dock and bulkhead, as well as serve to remove treated wood that is a source of contamination to the environment. Monitoring and institutional controls will be used to ensure the long-term effectiveness of the remedy. Dredged sediments will be disposed of in a permitted landfill.

13.2 Basis for Alternative Identification

The preferred remedial alternative was identified consistent with MTCA and SMS alternatives evaluation and remedy selection criteria. These criteria include the following:

- **Compliance with SMS Minimum Requirements:** Alternative 4 complies with minimum requirements discussed in Section 12.1, including protecting human health and the environment, and complying with the cleanup standards in a reasonable restoration time frame (10 years to meet all cleanup standards).
- **Use of Permanent Solutions to the Maximum Extent Practicable:** As described in Section 12.2, Alternative 4 uses permanent solutions to the maximum extent practicable, based on the findings of the MTCA disproportionate cost analysis.

Alternative 4 is costly, with an estimated cost of $12.4 million; however, significant human health and environmental benefits are achieved through the investments required under this alternative, and the costs are not disproportionate to these benefits. Other lower-cost alternatives provide a lower degree of environmental benefit than Alternative 4. Higher-cost alternatives were determined to be impracticable because their incremental costs were substantial and disproportionate to the incremental benefits of those alternatives.

13.3 Implementation of Site Cleanup

This RI/FS will inform Ecology's preliminary selection of a cleanup alternative for the I&J Waterway Site. The preliminary selected alternative will be articulated for public review in a draft 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 the preferred alternative in a timely manner. The Port has developed a funding plan for implementation of the preferred alternative, including anticipated grant funding from Ecology's Remedial Action Grant Program. The Port also believes that implementation of the preferred alternative can be conducted in a manner that is consistent with and that directly supports the Waterfront District Subarea Plan for this area of Bellingham's waterfront. 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 ongoing land use planning efforts.

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TABLES

Table 3-1
Salmon and Trout Fisheries in Bellingham Bay

Species	Fishery
Coho	mid-September to mid-November
Chum	early November to mid-December
Chinook	late July to mid-September
Pink	July in odd years
Sockeye	no fishery
Steelhead	mid-December to January
Cutthroat	no commercial fishery
Bull trout	no fishery

Table 4-1
Screening Levels

Analyte	Protection of Human Health[a]							
	Seafood Consumption		Clamming			Beach Play		
	10^{-6}, SCO_{HH}	10^{-5}, CSL_{HH}	10^{-6}, SCO_{HH}	10^{-5}, CSL_{HH}	HQ=1, SCO_{HH} and CSL_{HH}	10^{-6}, SCO_{HH}	10^{-5}, CSL_{HH}	HQ=1, SCO_{HH} and CSL_{HH}
Metals	**mg/kg dw**							
Arsenic	nc	nc	1.3	13	530	5.3	53	190
Cadmium	nc	nc	nc	nc	1,800	nc	nc	640
Chromium	nc	nc	nc	nc	--[i]	nc	nc	960,000
Copper	nc	nc	nc	nc	71,000	nc	nc	26,000
Lead	nc	nc	nc	nc	nc	nc	nc	nc
Mercury	nc	nc	nc	nc	530	nc	nc	190
Nickel	nc	nc	nc	nc	35,000	nc	nc	13,000
Silver	nc	nc	nc	nc	8,900	nc	nc	3,200
Zinc	nc	nc	nc	nc	530,000	nc	nc	190,000
Organic Compounds								
Dioxins/Furans	**n/a**		**ng TEQ/kg dw**			**ng TEQ/kg dw**		
Total Dioxin/Furans	nc	nc	19	190	1,800	87	870	730
Total Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)	**µg TEQ/kg dw**					**µg TEQ/kg dw**		
Total cPAHs site-wide	61	610	nc	nc	nc	nc	nc	nc
Total cPAHs intertidal	nc	nc	110	1,100	nc	850	8,500	nc
Total PCBs	**µg/kg dw**					**µg/kg dw**		
Total PCBs	nc	nc	390	3,900	nc	3,100	31,000	nc
Organic Compounds with OC-normalized Benthic Criteria	**µg/kg dw**					**µg/kg dw**		
1,2,4-Trichlorobenzene	nc	nc	27,000	270,000	7,200,000	210,000	2,100,000	4,900,000
1,2-Dichlorobenzene	nc	nc	nc	nc	65,000,000	nc	nc	45,000,000
1,4-Dichlorobenzene	nc	nc	nc	nc	nc	nc	nc	nc
2-Methylnaphthalene	nc	nc	nc	nc	2,900,000	nc	nc	2,000,000
Acenaphthene	nc	nc	nc	nc	43,000,000	nc	nc	30,000,000
Acenaphthylene	nc	nc	nc	nc	nc	nc	nc	nc
Anthracene	nc	nc	nc	nc	220,000,000	nc	nc	150,000,000
Benzo(a)anthracene	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Benzo(a)pyrene	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Benzo(g,h,i)perylene	nc	nc	nc	nc	nc	nc	nc	nc
Benzofluoranthenes (total)	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Bis(2-ethylhexyl)phthalate	nc	nc	55,000	550,000	14,000,000	440,000	4,400,000	9,900,000
Butylbenzyl phthalate	nc	nc	410,000	4,100,000	140,000,000	3,300,000	33,000,000	99,000,000
Chrysene	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Dibenzo(a,h)anthracene	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Dibenzofuran	nc	nc	nc	nc	720,000	nc	nc	490,000
Diethyl phthalate	nc	nc	nc	nc	580,000,000	nc	nc	400,000,000

Table 4-1
Screening Levels

	Protection of Human Health[a]							
	Seafood Consumption		Clamming			Beach Play		
Analyte	10^{-6}, SCO$_{HH}$	10^{-5}, CSL$_{HH}$	10^{-6}, SCO$_{HH}$	10^{-5}, CSL$_{HH}$	HQ=1, SCO$_{HH}$ and CSL $_{HH}$	10^{-6}, SCO$_{HH}$	10^{-5}, CSL$_{HH}$	HQ=1, SCO$_{HH}$ and CSL $_{HH}$
Dimethyl phthalate	nc	nc	nc	nc	nc	nc	nc	nc
Di-n-butyl phthalate	nc	nc	nc	nc	72,000,000	nc	nc	49,000,000
Di-n-octyl phthalate	nc	nc	nc	nc	nc	nc	nc	nc
Fluoranthene	nc	nc	nc	nc	29,000,000	nc	nc	20,000,000
Fluorene	nc	nc	nc	nc	29,000,000	nc	nc	20,000,000
Hexachlorobenzene	nc	nc	480	4,800	580,000	3,900	39,000	400,000
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	nc	nc	9,900	99,000	720,000	79,000	790,000	490,000
Indeno(1,2,3-c,d)pyrene	nc	nc	nc[h]	nc[h]	nc	nc[h]	nc[h]	nc
Naphthalene	nc	nc	nc	nc	14,000,000	nc	nc	9,900,000
N-Nitrosodiphenylamine	nc	nc	160,000	1,600,000	nc	1,300,000	13,000,000	nc
Phenanthrene	nc	nc	nc	nc	nc	nc	nc	nc
Pyrene	nc	nc	nc	nc	22,000,000	nc	nc	15,000,000
Total HPAHs	nc	nc	nc	nc	nc	nc	nc	nc
Total LPAHs	nc	nc	nc	nc	nc	nc	nc	nc
Organic Compounds with Dry Weight-based Benthic Criteria	n/a		µg/kg dw			µg/kg dw		
2,4-Dimethylphenol	nc	nc	nc	nc	14,000,000	nc	nc	9,900,000
2-Methylphenol (o-Cresol)	nc	nc	nc	nc	36,000,000	nc	nc	25,000,000
4-Methylphenol (p-Cresol)	nc	nc	nc	nc	3,600,000	nc	nc	2,500,000
Benzoic Acid	nc	nc	nc	nc	--[i]	nc	nc	--[i]
Benzyl alcohol	nc	nc	nc	nc	72,000,000	nc	nc	49,000,000
Pentachlorophenol	nc	nc	1,900	19,000	3,600,000	15,000	150,000	2,500,000
Phenol	nc	nc	nc	nc	220,000,000	nc	nc	150,000,000

Table 4-1
Screening Levels

Analyte	Protection of Benthic Community				Other Considerations			Screening Levels[e]		
	SCO$_{\text{benthic}}$	CSL$_{\text{benthic}}$	SCO$_{\text{benthic (LAET)}}$	CSL$_{\text{benthic (2LAET)}}$	Natural Background[b]	Preliminary Regional Background[c]	PQL[d]	SCO	CSL	Spatial Scale of Applicability[f]
Metals	**mg/kg dw**		**n/a**		**mg/kg dw**			**mg/kg dw**		
Arsenic	57	93	n/a	n/a	11	nc	20	20	20	points
Cadmium	5.1	6.7	n/a	n/a	1	nc	1.7	5.1	6.7	points
Chromium	260	270	n/a	n/a	62	nc	87	260	270	points
Copper	390	390	n/a	n/a	44	nc	130	390	390	points
Lead	450	530	n/a	n/a	21	nc	150	450	530	points
Mercury	0.41	0.59	n/a	n/a	0.2	nc	0.14	0.2	nc	area average
Nickel	140[g]	370[g]	n/a	n/a	50	nc	47	140[g]	370[g]	points
Silver	6.1	6.1	n/a	n/a	0.3	nc	2	6.1	6.1	points
Zinc	410	960	n/a	n/a	93	nc	137	410	960	points
Organic Compounds										
Dioxins/Furans	**n/a**		**n/a**		**ng TEQ/kg dw**			**ng TEQ/kg dw**		
Total Dioxin/Furans	n/a	n/a	n/a	n/a	4	16	5	5	16	area average
Total Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)	**n/a**		**n/a**		**µg TEQ/kg dw**			**µg TEQ/kg dw**		
Total cPAHs site-wide	n/a	n/a	n/a	n/a	16	70	9	61	610	area average
Total cPAHs intertidal	n/a	n/a	n/a	n/a	16	70	9	110	1,100	area average of intertidal
Total PCBs	**mg/kg OC**		**µg/kg dw**		**µg/kg dw**			**µg/kg dw**		
Total PCBs	12	65	130	1000	3.5	nc	6	6	nc	area average
Organic Compounds with OC-normalized Benthic Criteria	**mg/kg OC**		**µg/kg dw**		**µg/kg dw**			**mg/kg OC** (screen against dry weight concentrations when TOC <0.5% or >3.5%)		
1,2,4-Trichlorobenzene	0.81	1.8	31	51	nc	nc	31	0.81	1.8	points
1,2-Dichlorobenzene	2.3	2.3	35	50	nc	nc	35	2.3	2.3	points
1,4-Dichlorobenzene	3.1	9.0	110	110	nc	nc	37	3.1	9.0	points
2-Methylnaphthalene	38	64	670	670	nc	nc	223	38	64	points
Acenaphthene	16	57	500	500	nc	nc	167	16	57	points
Acenaphthylene	66	66	1,300	1,300	nc	nc	433	66	66	points
Anthracene	220	1,200	960	960	nc	nc	320	220	1,200	points
Benzo(a)anthracene	110	270	1,300	1,600	nc	nc	433	110	270	points
Benzo(a)pyrene	99	210	1,600	1,600	nc	nc	533	99	210	points
Benzo(g,h,i)perylene	31	78	670	720	nc	nc	223	31	78	points
Benzofluoranthenes (total)	230	450	3,200	3,600	nc	nc	1,067	230	450	points
Bis(2-ethylhexyl)phthalate	47	78	1,300	3,100	nc	nc	433	47	78	points
Butylbenzyl phthalate	4.9	64	63	900	nc	nc	21	4.9	64	points
Chrysene	110	460	1,400	2,800	nc	nc	467	110	460	points
Dibenzo(a,h)anthracene	12	33	230	230	nc	nc	77	12	33	points
Dibenzofuran	15	58	540	540	nc	nc	180	15	58	points
Diethyl phthalate	61	110	200	1,200	nc	nc	67	61	110	points

Table 4-1
Screening Levels

Analyte	Protection of Benthic Community				Other Considerations			Screening Levels^{e}		
	SCO$_{\text{benthic}}$	CSL$_{\text{benthic}}$	SCO$_{\text{benthic (LAET)}}$	CSL$_{\text{benthic (2LAET)}}$	Natural Background^{b}	Preliminary Regional Background^{c}	PQL^{d}	SCO	CSL	Spatial Scale of Applicability^{f}
Dimethyl phthalate	53	53	71	160	nc	nc	24	53	53	points
Di-n-butyl phthalate	220	1,700	1,400	5,100	nc	nc	467	220	1,700	points
Di-n-octyl phthalate	58	4,500	6,200	6,200	nc	nc	2,067	58	4,500	points
Fluoranthene	160	1,200	1,700	2,500	nc	nc	567	160	1,200	points
Fluorene	23	79	540	540	nc	nc	180	23	79	points
Hexachlorobenzene	0.38	2.3	22	70	nc	nc	22	0.38	2.3	points
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	11	120	nc	nc	11	3.9	6.2	points
Indeno(1,2,3-c,d)pyrene	34	88	600	690	nc	nc	200	34	88	points
Naphthalene	99	170	2,100	2,100	nc	nc	700	99	170	points
N-Nitrosodiphenylamine	11	11	28	40	nc	nc	28	11	11	points
Phenanthrene	100	480	1,500	1,500	nc	nc	500	100	480	points
Pyrene	1,000	1,400	2,600	3,300	nc	nc	867	1,000	1,400	points
Total HPAHs	960	5,300	12,000	17,000	nc	nc	nc	960	5,300	points
Total LPAHs	370	780	5,200	5,200	nc	nc	nc	370	780	points
Organic Compounds with Dry Weight-based Benthic Criteria	**µg/kg dw**		**n/a**		**µg/kg dw**			**µg/kg dw**		
2,4-Dimethylphenol	29	29	n/a	n/a	nc	nc	29	29	29	points
2-Methylphenol (o-Cresol)	63	63	n/a	n/a	nc	nc	63	63	63	points
4-Methylphenol (p-Cresol)	670	670	n/a	n/a	nc	nc	223	670	670	points
Benzoic Acid	650	650	n/a	n/a	nc	nc	217	650	650	points
Benzyl alcohol	57	73	n/a	n/a	nc	nc	57	57	73	points
Pentachlorophenol	360	690	n/a	n/a	nc	nc	120	360	690	points
Phenol	420	1,200	n/a	n/a	nc	nc	140	420	1,200	points

Table 4-1
Screening Levels

Notes:

a. See Appendix B for development of risk-based threshold concentrations for protection of human health.
b. Natural Background values are from the SCUM II Table 11-1 (Ecology 2013).
c. This was calculated for Bellingham Bay using methods in Appendix B.
d. PQLs are based on specific reporting limits at the I&J Waterway Site and recommended PQLs in the SCUM II guidance document.
e. Screening levels are determined based on the maximum of: 1) the minimum risk-based threshold concentration for protection of human health or the benthic community; 2) natural (SCO) or regional (CSL) background; or 3) PQL.
f. Screening levels are applied to points; however, cleanup levels are applied to the appropriate spatial scale. Cleanup levels for protection of human health are applied to average concentrations, and cleanup levels for protection of the benthic community are applied to point concentrations.
g. The former DMMP screening level (SL) and Bioaccumulation Trigger/Maximum Level (BT/ML) for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.
h. These were evaluated as cPAH TEQ.
i. The RBC is greater than 1,000,000 mg/kg.

µg = microgram
µg/kg = microgram per kilogram
2LAET = second lowest apparent effects threshold
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
dw = dry weight
HPAH = high-molecular-weight polycyclic aromatic hydrocarbon
kg = kilogram
LAET = lowest apparent effects threshold
LPAH = low-molecular-weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
n/a = not applicable
nc = not calculated
ng = nanogram
ng/kg = nanogram per kilogram
OC = organic carbon
PCB = polychlorinated biphenyl
PQL = Practical Quantitation Limit
RBC = risk-based concentration
SCO = Sediment Cleanup Objective
SCUM = Sediment Cleanup Users Manual
TEQ = toxic equivalents quotient
TOC = total organic carbon

Table 4-2
Analyte Screening

	Detection Frequency				Screening Level						Maximum Detected Value				Screening Comparison					
					Carbon Normalized Screening Level			Dry-weight Screening Level			Carbon Normalized Value (only samples with TOC >0.5% and <3.5%)		Dry-weight Value (only samples with TOC <0.5% or >3.5% for analytes with OC-normalized screening levels)		Detected Value Exceeding Appropriate Screening Criteria (LAET used for SCO and 2LAET used for CSL as appropriate)					
Analyte	N	Detect	Non-detect	% Detect	SCO	CSL	Unit	SCO (or LAET)	CSL (or 2LAET)	Unit	Max Detected	Unit	Max Detected	Unit	Exceeding SCO	Exceeding CSL	% Exceeding SCO	% Exceeding CSL	Retained as a COC?	Comments
Arsenic	24	9	15	38%	n/a	n/a	n/a	20	20	mg/kg	n/a	n/a	20	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Cadmium	24	21	3	88%	n/a	n/a	n/a	5.1	6.7	mg/kg	n/a	n/a	1.2	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Chromium	24	24	0	100%	n/a	n/a	n/a	260	270	mg/kg	n/a	n/a	90	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Copper	24	24	0	100%	n/a	n/a	n/a	390	390	mg/kg	n/a	n/a	87	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Lead	24	24	0	100%	n/a	n/a	n/a	450	530	mg/kg	n/a	n/a	40	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Mercury	24	24	0	100%	n/a	n/a	n/a	0.41	0.59	mg/kg	n/a	n/a	0.4	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances. Mercury is not associated with site releases.[a]
Nickel	24	24	0	100%	n/a	n/a	n/a	140	140	mg/kg	n/a	n/a	511	mg/kg	8	8	33%	33%	Yes	
Silver	24	0	24	0%	n/a	n/a	n/a	6.1	6.1	mg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Zinc	24	24	0	100%	n/a	n/a	n/a	410	960	mg/kg	n/a	n/a	211	mg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Total Dioxin/Furan TEQ	11	11	0	100%	n/a	n/a	n/a	5.0	16	ng/kg	n/a	n/a	58	ng/kg	11	7	100%	64%	No	Not included as a COC because dioxin/furan concentrations and congener profiles are consistent with elevated concentrations throughout Bellingham Bay.
Total cPAH TEQ	24	24	0	100%	n/a	n/a	n/a	61	610	µg/kg	n/a	n/a	2,475	µg/kg	18	5	75%	21%	Yes	
1,2,4-Trichlorobenzene	24	0	24	0%	0.81	1.8	mg/kg OC	31	51	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
1,2-Dichlorobenzene	24	0	24	0%	2.3	2.3	mg/kg OC	35	50	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
1,4-Dichlorobenzene	24	0	24	0%	3.1	9	mg/kg OC	110	110	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
2-Methylnaphthalene	24	12	12	50%	38	64	mg/kg OC	670	670	µg/kg	6.5	mg/kg OC	870	µg/kg	1	1	4%	4%	Yes	
Acenaphthene	24	9	15	38%	16	57	mg/kg OC	500	500	µg/kg	29	mg/kg OC	2,000	µg/kg	2	1	8%	4%	Yes	
Acenaphthylene	24	9	15	38%	66	66	mg/kg OC	1,300	1,300	µg/kg	5	mg/kg OC	190	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Anthracene	24	18	6	75%	220	1,200	mg/kg OC	960	960	µg/kg	61	mg/kg OC	1,200	µg/kg	1	1	4%	4%	Yes	
Benzo(a)anthracene	24	23	1	96%	110	270	mg/kg OC	1,300	1,600	µg/kg	107	mg/kg OC	2,300	µg/kg	1	1	4%	4%	Yes	
Benzo(a)pyrene	24	20	4	83%	99	210	mg/kg OC	1,600	1,600	µg/kg	84	mg/kg OC	800	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Benzo(g,h,i)perylene	24	14	10	58%	31	78	mg/kg OC	670	720	µg/kg	22	mg/kg OC	280	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
bis(2-Ethylhexyl)phthalate	24	18	6	75%	47	78	mg/kg OC	1,300	3,100	µg/kg	473	mg/kg OC	1,400	µg/kg	3	2	13%	8%	Yes	
Butylbenzyl phthalate	24	11	13	46%	5	64	mg/kg OC	63	900	µg/kg	2	mg/kg OC	9	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Chrysene	24	24	0	100%	110	460	mg/kg OC	1,400	2,800	µg/kg	121	mg/kg OC	3,300	µg/kg	2	1	8%	4%	Yes	
Dibenzo(a,h)anthracene	24	12	12	50%	12	33	mg/kg OC	230	230	µg/kg	14	mg/kg OC	89	µg/kg	1	0	4%	0%	Yes	
Dibenzofuran	24	12	12	50%	15	58	mg/kg OC	540	540	µg/kg	23	mg/kg OC	2,000	µg/kg	2	1	8%	4%	Yes	
Diethyl phthalate	24	0	24	0%	61	110	mg/kg OC	200	1,200	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.

Table 4-2
Analyte Screening

					Screening Level						Maximum Detected Value				Screening Comparison					
	Detection Frequency				Carbon Normalized Screening Level			Dry-weight Screening Level			Carbon Normalized Value (only samples with TOC >0.5% and <3.5%)		Dry-weight Value (only samples with TOC <0.5% or >3.5% for analytes with OC-normalized screening levels)		Detected Value Exceeding Appropriate Screening Criteria (LAET used for SCO and 2LAET used for CSL as appropriate)					
Analyte	N	Detect	Non-detect	% Detect	SCO	CSL	Unit	SCO (or LAET)	CSL (or 2LAET)	Unit	Max Detected	Unit	Max Detected	Unit	Exceeding SCO	Exceeding CSL	% Exceeding SCO	% Exceeding CSL	Retained as a COC?	Comments
Dimethyl phthalate	24	12	12	50%	53	53	mg/kg OC	71	160	µg/kg	9.0	mg/kg OC	130	µg/kg	1	0	4%	0%	Yes	
Di-n-butyl phthalate	24	2	22	8%	220	1,700	mg/kg OC	1,400	5,100	µg/kg	1.8	mg/kg OC	23	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Di-n-octyl phthalate	24	2	22	8%	58	4,500	mg/kg OC	6,200	6,200	µg/kg	0.86	mg/kg OC	21	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Fluoranthene	24	24	0	100%	160	1,200	mg/kg OC	1,700	2,500	µg/kg	346	mg/kg OC	11,000	µg/kg	3	1	13%	4%	Yes	
Fluorene	24	12	12	50%	23	79	mg/kg OC	540	540	µg/kg	38	mg/kg OC	1,800	µg/kg	2	1	8%	4%	Yes	
Hexachlorobenzene	24	0	24	0%	0.38	2.3	mg/kg OC	22	70	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	24	0	24	0%	4	6	mg/kg OC	11	120	µg/kg	n/a	n/a	n/a	n/a	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Indeno(1,2,3-c,d)pyrene	24	14	10	58%	34	88	mg/kg OC	600	690	µg/kg	28	mg/kg OC	280	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Naphthalene	24	12	12	50%	99	170	mg/kg OC	2,100	2,100	µg/kg	14	mg/kg OC	1,800	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
n-Nitrosodiphenylamine	24	2	22	8%	11	11	mg/kg OC	28	40	µg/kg	1.3	mg/kg OC	180	µg/kg	1	1	4%	4%	Yes	
Phenanthrene	24	23	1	96%	100	480	mg/kg OC	1,500	1,500	µg/kg	206	mg/kg OC	7,100	µg/kg	2	1	8%	4%	Yes	
Pyrene	24	24	0	100%	1,000	1,400	mg/kg OC	2,600	3,300	µg/kg	196	mg/kg OC	9,200	µg/kg	1	1	4%	4%	Yes	
Total Benzofluoranthenes (b,j,k)	24	23	1	96%	230	450	mg/kg OC	3,200	3,600	µg/kg	154	mg/kg OC	2,100	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Total HPAH	24	24	0	100%	960	5,300	mg/kg OC	12,000	17,000	µg/kg	1,073	mg/kg OC	29,349	µg/kg	2	1	8%	4%	Yes	
Total LPAH	24	23	1	96%	370	780	mg/kg OC	5,200	5,200	µg/kg	340	mg/kg OC	14,090	µg/kg	1	1	4%	4%	Yes	
Total PCBs	24	4	20	17%	12	65	mg/kg OC	130	1,000	µg/kg	4.1	mg/kg OC	80	µg/kg	0	0	0%	0%	No	Eliminated because PCBs are not associated with site releases.
2,4-Dimethylphenol	24	7	17	29%	n/a	n/a	n/a	29	29	µg/kg	n/a	n/a	210	µg/kg	2	2	8%	8%	Yes	
2-Methylphenol (o-Cresol)	24	10	14	42%	n/a	n/a	n/a	63	63	µg/kg	n/a	n/a	120	µg/kg	1	1	4%	4%	Yes	
4-Methylphenol (p-Cresol)	24	12	12	50%	n/a	n/a	n/a	670	670	µg/kg	n/a	n/a	1,200	µg/kg	1	1	4%	4%	Yes	
Benzoic acid	24	5	19	21%	n/a	n/a	n/a	650	650	µg/kg	n/a	n/a	700	µg/kg	1	1	4%	4%	Yes	
Benzyl alcohol	24	11	13	46%	n/a	n/a	n/a	57	73	µg/kg	n/a	n/a	65	µg/kg	1	0	4%	0%	Yes	
Pentachlorophenol	24	4	20	17%	n/a	n/a	n/a	360	690	µg/kg	n/a	n/a	41	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.
Phenol	24	11	13	46%	n/a	n/a	n/a	420	1,200	µg/kg	n/a	n/a	340	µg/kg	0	0	0%	0%	No	Eliminated based on lack of exceedances.

Notes:

a. Maximum mercury concentration based on the average of an initial run (0.50 mg/kg) and a duplicate analysis (0.30 mg/kg).

µg/kg = microgram per kilogram
2LAET = second lowest apparent effects threshold
CSL = Cleanup Screening Level
COC = constituent of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
HPAH = high-molecular-weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular-weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
n/a = not applicable
ng/kg = nanogram per kilogram
OC = organic carbon
PCB = polychlorinated biphenyl
SCO = Sediment Cleanup Objective
TEQ = toxic equivalents quotient
TOC = total organic carbon

Table 5-1a
2005 Surface Sediment Chemistry and Physical Testing Results

Location ID			**SSIJW01-g1**	**SSIJW02-g1**	**SSIJW03-g1**	**SSIJW04-g1**	**SSIJW05-g1**	**SSIJW06-g1**	**SSIJW07-g1**	**SSIJW08-g1**	**SSIJW09-g1**	**SSIJW10-g1**	**SSIJW11-g1**	**SSIJW12-g1**	**SSIJW13-g1**	**SSRR01-g1**	**SSRR02-g1**
Sample ID			**IJW-SS-01**	**IJW-SS-02**	**IJW-SS-03**	**IJW-SS-04**	**IJW-SS-05**	**IJW-SS-06**	**IJW-SS-07**	**IJW-SS-08**	**IJW-SS-09**	**IJW-SS-10**	**IJW-SS-11**	**IJW-SS-12**	**IJW-SS-13**	**IJW-RR-01**	**IJW-RR-02**
Sample Date			**8/31/05**	**8/31/05**	**9/1/05**	**9/1/05**	**8/31/05**	**8/31/05**	**8/31/05**	**9/1/05**	**8/31/05**	**9/1/05**	**8/31/05**	**9/1/05**	**9/1/05**	**9/2/05**	**9/2/05**
Sample Depth			**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**
Sample Type			**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**															
Conventional Parameters (mg/kg)																	
Ammonia	--	--	**37.2**	**26.2**	**20.3**	**31.3**	**47.6**	**62.7**	**38.9**	**44**	**33.9**	**9.02**	**6.55**	**28.4**	**68**	**4.06**	**23.2**
Sulfide	--	--	**3600**	**3200**	**3900**	**4900**	**3500**	**3400**	**3600**	**3300**	**4000**	**2100**	**1000**	**1900**	**4500**	**22**	**480**
Conventional Parameters (pct)																	
Total organic carbon	--	--	**2.32**	**2.39**	**2.46**	**2.34**	**2.24**	**2.14**	**2.45**	**2.75**	**2.01**	**2.79**	**3.18**	**3.87**	**2.45**	**1.34**	**1.25**
Total solids	--	--	**34.7**	**35.2**	**38.2**	**31**	**36.6**	**47.2**	**32.7**	**39.3**	**30.8**	**53.5**	**66.9**	**56**	**25.4**	**72.9**	**36.9**
Total solids (preserved)	--	--	**30.2**	**31.6**	**34.5**	**23.2**	**36**	**41.6**	**33.3**	**38.3**	**25.4**	**53.9**	**63.4**	**54.5**	**25.5**	**72.3**	**34.3**
Total volatile solids	--	--	**8.75**	**8.31**	**8.61**	**8.74**	**8.12**	**7.45**	**8.92**	**8.51**	**9**	**7**	**5.92**	**6.28**	**9.82**	**1.91**	**7.43**
Conventional Parameters (su)																	
pH	--	--	**7.64**	**7.85**	**7.95**	**7.92**	**7.93**	**8.04**	**7.86**	**7.85**	**7.89**	**7.99**	**7.63**	**7.79**	**7.84**	**7.94**	**7.82**
Grain Size (pct)																	
Total Gravel	--	--	**0.2**	**0.2**	**2.9**	0.01 U	0.01 U	**26.9**	**0.4**	0.01 U	0.01 U	**14.2**	**7.2**	**31.3**	0.01 U	0.01 U	0.01 U
Total Sand	--	--	**15.2**	**15.3**	**20.2**	**18.5**	**15**	**40.7**	**17.2**	**17.5**	**15.4**	**39.3**	**81.6**	**28.7**	**15.2**	**84.5**	**10.1**
Total Silt	--	--	**53.2**	**49.2**	**47.5**	**55.2**	**55.1**	**25.3**	**55.7**	**49.3**	**58.2**	**31.7**	**5.5**	**23.6**	**66.5**	**9.5**	**55.7**
Total Fines (silt + clay)	--	--	**84.7**	**84.4**	**76.9**	**81.6**	**85**	**32.5**	**82.4**	**82.6**	**84.4**	**46.5**	**8.3**	**39.9**	**84.8**	**15.4**	**89.9**
Total Clay	--	--	**31.5**	**35.2**	**29.4**	**26.4**	**29.9**	**7.2**	**26.7**	**33.3**	**26.2**	**14.8**	**2.8**	**16.3**	**18.3**	**5.9**	**34.2**
Metals (mg/kg)																	
Antimony			**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**
Arsenic	57	93	20 U	10 U	**20**	20 U	**20**	30 U	**10**	**20**	20 U	**16**	8 U	**14**	20 U	7 U	10 U
Cadmium	5.1	6.7	**0.7**	**0.7**	**0.9**	**0.7**	**0.8**	1 U	**0.8**	**0.9**	**0.8**	**0.6**	0.3 U	**0.6**	**0.9**	**0.4**	0.5 U
Chromium	260	270	**74**	**75**	**75**	**74**	**75**	**38**	**72**	**73**	**74**	**47.1**	**23.4**	**54.2**	**71**	**18.2**	**48**
Copper	390	390	**71**	**68.3**	**83.6**	**67**	**72.3**	**61**	**73.2**	**73.8**	**71.5**	**51.8**	**20.1**	**62.2**	**69.9**	**8.2**	**33.3**
Lead	450	530	**15**	**16**	**20**	**17**	**17**	**10**	**20**	**22**	**19**	**29**	**17**	**40**	**17**	**4**	**13**
Mercury	0.41	0.59	**0.4**	**0.3**	**0.3**	**0.4**	**0.4[b]**	**0.17**	**0.4**	**0.4**	**0.3**	**0.23**	**0.08**	**0.22**	**0.4**	0.07 U	**0.1**
Nickel[a]	--	--	**117**	**122**	**117**	**119**	**125**	**57**	**174**	**156**	**192**	**511**	**211**	**152**	**133**	**22**	**40**
Silver	6.1	6.1	0.9 U	0.9 U	0.8 U	1 U	0.8 U	2 U	0.9 U	0.7 U	0.9 U	0.5 U	0.5 U	0.5 U	1 U	0.4 U	0.8 U
Zinc	410	960	**140**	**142**	**174**	**148**	**150**	**138**	**164**	**166**	**153**	**142**	**69.7**	**139**	**159**	**36.1**	**98**
Volatile Organics (µg/kg)																	
4-Chloronitrobenzene	--	--	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**30000000**	**--**	**--**	**--**	**--**
Ethylbenzene	--	--	3.3 U	3.1 U	2.8 U	3.9 U	2.8 U	1.7 U	2.6 U	2.6 U	3.3 U	1.9 U	1.4 U	1.6 U	3.6 U	1.3 U	2.9 U
m,p-Xylene	--	--	3.3 U	3.1 U	**3.5**	3.9 U	2.8 U	1.7 U	2.6 U	2.6 U	3.3 U	1.9 U	1.4 U	1.6 U	3.6 U	1.3 U	2.9 U
o-Xylene	--	--	3.3 U	3.1 U	2.8 U	3.9 U	2.8 U	1.7 U	2.6 U	2.6 U	3.3 U	1.9 U	1.4 U	1.6 U	3.6 U	1.3 U	2.9 U
Tetrachloroethene (PCE)	--	--	3.3 U	3.1 U	2.8 U	3.9 U	2.8 U	1.7 U	2.6 U	2.6 U	3.3 U	1.9 U	1.4 U	1.6 U	3.6 U	1.3 U	2.9 U
Trichloroethene (TCE)	--	--	3.3 U	3.1 U	2.8 U	3.9 U	2.8 U	1.7 U	2.6 U	2.6 U	3.3 U	1.9 U	1.4 U	1.6 U	3.6 U	1.3 U	2.9 U
Semivolatile Organics (µg/kg)																	
2,4-Dimethylphenol	29	29	59 U[1]	60 U[1]	99 U[1]	99 U[1]	60 U[1]	59 U[1]	59 U[1]	58 U[1]	59 U[1]	98 U[1]	58 U[1]	58 U[1]	59 U[1]	20 U	20 U
2-Methylphenol (o-Cresol)	63	63	59 U	60 U	99 U[1]	99 U[1]	60 U	59 U	59 U	58 U	59 U	98 U[1]	58 U	58 U	59 U	20 U	20 U
4-Methylphenol (p-Cresol)	670	670	59 U	60 U	99 U	99 U	60 U	**85**	59 U	58 U	59 U	98 U	58 U	58 U	59 U	20 U	**55**
Benzoic acid	650	650	590 U	600 U	990 U[1]	990 U[1]	600 U	590 U	590 U	580 U	590 U	980 U[1]	580 U	580 U	590 U	200 U	200 U
Benzyl alcohol	57	73	59 U[1]	60 U[1]	99 U[1]	99 U[1]	60 U[1]	59 U[1]	59 U[1]	58 U[1]	59 U[1]	98 U[1]	58 U[1]	58 U[1]	59 U[1]	20 U	20 U

Table 5-1a
2005 Surface Sediment Chemistry and Physical Testing Results

Location ID			**SSIJW01-g1**	**SSIJW02-g1**	**SSIJW03-g1**	**SSIJW04-g1**	**SSIJW05-g1**	**SSIJW06-g1**	**SSIJW07-g1**	**SSIJW08-g1**	**SSIJW09-g1**	**SSIJW10-g1**	**SSIJW11-g1**	**SSIJW12-g1**	**SSIJW13-g1**	**SSRR01-g1**	**SSRR02-g1**
Sample ID			**IJW-SS-01**	**IJW-SS-02**	**IJW-SS-03**	**IJW-SS-04**	**IJW-SS-05**	**IJW-SS-06**	**IJW-SS-07**	**IJW-SS-08**	**IJW-SS-09**	**IJW-SS-10**	**IJW-SS-11**	**IJW-SS-12**	**IJW-SS-13**	**IJW-RR-01**	**IJW-RR-02**
Sample Date			**8/31/05**	**8/31/05**	**9/1/05**	**9/1/05**	**8/31/05**	**8/31/05**	**8/31/05**	**9/1/05**	**8/31/05**	**9/1/05**	**8/31/05**	**9/1/05**	**9/1/05**	**9/2/05**	**9/2/05**
Sample Depth			**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**	**0 -0.4 ft**
Sample Type			**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**															
Pentachlorophenol	360	690	300 U	300 U	500 U[1]	490 U[1]	300 U	300 U	300 U	290 U	300 U	490 U[1]	290 U	290 U	300 U	97 U	99 U
Phenol	420	1200	59 U	60 U	99 U	99 U	60 U	59 U	59 U	58 U	59 U	98 U	58 U	58 U	59 U	20 U	**24**
Semivolatile Organics (mg/kg-OC)																	
1,2,4-Trichlorobenzene	0.81	1.8	2.543 U[1]	2.51 U[1]	4.024 U[1]	4.231 U[1]	2.679 U[1]	2.757 U[1]	2.408 U[1]	2.109 U[1]	2.935 U[1]	3.513 U[1]	1.824 U[1]	1.499 U[1]	2.408 U[1]	1.493 U[1]	1.6 U[1]
1,2-Dichlorobenzene	2.3	2.3	2.543 U[1]	2.51 U[1]	4.024 U[1]	4.231 U[1]	2.679 U[1]	2.757 U[1]	2.408 U[1]	2.109 U	2.935 U[1]	3.513 U[1]	1.824 U	1.499 U	2.408 U[1]	1.493 U	1.6 U
1,4-Dichlorobenzene	3.1	9	2.543 U	2.51 U	4.024 U[1]	4.231 U[1]	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U[1]	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
bis(2-Ethylhexyl)phthalate	47	78	**10.345**	**2.636**	**16.26**	**9.402**	**5.804**	**392.523**	**10.204**	**10.182**	**7.463**	**21.864**	**28.931**	**13.953**	**11.837**	1.493 U	**2.96**
Butylbenzyl phthalate	4.9	64	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U	**2.421**	1.499 U	2.408 U	1.493 U	1.6 U
Dibenzofuran	15	58	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**23.364**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Diethyl phthalate	61	110	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Dimethyl phthalate	53	53	2.543 U	2.51 U	4.024 U	**8.974**	2.679 U	**2.991**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Di-n-butyl phthalate	220	1700	35.776 U	34.31 U	26.016 U	55.556 U	35.714 U	46.729 U	34.694 U	28.727 U	46.766 U	35.125 U	26.415 U	22.997 U	26.939 U	67.91 U	80 U
Di-n-octyl phthalate	58	4500	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Hexachlorobenzene	0.38	2.3	2.543 U[1]	2.51 U[1]	4.024 U[1]	4.231 U[1]	2.679 U[1]	2.757 U[1]	2.408 U[1]	2.109 U[1]	2.935 U[1]	3.513 U[1]	1.824 U[1]	1.499 U[1]	2.408 U[1]	1.493 U[1]	1.6 U[1]
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	2.543 U	2.51 U	4.024 U[1]	4.231 U[1]	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
n-Nitrosodiphenylamine	11	11	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Polycyclic Aromatic Hydrocarbons (µg/kg)																	
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	--	--	**23.2**	0.82	**235.3**	**44.4**	**94.4**	**2475**	**137**	**226.3**	**142.7**	**1149**	**501.1**	**508.9**	**26.2**	**30.26**	20 U
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 1/2)	--	--	**58.6**	**45.82**	**245.2**	**103.8**	**100.4**	**2475**	**142.9**	**232.1**	**148.6**	**1153.9**	**504**	**511.8**	**61.6**	**33.26**	20 U
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)																	
2-Methylnaphthalene	38	64	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**6.542**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Acenaphthene	16	57	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**28.972 J**	2.408 U	2.109 U	**3.234**	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Acenaphthylene	66	66	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	2.757 U	2.408 U	2.109 U	2.935 U	**5.018**	1.824 U	**2.481**	2.408 U	1.493 U	1.6 U
Anthracene	220	1200	2.543 U	2.51 U	**6.504**	4.231 U	2.679 U	**60.748**	2.408 U	**2.764**	**4.179**	**9.677**	**3.459**	**4.393**	2.408 U	1.493 U	1.6 U
Benzo(a)anthracene	110	270	**3.103**	2.51 U	**10.976**	**5.983**	**4.42**	**107.477**	**4.49**	**7.636**	**6.468**	**25.448**	**11.006**	**11.37**	**3.102**	**2.015**	1.6 U
Benzo(a)pyrene	99	210	2.543 U	2.51 U	**6.098**	4.231 U	**2.857**	**84.112**	**3.918**	**5.455**	**4.776**	**27.599**	**11.321**	**8.786**	2.408 U	**1.866**	1.6 U
Benzo(g,h,i)perylene	31	78	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**22.43**	2.408 U	2.109 U	2.935 U	**5.735**	**2.987**	1.499 U	2.408 U	1.493 U	1.6 U
Chrysene	110	460	**6.034**	**3.431**	**21.545**	**10.256**	**8.482**	**121.495**	**8.163**	**15.636**	**13.433**	**71.685**	**16.038**	**19.38**	**5.714**	**1.94**	1.6 U
Dibenzo(a,h)anthracene	12	33	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**13.551**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Fluoranthene	160	1200	**9.052**	**4.1**	**21.951**	**14.957**	**8.929**	**345.794**	**12.245**	**16**	**18.905**	**86.022**	**37.736**	**33.592**	**11.837**	**4.104**	1.6 U
Fluorene	23	79	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**38.318**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Indeno(1,2,3-c,d)pyrene	34	88	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**28.037**	2.408 U	2.109 U	2.935 U	**6.452**	**3.459**	**1.912**	2.408 U	1.493 U	1.6 U
Naphthalene	99	170	2.543 U	2.51 U	4.024 U	4.231 U	2.679 U	**6.075**	2.408 U	2.109 U	2.935 U	3.513 U	1.824 U	1.499 U	2.408 U	1.493 U	1.6 U
Phenanthrene	100	480	**4.741**	2.51 U	**6.098**	**6.838**	**4.196**	**205.607**	**3.755**	**5.091**	**7.96**	**18.996**	**11.321**	**6.202**	**6.531**	1.493 U	1.6 U
Pyrene	1000	1400	**7.759**	**3.347**	**30.488**	**16.667**	**8.036**	**196.262**	**9.796**	**14.182**	**12.935**	**121.864**	**26.415**	**22.739**	**7.347**	**3.433**	1.6 U
Total Benzofluoranthenes (b,j,k) (U = 0)	230	450	**6.293**	2.51 U	**21.545**	**11.966**	**8.304**	**154.206**	**11.429**	**18.545**	**15.423**	**96.774**	**28.302**	**28.424**	**7.02**	**1.716**	1.6 U
Total HPAH (SMS) (U = 0)	960	5300	**32.241**	**10.879**	**112.602**	**59.829**	**41.027**	**1073.364**	**50.041**	**77.455**	**71.94**	**441.577**	**137.264**	**126.202**	**35.02**	**15.075**	1.6 U
Total LPAH (SMS) (U = 0)	370	780	**4.741**	2.51 U	**12.602**	**6.838**	**4.196**	**339.72 J**	**3.755**	**7.855**	**15.373**	**33.692**	**14.78**	**13.075**	**6.531**	1.493 U	1.6 U

Table 5-1a
2005 Surface Sediment Chemistry and Physical Testing Results

Location ID			SSIJW01-g1	SSIJW02-g1	SSIJW03-g1	SSIJW04-g1	SSIJW05-g1	SSIJW06-g1	SSIJW07-g1	SSIJW08-g1	SSIJW09-g1	SSIJW10-g1	SSIJW11-g1	SSIJW12-g1	SSIJW13-g1	SSRR01-g1	SSRR02-g1
Sample ID			IJW-SS-01	IJW-SS-02	IJW-SS-03	IJW-SS-04	IJW-SS-05	IJW-SS-06	IJW-SS-07	IJW-SS-08	IJW-SS-09	IJW-SS-10	IJW-SS-11	IJW-SS-12	IJW-SS-13	IJW-RR-01	IJW-RR-02
Sample Date			8/31/05	8/31/05	9/1/05	9/1/05	8/31/05	8/31/05	8/31/05	9/1/05	8/31/05	9/1/05	8/31/05	9/1/05	9/1/05	9/2/05	9/2/05
Sample Depth			0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft	0 -0.4 ft
Sample Type			N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Analytes	SMS SCO	SMS CSL															
PCB Aroclors (mg/kg-OC)																	
Aroclor 1016	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.491 U	0.816 U	1.418 U	1.6 U
Aroclor 1221	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.491 U	0.816 U	1.418 U	1.6 U
Aroclor 1232	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.491 U	0.816 U	1.418 U	1.6 U
Aroclor 1242	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.491 U	0.816 U	1.418 U	1.6 U
Aroclor 1248	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.491 U	0.816 U	1.418 U	1.6 U
Aroclor 1254	--	--	0.862 U	0.837 U	0.732 U	1.282 U	0.893 U	**1.495**	0.816 U	0.691 U	0.995 U	0.717 U	0.629 U	0.749 U	0.816 U	1.418 U	1.6 U
Aroclor 1260	--	--	0.862 U	0.837 U	0.732 U	0.855 U	0.893 U	0.935 U	0.816 U	0.691 U	**1.542 J**	0.717 U	0.629 U	0.749 U	0.816 U	1.418 U	1.6 U
Total PCB Aroclors (SMS Marine 2013) (U = 0)	12	65	0.862 U	0.837 U	0.732 U	1.282 U	0.893 U	**1.495**	0.816 U	0.691 U	**1.542 J**	0.717 U	0.629 U	0.749 U	0.816 U	1.418 U	1.6 U

Notes:

🟨 Detected concentration is greater than SMS SCO.

🟩 Detected concentration is greater than SMS CSL.

🟪 Detected concentration is greater than the former DMMP SL.[a]

🟧 Detected concentration is greater than the former DMMP ML.[a]

Bold = Detected result

1. Non-detected concentration is above one or more identified screening levels.

a. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.

b. This sample is the average of an initial run (0.50 mg/kg) and a duplicate analysis (0.30 mg/kg).

J = Estimated value

N = normal field sample

R = Rejected

U = Compound analyzed, but not detected above detection limit

-- = Results or values not reported or not applicable

µg/kg = microgram per kilogram

BT = Bioaccumulation Trigger

cPAH = carcinogenic polycyclic aromatic hydrocarbon

CSL = Cleanup Screening Level

DMMP = Dredged Material Management Program

dw = dry weight

ft = feet

HPAH = high-molecular weight polycyclic aromatic hydrocarbon

LPAH = low-molecular weight polycyclic aromatic hydrocarbon

mg/kg = milligram per kilogram

mg/kg-OC = milligram per kilogram organic carbon normalized

ML = maximum level

ng/kg = nanogram per kilogram

PCB = polychlorinated biphenyls

pct = percent

SCO = Sediment Cleanup Objective

SL = screening level

SMS = Sediment Management Standards

TEF = toxic equivalency factor

TEQ = toxic equivalents quotient

Results are reported in dry weight basis and as OC-normalized basis.

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.

Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.

Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Total cPAH TEQ values were calculated with 2005 California EPA (CAEPA) TEF values (7 minimum).

Data have been validated according to QA-2 protocols.

Table 5-1b
March 2006 Surface Sediment Conventional and Grain Size Testing Results

Sample ID	Conventionals						Grain Size			
	Ammonia mg-N/kg	pH	Sulfide mg/kg	Total Organic Carbon %	Total Solids %	Total Volatile Solids %	Gravel %	Sand %	Silt %	Clay %
IJW-SS-04	10.1	7.88	2,200	2.63	41.1	7.38	0.1	5.9	52.9	41.2
IJW-SS-06	20.0	7.62	890	3.29	45.1	8.15	30.7	32	23.4	13.7
IJW-SS-07	19.5	7.95	2,000	1.72	36.5	8.10	0	10.3	53.9	35.6
IJW-SS-08	21.4	7.78	2,300	2.35	41.8	7.62	0.4	8.5	49.7	41.4
IJW-SS-09	18.9	7.74	2,900	2.38	38.7	7.69	0.4	10.3	49.4	40.1
IJW-SS-10	7.85	7.72	1,200	3.43	49.8	7.93	13.2	26.9	37.2	22.7
IJW-SS-11	5.32	7.63	200	4.04	65.8	5.49	8.9	74.5	9.2	7.5
IJW-SS-12	24.9	7.80	610	2.41	58.2	5.80	32.8	27.2	17.9	22.1
IJW-SS-13	17.2	7.84	3,500	2.27	37.1	7.57	0.7	8.8	45.9	44.5
IJW-RR-01	5.19	7.76	67	1.22	73.0	1.79	0	82.4	9.8	7.7
IJW-RR-02	8.36	7.68	590	1.67	36.7	7.03	0	7.7	55.4	36.8

Notes:

Sediment samples collected from 0 to 12 centimeters on March 13 and 14, 2006
mg/kg = milligram per kilogram
mg-N/kg = milligram nitrogen per kilogram

Table 5-2
2012 Surface Sediment Chemical and Physical Testing Results

			Location ID	Reference	Reference	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08a	IJ12-08a	IJ12-11
			Sample ID	CR-12	CR-023	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08A	IJ12-58A	IJ12-11
			Sample Date	5/30/12	5/30/12	4/25/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12
			Sample Depth	0-10 cm	0-10 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm
			Sample Type	N	N	N	N	N	N	N	N	N	N	FD	N
Analytes	SMS SCO	SMS CSL	PS LAET[a]												
Conventional Parameters (mg/kg)															
Ammonia	--	--	--	--	--	**11.6**	**15.8**	**17.3**	**30.4**	**19.2**	**20.1**	**19.3**	**18**	**23.4**	**10.8**
Sulfide	--	--	--	--	--	**905**	**997**	**2610**	**1210**	**2130**	**614**	**389**	**2090**	**2630**	**275**
Conventional Parameters (pct)															
Total Organic Carbon	--	--	--	**0.351**	**3.45**	**4.98**	**2.45**	**2.9**	**2.1**	**3.11**	**2.55**	**2.6**	**3.76**	**4.31**	**2.02**
Total Solids	--	--	--	**75.4**	**32.8**	**56.6**	**40.1**	**37.4**	**63.8**	**38.3**	**43**	**41.3**	**39.4**	**38**	**52.8**
Total Solids (preserved)	--	--	--			**39.2**	**38.2**	**34.7**	**60.1**	**35.3**	**38**	**40.1**	**32.4**	**33.8**	**44.2**
Grain Size (pct)															
Total Gravel	--	--	--	**0.2**	0.1 U	**16.4**	**0.3**	0.1 U	**48.8**	0.1 U	0.1 U	**0.3**	**1.2**	**0.2**	0.1 U
Total Sand	--	--	--	**95.3**	**2.9**	**71.3**	**7.1**	**9.3**	**30**	**5.9**	**3.9**	**5.8**	**10.1**	**9.1**	**28**
Total Silt	--	--	--	**2.4**	**56.9**	**6.5**	**54.6**	**57.6**	**9.7**	**50.8**	**49.2**	**48.7**	**60.6**	**54.7**	**38.3**
Total Fines (silt + clay)	--	--	--	**4.5**	**97.2**	**12.4**	**92.6**	**90.8**	**21.1**	**94.3**	**96**	**94**	**88.7**	**90.7**	**72.1**
Total Clay	--	--	--	**2.1**	**40.3**	**5.9**	**38**	**33.2**	**11.4**	**43.5**	**46.8**	**45.3**	**28.1**	**36**	**33.8**
Metals (mg/kg)															
Arsenic	57	93	--	--	--	9 U	10 U	10 U	20 U	10 U	10 U	**10**	10 U	10 U	9 U
Cadmium	5.1	6.7	--	--	--	**0.4**	**1.1**	**1.2**	0.8 U	**1.1**	**1**	**0.9**	**1**	**1.2**	**0.5**
Chromium	260	270	--	--	--	**40**	**82**	**79**	**33**	**90**	**86**	**85**	**80**	**85**	**66.9**
Copper	390	390	--	--	--	**37.2**	**71.3**	**71**	**35.4**	**77.6**	**72.4**	**75.9**	**87**	**86**	**51.9**
Lead	450	530	--	--	--	**18**	**17**	**17**	**25**	**17**	**15**	**14**	**15**	**16**	**11**
Mercury	0.41	0.59	--	--	--	**0.05**	**0.27**	**0.25**	**0.12**	**0.29**	**0.29**	**0.27**	**0.26**	**0.29**	**0.27**
Nickel[b]	--	--	--	--	--	**337**	**148**	**140**	**116**	**137**	**126**	**123**	**113**	**120**	**90**
Silver	6.1	6.1	--	--	--	0.5 U	0.7 U	0.8 U	1 U	0.8 U	0.7 U	0.6 U	0.8 U	0.7 U	0.6 U
Zinc	410	960	--	--	--	**83**	**135**	**141**	**110**	**147**	**132**	**131**	**146**	**152**	**94**
Semivolatile Organics (µg/kg)															
1,2,4-Trichlorobenzene	--	--	31	--	--	4.7 U	4.8 U	4.9 U	4.8 UJ	4.9 U	4.9 U	5 U	4.8 U	4.9 U	4.9 U
1,2-Dichlorobenzene	--	--	35	--	--	4.7 U	4.8 U	4.9 U	4.8 UJ	4.9 U	4.9 U	5 U	4.8 U	4.9 U	4.9 U
1,4-Dichlorobenzene	--	--	110	--	--	4.7 U	4.8 U	4.9 U	4.8 UJ	4.9 U	4.9 U	5 U	4.8 U	4.9 U	4.9 U
2,4-Dimethylphenol	29	29	--	--	--	**16 J**	19 UJ	**15 J**	19 UJ	20 UJ	20 UJ	**15 J**	**12 J**	**26 J**	**15 J**
2-Methylphenol (o-Cresol)	63	63	--	--	--	**8.1 J**	**3.3 J**	**6.4 J**	4.8 UJ	**3.3 J**	**3.9 J**	**6 J**	**38**	**13 J**	**6.3 J**
4-Methylphenol (p-Cresol)	670	670	--	--	--	**60**	**44**	**54**	**18 J**	**35 J**	**44**	**50**	**45**	**94**	**50**
Benzoic acid	650	650	--	--	--	**210 J**	390 U	**100 J**	390 UJ	390 U	390 U	400 U	380 U	**120 J**	390 U
Benzyl alcohol	57	73	--	--	--	**31**	**19**	**32**	**13 J**	**16 J**	**20**	**34**	**14 J**	**46**	**33**
Bis(2-ethylhexyl)phthalate	--	--	1300	--	--	**320**	100 U	100 U	**320 J**	**500**	71 U	51 U	100 U	160 U	37 U
Butylbenzyl phthalate	--	--	63	--	--	4.7 U	**11 J**	**15 J**	**9.6**	**12 J**	**6.7**	**4.8 J**	**6.1**	**12**	**4 J**
Dibenzofuran	--	--	540	--	--	**66**	**14 J**	**22**	**79 J**	**13 J**	**15 J**	**23**	**19**	**130**	**20**
Diethyl phthalate	--	--	200	--	--	7.3 U	6.6 U	14 U	4.8 U	17 U	9.1 U	19 U	8 U	6.8 U	7 U
Dimethyl phthalate	--	--	71	--	--	**40**	**8.2**	4.9 U	**11 J**	**6.9**	**6**	**7.4**	**54**	**16**	**6.8**
Di-n-butyl phthalate	--	--	1400	--	--	**23**	19 U	20 U	**37**	20 U	20 U	20 U	19 U	20 U	20 U
Di-n-octyl phthalate	--	--	6200	--	--	**21**	**21**	20 U	19 U	20 U	20 U	20 U	19 U	20 U	20 U
Hexachlorobenzene	--	--	22	--	--	4.7 U	4.8 U	4.9 U	4.8 U	4.9 U	4.9 U	5 U	4.8 U	4.9 U	4.9 U

Table 5-2

2012 Surface Sediment Chemical and Physical Testing Results

			Location ID	Reference	Reference	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08a	IJ12-08a	IJ12-11
			Sample ID	CR-12	CR-023	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08A	IJ12-58A	IJ12-11
			Sample Date	5/30/12	5/30/12	4/25/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12
			Sample Depth	0-10 cm	0-10 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm
			Sample Type	N	N	N	N	N	N	N	N	N	N	FD	N
Analytes	SMS SCO	SMS CSL	PS LAET[a]												
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	--	--	11	--	--	4.7 U	4.8 U	4.9 U	4.8 UJ	4.9 U	4.9 U	5 U	4.8 U	4.9 U	4.9 U
N-Nitrosodiphenylamine	--	--	28	--	--	19 U	19 U	20 U	19 U	20 U	20 U	20 U	19 U	20 U	20 U
Pentachlorophenol	360	690	--	--	--	**25 J**	48 U	49 U	**33 J**	49 U	49 U	50 U	48 U	**34 J**	49 U
Phenol	420	1200	--	--	--	**56**	**18 J**	**34**	**140**	**17 J**	**22**	**35**	**27**	**39**	**52**
Semivolatile Organics (mg/kg-OC)															
1,2,4-Trichlorobenzene	0.81	1.8	--	--	--	0.094 U	0.196 U	0.169 U	0.229 UJ	0.158 U	0.192 U	0.192 U	0.128 U	0.114 U	0.243 U
1,2-Dichlorobenzene	2.3	2.3	--	--	--	0.094 U	0.196 U	0.169 U	0.229 UJ	0.158 U	0.192 U	0.192 U	0.128 U	0.114 U	0.243 U
1,4-Dichlorobenzene	3.1	9	--	--	--	0.094 U	0.196 U	0.169 U	0.229 UJ	0.158 U	0.192 U	0.192 U	0.128 U	0.114 U	0.243 U
Bis(2-ethylhexyl)phthalate	47	78	--	--	--	**6.426**	4.082 U	3.448 U	**15.238 J**	**16.077**	2.784 U	1.962 U	2.66 U	3.712 U	1.832 U
Butylbenzyl phthalate	4.9	64	--	--	--	0.094 U	**0.449 J**	**0.517 J**	**0.457**	**0.386 J**	**0.263**	**0.185 J**	**0.162**	**0.278**	**0.198 J**
Dibenzofuran	15	58	--	--	--	**1.325**	**0.571 J**	**0.759**	**3.762 J**	**0.418 J**	**0.588 J**	**0.885**	**0.505**	**3.016**	**0.99**
Diethyl phthalate	61	110	--	--	--	0.147 U	0.269 U	0.483 U	0.229 U	0.547 U	0.357 U	0.731 U	0.213 U	0.158 U	0.347 U
Dimethyl phthalate	53	53	--	--	--	**0.803**	**0.335**	0.169 U	**0.524 J**	**0.222**	**0.235**	**0.285**	**1.436**	**0.371**	**0.337**
Di-n-butyl phthalate	220	1700	--	--	--	**0.462**	0.776 U	0.69 U	**1.762**	0.643 U	0.784 U	0.769 U	0.505 U	0.464 U	0.99 U
Di-n-octyl phthalate	58	4500	--	--	--	**0.422**	**0.857**	0.69 U	0.905 U	0.643 U	0.784 U	0.769 U	0.505 U	0.464 U	0.99 U
Hexachlorobenzene	0.38	2.3	--	--	--	0.094 U	0.196 U	0.169 U	0.229 U	0.158 U	0.192 U	0.192 U	0.128 U	0.114 U	0.243 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	--	--	--	0.094 U	0.196 U	0.169 U	0.229 UJ	0.158 U	0.192 U	0.192 U	0.128 U	0.114 U	0.243 U
N-Nitrosodiphenylamine	11	11	--	--	--	0.382 U	0.776 U	0.69 U	0.905 U	0.643 U	0.784 U	0.769 U	0.505 U	0.464 U	0.99 U
Polycyclic Aromatic Hydrocarbons (µg/kg)															
2-Methylnaphthalene	--	--	670	--	--	**76**	**15 J**	**27**	**28 J**	**14 J**	**16 J**	**24**	**19**	**68**	**29**
Acenaphthene	--	--	500	--	--	**47**	19 U	**9.7 J**	**68 J**	20 U	20 U	**11 J**	19 U	**57**	20 U
Acenaphthylene	--	--	1300	--	--	**32**	19 U	**12 J**	**77**	20 U	20 U	**11 J**	**11 J**	**35**	20 U
Anthracene	--	--	960	--	--	**100**	**23**	**30**	**160**	**22**	**22**	**29**	**38**	**110**	**27**
Benzo(a)anthracene	--	--	1300	--	--	**360**	**59**	**80**	**560**	**57**	**49**	**59**	**76**	**170**	**24**
Benzo(a)pyrene	--	--	1600	--	--	**380**	**60**	**76**	**400**	**46**	**38**	**42**	**60**	**110**	**19 J**
Benzo(b,j,k)fluoranthenes	--	--	--	--	--	**850**	**160**	**200**	**2000 J**	**140**	**97**	**140**	**190**	**400**	**55**
Benzo(g,h,i)perylene	--	--	670	--	--	**180**	**47**	**59**	**210 J**	**31**	**28**	**22**	**25**	**46**	**11 J**
Chrysene	--	--	1400	--	--	**700**	**150**	**170**	**2000**	**150**	**84**	**130**	**170**	**430**	**49**
Dibenzo(a,h)anthracene	--	--	230	--	--	**74**	**14**	**18**	**70**	**12 J**	**8.6**	**8.3**	**11 J**	**21**	**3.1 J**
Fluoranthene	--	--	1700	--	--	**1400**	**170**	**220**	**6500**	**190**	**130**	**210**	**210**	**1100**	**91**
Fluorene	--	--	540	--	--	**72 J**	**14 J**	**21 J**	**140 J**	**13 J**	**16 J**	**21 J**	**19 J**	**110 J**	**18 J**
Indeno(1,2,3-c,d)pyrene	--	--	600	--	--	**180**	**40**	**51**	**220**	**27**	**22**	**22**	**24**	**46**	20 U
Naphthalene	--	--	2100	--	--	**130**	**23**	**47**	**28 J**	**20**	**23**	**38**	**28**	**76**	**51**
Phenanthrene	--	--	1500	--	--	**650**	**76**	**99**	**1900**	**48**	**60**	**72**	**95**	**1300**	**55**
Pyrene	--	--	2600	--	--	**1100**	**160**	**200**	**3900**	**160**	**110**	**170**	**230**	**800**	**78**
Total HPAH (SMS) (U = 0)	--	--	12000	--	--	**5224**	**860**	**1074**	**15860 J**	**813 J**	**566.6**	**803.3**	**996 J**	**3123**	**330.1 J**
Total LPAH (SMS) (U = 0)	--	--	5200	--	--	**1031 J**	**136 J**	**218.7 J**	**2373 J**	**103 J**	**121 J**	**182 J**	**191 J**	**1688 J**	**151 J**
Total PAH (SMS) (U = 0)	--	--	--	--	--	**6255 J**	**996 J**	**1292.7 J**	**18233 J**	**916 J**	**687.6 J**	**985.3 J**	**1187 J**	**4811 J**	**481.1 J**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	--	--	--	--	--	**533.4**	**88.8**	**112.6**	**705 J**	**71.1 J**	**56.5**	**66.2**	**91.8 J**	**178**	**27.7 J**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 1/2)	--	--	--	--	--	**533.4**	**88.8**	**112.6**	**705 J**	**71.1 J**	**56.5**	**66.2**	**91.8 J**	**178**	**28.7 J**

Table 5-2
2012 Surface Sediment Chemical and Physical Testing Results

			Location ID	Reference	Reference	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08a	IJ12-08a	IJ12-11
			Sample ID	CR-12	CR-023	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08A	IJ12-58A	IJ12-11
			Sample Date	5/30/12	5/30/12	4/25/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12
			Sample Depth	0-10 cm	0-10 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm
			Sample Type	N	N	N	N	N	N	N	N	N	N	FD	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET**[a]												
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)															
2-Methylnaphthalene	38	64	--	--	--	**1.526**	**0.612 J**	**0.931**	**1.333 J**	**0.45 J**	**0.627 J**	**0.923**	**0.505**	**1.578**	**1.436**
Acenaphthene	16	57	--	--	--	**0.944**	0.776 U	**0.334 J**	**3.238 J**	0.643 U	0.784 U	**0.423 J**	0.505 U	**1.323**	0.99 U
Acenaphthylene	66	66	--	--	--	**0.643**	0.776 U	**0.414 J**	**3.667**	0.643 U	0.784 U	**0.423 J**	**0.293 J**	**0.812**	0.99 U
Anthracene	220	1200	--	--	--	**2.008**	**0.939**	**1.034**	**7.619**	**0.707**	**0.863**	**1.115**	**1.011**	**2.552**	**1.337**
Benzo(a)anthracene	110	270	--	--	--	**7.229**	**2.408**	**2.759**	**26.667**	**1.833**	**1.922**	**2.269**	**2.021**	**3.944**	**1.188**
Benzo(a)pyrene	99	210	--	--	--	**7.631**	**2.449**	**2.621**	**19.048**	**1.479**	**1.49**	**1.615**	**1.596**	**2.552**	**0.941 J**
Benzo(b,j,k)fluoranthenes	230	450	--	--	--	**17.068**	**6.531**	**6.897**	**95.238 J**	**4.502**	**3.804**	**5.385**	**5.053**	**9.281**	**2.723**
Benzo(g,h,i)perylene	31	78	--	--	--	**3.614**	**1.918**	**2.034**	**10 J**	**0.997**	**1.098**	**0.846**	**0.665**	**1.067**	**0.545 J**
Chrysene	110	460	--	--	--	**14.056**	**6.122**	**5.862**	**95.238**	**4.823**	**3.294**	**5**	**4.521**	**9.977**	**2.426**
Dibenzo(a,h)anthracene	12	33	--	--	--	**1.486**	**0.571**	**0.621**	**3.333**	**0.386 J**	**0.337**	**0.319**	**0.293 J**	**0.487**	**0.153 J**
Fluoranthene	160	1200	--	--	--	**28.112**	**6.939**	**7.586**	**309.524**	**6.109**	**5.098**	**8.077**	**5.585**	**25.522**	**4.505**
Fluorene	23	79	--	--	--	**1.446 J**	**0.571 J**	**0.724 J**	**6.667 J**	**0.418 J**	**0.627 J**	**0.808 J**	**0.505 J**	**2.552 J**	**0.891 J**
Indeno(1,2,3-c,d)pyrene	34	88	--	--	--	**3.614**	**1.633**	**1.759**	**10.476**	**0.868**	**0.863**	**0.846**	**0.638**	**1.067**	0.99 U
Naphthalene	99	170	--	--	--	**2.61**	**0.939**	**1.621**	**1.333 J**	**0.643**	**0.902**	**1.462**	**0.745**	**1.763**	**2.525**
Phenanthrene	100	480	--	--	--	**13.052**	**3.102**	**3.414**	**90.476**	**1.543**	**2.353**	**2.769**	**2.527**	**30.162**	**2.723**
Pyrene	1000	1400	--	--	--	**22.088**	**6.531**	**6.897**	**185.714**	**5.145**	**4.314**	**6.538**	**6.117**	**18.561**	**3.861**
Total HPAH (SMS) (U = 0)	960	5300	--	--	--	**104.9**	**35.102**	**37.034**	**755.238 J**	**26.141 J**	**22.22**	**30.896**	**26.489 J**	**72.459**	**16.342 J**
Total LPAH (SMS) (U = 0)	370	780	--	--	--	**20.703 J**	**5.551 J**	**7.541 J**	**113 J**	**3.312 J**	**4.745 J**	**7 J**	**5.08 J**	**39.165 J**	**7.475 J**
Total PAH (SMS) (U = 0)	--	--	--	--	--	**125.602 J**	**40.653 J**	**44.576 J**	**868.238 J**	**29.453 J**	**26.965 J**	**37.896 J**	**31.569 J**	**111.624 J**	**23.817 J**
Dioxin Furans (ng/kg)															
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	--	--	--	--	--	**235**	**301**	**173**	**255**	**304**	**195**	**150**	**362**	**197**	**113**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	--	--	--	--	--	**9860**	**5630**	**2930**	**15200**	**5800**	**3800**	**3160**	**11000**	**5240**	**2080**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	--	--	--	--	--	**89.9**	**84.6**	**43.3**	**106**	**79.6**	**58.8**	**44.6**	**118**	**55.8**	**34.7**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	--	--	**891**	**629**	**334**	**1510**	**640**	**443**	**356**	**1200**	**575**	**251**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	--	--	--	--	--	**4.82**	**5.38**	**2.83**	**5.41**	**5.04**	**3.79**	**2.73**	**7.71**	**3.25**	**2.24**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	--	--	**6.66**	**5.35**	**2.67**	**10.1**	**5.33**	**4.29**	**3.37**	**9.26**	**5.04**	**2.89**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	--	--	**7.12**	**8.05**	**3.86**	**9.16**	**7.53**	**5.85**	**4.3**	**10.2**	**4.34**	**4.13**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	--	--	**3.7**	**2.88**	**1.67 J**	**4.63**	**2.78**	**2.28**	**1.53 J**	**4.1**	**2.38**	**1.41 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	--	--	**36.9**	**23.5**	**11.9**	**44.1**	**23**	**18.5**	**14.3**	**41.1**	**19.3**	**11.8**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	--	--	--	--	--	**2.61**	**1.9 J**	**1.18 J**	**3.84**	**1.52 J**	**1.19 J**	**1.11 J**	**2.93**	**1.59 J**	**1.09 J**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	--	--	**15.3**	**15.2**	**6.72**	**18.3**	**13.7**	**10.4**	**7.31**	**18.7 J**	**9.17**	**6.39**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	--	--	**2.13**	**1.35 J**	**0.738 J**	**2.77**	**1.38 J**	**1.21 J**	**0.972 J**	**2.15 J**	**0.89 J**	**0.992 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	--	--	**3.94**	**3.97**	**2**	**4.21**	**3.8**	**2.93**	**2.25 J**	**5.34**	**2.03 J**	**1.92**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	--	--	**5.93**	**5.03**	**1.35 J**	**6.81**	**4.96**	**3.65**	**1.56 J**	**7.03**	**1.49 J**	**2.22**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	--	--	**2.28**	**1.66**	**0.903 J**	**3.09**	**1.59**	**1.21**	**1**	**2.55**	**1.25**	**1.05**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	--	--	--	--	--	**1.34**	**4.52**	**2.28**	**2.11**	**4.55**	**4.37**	**3.59**	**5.26**	**2.28**	**4.29**
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	--	--	**0.429 J**	**0.5 J**	**0.264 J**	**0.487 J**	**0.496 J**	**0.457 J**	**0.374 J**	**0.629 J**	**0.266 J**	**0.3 J**
Total Heptachlorodibenzofuran (HpCDF)	--	--	--	--	--	**278**	**288 J**	**156**	**342 J**	**285**	**211 J**	**162 J**	**423**	**195**	**131**
Total Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	--	--	**2270**	**1650**	**869**	**4940**	**1590**	**1140**	**963**	**3630**	**1520**	**613**

Table 5-2
2012 Surface Sediment Chemical and Physical Testing Results

			Location ID	Reference	Reference	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08a	IJ12-08a	IJ12-11
			Sample ID	CR-12	CR-023	IJ12-01	IJ12-02	IJ12-03	IJ12-04	IJ12-05	IJ12-06	IJ12-07	IJ12-08A	IJ12-58A	IJ12-11
			Sample Date	5/30/12	5/30/12	4/25/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12	4/24/12
			Sample Depth	0-10 cm	0-10 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm	0-12 cm
			Sample Type	N	N	N	N	N	N	N	N	N	N	FD	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET**[a]												
Total Hexachlorodibenzofuran (HxCDF)	--	--	--	--	--	**202 J**	**138 J**	**70.9 J**	**261 J**	**141 J**	**108 J**	**83.8 J**	**219 J**	**93.1 J**	**65.4 J**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	--	--	**226**	**308 J**	**139**	**463**	**320**	**277**	**193 J**	**504 J**	**190**	**226**
Total Pentachlorodibenzofuran (PeCDF)	--	--	--	--	--	**81.9 J**	**49.4 J**	**28.7 J**	**73.6 J**	**46.3 J**	**35.7 J**	**27.5 J**	**62.2 J**	**25.2 J**	**24.1 J**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	--	--	**25.9**	**128 J**	**56.5 J**	**40.8 J**	**140 J**	**134**	**92.7 J**	**162 J**	**52.2 J**	**131 J**
Total Tetrachlorodibenzofuran (TCDF)	--	--	--	--	--	**22.5 J**	**28.2 J**	**16.4 J**	**18.9 J**	**26.9 J**	**25.1 J**	**19.5 J**	**31.2 J**	**15.4 J**	**22.8 J**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	--	--	**14.7 J**	**109 J**	**51.5 J**	**19.8 J**	**119 J**	**121 J**	**82.5 J**	**130 J**	**45.1 J**	**119 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	--	--	--	--	--	**25.959 J**	**20.621 J**	**10.452 J**	**36.463 J**	**20.229 J**	**15.094 J**	**11.686 J**	**33.322 J**	**15.228 J**	**9.524 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	--	--	--	--	--	**25.959 J**	**20.621 J**	**10.452 J**	**36.463 J**	**20.229 J**	**15.094 J**	**11.686 J**	**33.322 J**	**15.228 J**	**9.524 J**
PCB Aroclors (µg/kg)															
Aroclor 1016	--	--	--	--	--	19 U	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1221	--	--	--	--	--	19 U	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1232	--	--	--	--	--	19 U	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1242	--	--	--	--	--	19 UJ	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1248	--	--	--	--	--	19 UJ	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1254	--	--	--	--	--	19 UJ	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Aroclor 1260	--	--	--	--	--	19 UJ	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
Total PCB Aroclors (U = 0)	--	--	130	--	--	19 UJ	19 U	20 U	19 U	20 U	19 U	19 U	19 U	19 U	20 U
PCB Aroclors (mg/kg-OC)															
Aroclor 1016	--	--	--	--	--	0.382 U	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1221	--	--	--	--	--	0.382 U	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1232	--	--	--	--	--	0.382 U	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1242	--	--	--	--	--	0.382 UJ	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1248	--	--	--	--	--	0.382 UJ	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1254	--	--	--	--	--	0.382 UJ	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Aroclor 1260	--	--	--	--	--	0.382 UJ	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U
Total PCB Aroclors (U = 0)	12	65	--	--	--	0.382 UJ	0.776 U	0.69 U	0.905 U	0.643 U	0.745 U	0.731 U	0.505 U	0.441 U	0.99 U

Table 5-2
2012 Surface Sediment Chemical and Physical Testing Results

Notes:

🟨 Detected concentration is greater than SMS SCO.
🟩 Detected concentration is greater than SMS CSL.
🟦 Detected concentration is greater than Puget Sound Estuary Program LAET SL.
🟪 Detected concentration is greater than the former DMMP SL.[b]
▨ Concentration not compared to indicated criteria value.
Bold = Detected result

a. Only samples with TOC > 3.5% were screened against the PS LAET SL.
b. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.

J = estimated value
FD = field duplicate
N = normal field sample
U = compound analyzed, but not detected above detection limit
UJ = compound analyzed, but not detected above estimated detection limit
-- = Results or values not reported or not applicable

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
cm = centimeter
DMMP = Dredged Material Management Program
dw = dry weight
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized

ML = maximum level
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
pct = percent
PS = Puget Sound Estuary Program
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient

Results are reported in dry weight basis and as OC-normalized basis.
Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.
Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.
Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Total PAH are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. 2-nethylnapthalene is not included.
Benzo(j)fluoranthene is included in the total of benzo(b&k)fluoranthenes.
Dioxin TEQ values were calculated with 2005 World Health Organization (WHO) TEF values for mammals.
Total cPAH TEQ values were calculated with 2005 California EPA (CAEPA) TEF values (7 minimum).
U.S. Environmental Protection Agency (USEPA) Stage 2B data validation was completed by Laboratory Data Consultants (LDC).

Table 5-3
2013 Surface Sediment Chemical and Physical Testing Results

			Location ID	IJ13-SS-101	IJ13-SS-101	IJ13-SS-102
			Sample ID	IJ13-SS-101	IJ13-SS-151	IJ13-SS-102
			Sample Date	08/20/2013	08/20/2013	08/20/2013
			Sample Depth	0 - 12 cm	0 - 12 cm	0 - 12 cm
			Sample Type	N	FD	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**			
Conventional Parameters (mg/kg)						
Ammonia	--	--	--	**25.7**	**26**	**39.6**
Sulfide	--	--	--	**2860**	**2600**	**3380**
Conventional Parameters (pct)						
Plastic limit	--	--	--	**25.5**	**26.3**	**33.2**
Plasticity index	--	--	--	**17.3**	**16.4**	**21.7**
Liquid limit	--	--	--	**42.8**	**42.7**	**54.9**
Moisture (water) content	--	--	--	**84.4**	**65.45**	**107.74**
Total organic carbon	--	--	--	**3.43**	**3.1**	**5.4**
Total solids	--	--	--	**52.3**	**55.57**	**43.97**
Total solids (preserved)	--	--	--	**49.71**	**52.3**	**47.84**
Total volatile solids	--	--	--	**8.03**	**6.53**	**10.98**
Conventional Parameters (unitless)						
Atterberg classification	--	--	--	**-- CL**	**-- ML**	**-- MH**
Grain Size (pct)						
Total Gravel	--	--	--	**26.1**	**34**	**33**
Total Sand	--	--	--	**50**	**44.8**	**31.3**
Total Silt	--	--	--	**5.1**	**8.4**	**9.8**
Total Fines (silt + clay)	--	--	--	**23.9**	**21.1**	**35.7**
Total Clay	--	--	--	**18.8**	**12.7**	**25.9**
Metals (mg/kg)						
Arsenic	57	93	--	**10**	**10**	**10**
Cadmium	5.1	6.7	--	**0.5**	0.4 U	**0.6**
Chromium	260	270	--	**35 J**	**31 J**	**41 J**
Copper	390	390	--	**58.6**	**44**	**58.2**
Lead	450	530	--	**31**	**33**	**25**
Mercury	0.41	0.59	--	**0.14**	**0.11**	**0.15**
Nickel[b]	--	--	--	**90**	**68**	**62**
Silver	6.1	6.1	--	0.6 U	0.6 U	0.6 U
Zinc	410	960	--	**212**	**210**	**150**
Semivolatile Organics (µg/kg)						
1,2,4-Trichlorobenzene	--	--	31	14 U	14 U	15 U
1,2-Dichlorobenzene	--	--	35	14 U	14 U	15 U
1,4-Dichlorobenzene	--	--	110	14 U	14 U	15 U
2,4-Dimethylphenol	29	29	--	**38 J**	**42 J**	**210**
2-Methylphenol (o-Cresol)	63	63	--	**25**	**30**	**120**
4-Methylphenol (p-Cresol)	670	670	--	**470**	**530**	**1200**
Benzoic acid	650	650	--	560 U	**290 J**	**700**
Benzyl alcohol	57	73	--	**59 J**	**53 J**	**65**
bis(2-Ethylhexyl)phthalate	--	--	1300	**370**	**29000**	**1400**
Butylbenzyl phthalate	--	--	63	**21**	14 U	**9.2 J**
Dibenzofuran	--	--	540	**310**	**290**	**2000**
Diethyl phthalate	--	--	200	66 U	56 U	59 U
Dimethyl phthalate	--	--	71	**50**	**56**	**130**
Di-n-butyl phthalate	--	--	1400	56 U	56 U	59 U
Di-n-octyl phthalate	--	--	6200	56 U	56 U	59 U
Hexachlorobenzene	--	--	22	14 U	14 U	15 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	--	--	11	14 U[1]	14 U[1]	15 U[1]
n-Nitrosodiphenylamine	--	--	28	**59**	**39**	**180**
Pentachlorophenol	360	690	--	56 UJ	56 UJ	**37 J**
Phenol	420	1200	--	**220**	**160**	**340**
Semivolatile Organics (mg/kg-OC)						
1,2,4-Trichlorobenzene	0.81	1.8	--	0.408 U	0.452 U	0.278 U
1,2-Dichlorobenzene	2.3	2.3	--	0.408 U	0.452 U	0.278 U
1,4-Dichlorobenzene	3.1	9	--	0.408 U	0.452 U	0.278 U
bis(2-Ethylhexyl)phthalate	47	78	--	**10.787**	**935.484**	**25.926**
Butylbenzyl phthalate	4.9	64	--	**0.612**	0.452 U	**0.17 J**
Dibenzofuran	15	58	--	**9.038**	**9.355**	**37.037**
Diethyl phthalate	61	110	--	1.924 U	1.806 U	1.093 U
Dimethyl phthalate	53	53	--	**1.458**	**1.806**	**2.407**
Di-n-butyl phthalate	220	1700	--	1.633 U	1.806 U	1.093 U
Di-n-octyl phthalate	58	4500	--	1.633 U	1.806 U	1.093 U
Hexachlorobenzene	0.38	2.3	--	0.408 U[1]	0.452 U[1]	0.278 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	--	0.408 U	0.452 U	0.278 U
n-Nitrosodiphenylamine	11	11	--	**1.72**	**1.258**	**3.333**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
2-Methylnaphthalene	--	--	670	**200**	**190**	**870**
Acenaphthene	--	--	500	**310**	**310**	**2000**
Acenaphthylene	--	--	1300	**120**	**140**	**190**
Anthracene	--	--	960	**340**	**390**	**1200**
Benzo(a)anthracene	--	--	1300	**1200**	**930**	**2300**

Table 5-3
2013 Surface Sediment Chemical and Physical Testing Results

			Location ID	IJ13-SS-101	IJ13-SS-101	IJ13-SS-102
			Sample ID	IJ13-SS-101	IJ13-SS-151	IJ13-SS-102
			Sample Date	08/20/2013	08/20/2013	08/20/2013
			Sample Depth	0 - 12 cm	0 - 12 cm	0 - 12 cm
			Sample Type	N	FD	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**			
Benzo(a)pyrene	--	--	1600	**640**	**500**	**800**
Benzo(b,j,k)fluoranthenes	--	--	--	**1700**	**1600**	**2100**
Benzo(g,h,i)perylene	--	--	670	**260**	**190**	**280**
Chrysene	--	--	1400	**1600**	**1800**	**3300**
Dibenzo(a,h)anthracene	--	--	230	**78**	**67**	**89**
Fluoranthene	--	--	1700	**2400**	**4500**	**11000**
Fluorene	--	--	540	**270**	**310**	**1800**
Indeno(1,2,3-c,d)pyrene	--	--	600	**250**	**210**	**280**
Naphthalene	--	--	2100	**430**	**470**	**1800**
Phenanthrene	--	--	1500	**1000**	**1400**	**7100**
Pyrene	--	--	2600	**2900**	**4100**	**9200**
Total Benzofluoranthenes (b,j,k) (U = 0)	--	--	3200	**1700**	**1600**	**2100**
Total HPAH (SMS) (U = 0)	--	--	12000	**11107**	**13897**	**29349**
Total LPAH (SMS) (U = 0)	--	--	5200	**2470**	**3010**	**14090**
Total PAH (SMS) (U = 0)	--	--	--	**13577**	**16907**	**43439**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 0)	--	--	--	**986.7**	**798.7**	**1309.9**
Total cPAH TEQ (7 minimum CAEPA 2005) (U = 1/2)	--	--	--	**986.7**	**798.7**	**1309.9**
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)						
2-Methylnaphthalene	38	64	--	**5.831**	**6.129**	**16.111**
Acenaphthene	16	57	--	**9.038**	**9.677**	**37.037**
Acenaphthylene	66	66	--	**3.499**	**4.516**	**3.519**
Anthracene	220	1200	--	**9.913**	**12.581**	**22.222**
Benzo(a)anthracene	110	270	--	**34.985**	**30**	**42.593**
Benzo(a)pyrene	99	210	--	**18.659**	**16.129**	**14.815**
Benzo(g,h,i)perylene	31	78	--	**7.58**	**6.129**	**5.185**
Chrysene	110	460	--	**46.647**	**58.065**	**61.111**
Dibenzo(a,h)anthracene	12	33	--	**2.274**	**2.161**	**1.648**
Fluoranthene	160	1200	--	**69.971**	**145.161**	**203.704**
Fluorene	23	79	--	**7.872**	**10**	**33.333**
Indeno(1,2,3-c,d)pyrene	34	88	--	**7.289**	**6.774**	**5.185**
Naphthalene	99	170	--	**12.536**	**15.161**	**33.333**
Phenanthrene	100	480	--	**29.155**	**45.161**	**131.481**
Pyrene	1000	1400	--	**84.548**	**132.258**	**170.37**
Total Benzofluoranthenes (b,j,k) (U = 0)	230	450	--	**49.563**	**51.613**	**38.889**
Total HPAH (SMS) (U = 0)	960	5300	--	**323.819**	**448.29**	**543.5**
Total LPAH (SMS) (U = 0)	370	780	--	**72.012**	**97.097**	**260.926**
Total PAH (SMS) (U = 0)	--	--	--	**395.831**	**545.387**	**804.426**
Dioxin Furans (ng/kg)						
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**0.712 J**	**0.684 J**	**0.911 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**4.36**	**4.42**	**5.5**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**7.58**	**8.12**	**10.3**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**44 J**	**44.2 J**	**68.2 J**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**15.2**	**17.4**	**20.8**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**1500**	**1710**	**2680 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	--	--	--	**12400 J**	**13700 J**	**20200**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**25 J**	**25.4 J**	**26.9 J**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**44.7 J**	**52.3**	**79.2**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**513 J**	**665 J**	**1410 J**
Total Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**4900**	**6410**	**13800**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	--	--	--	**2.7**	**2.43**	**3.48**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**2.54 J**	**2.83**	**4.79 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**2.57**	**2.95**	**4.43**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**8.92**	**10.4**	**18**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**4.34**	**4.95**	**7.66**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	--	--	--	**3.36 J**	**3.95 J**	**8.68 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**3.58**	**4.31**	**7**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	--	--	--	**162**	**145**	**214**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	--	--	--	**10.1**	**11.4**	**18.2**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	--	--	--	**675**	**791**	**664**
Total Tetrachlorodibenzofuran (TCDF)	--	--	--	**24.3 J**	**21.3 J**	**29.8 J**
Total Pentachlorodibenzofuran (PeCDF)	--	--	--	**53**	**56.5 J**	**84.9 J**
Total Hexachlorodibenzofuran (HxCDF)	--	--	--	**237 J**	**259 J**	**402 J**
Total Heptachlorodibenzofuran (HpCDF)	--	--	--	**617 J**	**634 J**	**902 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	--	--	--	**35.531 J**	**38.661 J**	**57.677 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	--	--	--	**35.531 J**	**38.661 J**	**57.677 J**
PCB Aroclors (µg/kg)						
Aroclor 1016	--	--	--	19 U	19 U	19 UJ
Aroclor 1221	--	--	--	19 U	19 U	19 UJ
Aroclor 1232	--	--	--	19 U	19 U	19 UJ
Aroclor 1242	--	--	--	19 U	19 U	19 UJ
Aroclor 1248	--	--	--	38 U	28 U	**48 J**

Table 5-3
2013 Surface Sediment Chemical and Physical Testing Results

			Location ID	**IJ13-SS-101**	**IJ13-SS-101**	**IJ13-SS-102**
			Sample ID	**IJ13-SS-101**	**IJ13-SS-151**	**IJ13-SS-102**
			Sample Date	**08/20/2013**	**08/20/2013**	**08/20/2013**
			Sample Depth	**0 - 12 cm**	**0 - 12 cm**	**0 - 12 cm**
			Sample Type	**N**	**FD**	**N**
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**			
Aroclor 1254	--	--	--	**190**	**81**	**80 J**
Aroclor 1260	--	--	--	38 U	19 U	19 UJ
Total PCB Aroclors (U = 0)	--	--	130	**190**	**81**	**80 J**
PCB Aroclors (mg/kg-OC)						
Aroclor 1016	--	--	--	0.554 U	0.613 U	0.352 UJ
Aroclor 1221	--	--	--	0.554 U	0.613 U	0.352 UJ
Aroclor 1232	--	--	--	0.554 U	0.613 U	0.352 UJ
Aroclor 1242	--	--	--	0.554 U	0.613 U	0.352 UJ
Aroclor 1248	--	--	--	1.108 U	0.903 U	**0.889 J**
Aroclor 1254	--	--	--	**5.539**	**2.613**	**1.481 J**
Aroclor 1260	--	--	--	1.108 U	0.613 U	0.352 UJ
Total PCB Aroclors (SMS Marine 2013) (U = 0)	12	65	--	**5.539**	**2.613**	**1.481 J**

Table 5-3
2013 Surface Sediment Chemical and Physical Testing Results

Notes:

🟨 Detected concentration is greater than SMS SCO.
🟩 Detected concentration is greater than SMS CSL.
🟦 Detected concentration is greater than LAET screening level when TOC > 3.5%.
🟪 Detected concentration is greater than the former DMMP SL.[b]
▨ Concentration not compared to indicated criteria value.
Bold = Detected result

1. Non-detected concentration is above one or more identified screening levels.
a. Only samples with TOC > 3.5% were screened against the PS LAET SL.
b. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw.

J = Estimated value
FD = field duplicate
N = normal field sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
-- = Results or values not reported or not applicable

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
cm = centimeter
DMMP = Dredged Material Management Program
dw = dry weight
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized
ML = maximum level
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
pct = percent
PS = Puget Sound Estuary Program
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient

Results are reported in dry weight basis and as OC-normalized basis.

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest limit value is reported as the sum.

Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.

Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Total PAH are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. 2-methylnapthalene is not included.

Benzo(j)fluoranthene is included in the total of benzo(b&k)fluoranthenes.

Dioxin TEQ values were calculated with 2005 World Health Organization (WHO) TEF values for mammals.

Total cPAH TEQ values were calculated with 2005 California EPA (CAEPA) TEF values (7 minimum).

U.S. Environmental Protection Agency (USEPA) Stage 2B data validation was completed by Laboratory Data Consultants (LDC).

Table 5-4
2005/2006 Biological Testing Endpoint Evaluation

Bioassay Test	Site	Statistical Difference Present (Yes/No)[1]		Exceeds SQS Effect Criteria (Yes/No)		Exceeds CSL Effect Criteria (Yes/No)		SQS/CSL Biological Criteria (Pass/Fail)[2]
		RR-01	RR-02	RR-01	RR-02	RR-01	RR-02	
Amphipod[3]				*M_T > 25%, Absolute*		*M_R-M_T>30%*		
	SS-04	--	No	--	No	--	No	Pass
	SS-06	No	--	No	--	No	--	Pass
	SS-07	--	No	--	No	--	No	Pass
	SS-08	--	No	--	No	--	No	Pass
	SS-09	--	No	--	No	--	No	Pass
	SS-10	--	No	--	No	--	No	Pass
	SS-11	No	--	No	--	No	--	Pass
	SS-12	No	--	No	--	No	--	Pass
	SS-13	--	No	--	No	--	No	Pass
Larval				*(N_T/N_R)<0.85*		*(N_T/N_R)<0.70*		
	SS-04	--	Yes	--	Yes	--	Yes	Fail: CSL
	SS-06	Yes	--	Yes	--	Yes	--	Fail: CSL
	SS-07	--	Yes	--	Yes	--	Yes	Fail: CSL
	SS-08	--	Yes	--	Yes	--	Yes	Fail: CSL
	SS-09	--	Yes	--	Yes	--	Yes	Fail: CSL
	SS-10	--	Yes	--	Yes	--	Yes	Fail: CSL
	SS-11	No	--	No	--	No	--	Pass
	SS-12	No	--	Yes	--	No	--	Pass
	SS-13	--	Yes	--	Yes	--	Yes	Fail: CSL

Table 5-4
2005/2006 Biological Testing Endpoint Evaluation

Bioassay Test	Site	Statistical Difference Present (Yes/No) [1]		Exceeds SQS Effect Criteria (Yes/No)		Exceeds CSL Effect Criteria (Yes/No)		SQS/CSL Biological Criteria (Pass/Fail)[2]
		RR-01	RR-02	RR-01	RR-02	RR-01	RR-02	
Juvenile Polychaete				$MIG_T/MIG_R < 0.70$		$MIG_T/MIG_R < 0.50$		
	SS-04	--	No	--	No	--	No	Pass
	SS-06	Yes	--	Yes	--	No	--	Fail: SQS
	SS-07	--	No	--	No	--	No	Pass
	SS-08	--	No	--	No	--	No	Pass
	SS-09	--	No	--	No	--	No	Pass
	SS-10	--	Yes	--	No	--	No	Pass
	SS-11	No	--	No	--	No	--	Pass
	SS-12	Yes	--	Yes	--	No	--	Fail: SQS
	SS-13	--	No	--	No	--	No	Pass

Notes:

1. Statistical analyses conducted using DMMP/SMS Bioassay Statistics Program Beta v2.0c developed by the Corps of Engineers, Seattle District. T-test, p=0.05
2. SQS and CSL Biological Criteria for each bioassay are included in WAC 173-204-320.
3. Amphipod results are from the August 2005 sampling event.

CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
M = mortality
MIG = mean individual growth rate
N = normal counts
R = reference sediment
RR-01 = Reference station 1 (16% fines)
RR-02 = Reference station 2 (92% fines)
SMS = Sediment Management Standards
SQS = Sediment Quality Standard
T = test sediment
WAC = Washington Administrative Code

Table 5-5
2012 Biological Testing Endpoint Evaluation

Station	Statistically Different (Yes/No)	Exceeds SQS Effect Criteria (Yes/No)	Exceeds CSL Effect Criteria (Yes/No)	SQS/CSL Biological Criteria (Pass/Fail)[1]
	CR-023	CR-023	CR-023	
Amphipod		$M_T-M_R>25\%$	$M_T-M_R>30\%$	
IJ12-01	No	No	No	Pass
IJ12-02	No	No	No	Pass
IJ12-03	Yes	No	No	Pass
IJ12-05	No	No	No	Pass
IJ12-07	No	No	No	Pass
Larval		$N_T/N_R<0.85$	$N_T/N_R<0.70$	
IJ12-01	Yes	Yes	No	Fail: SQS
IJ12-02	Yes	Yes	No	Fail: SQS
IJ12-03	Yes	Yes	No	Fail: SQS
IJ12-05	Yes	Yes	No	Fail: SQS
IJ12-07	Yes	No	No	Pass
Juvenile Polychaete		$MIG_T/MIG_R<0.70$	$MIG_T/MIG_R<0.50$	
IJ12-01	No	No	No	Pass
IJ12-02	No	No	No	Pass
IJ12-03	No	No	No	Pass
IJ12-05	No	No	No	Pass
IJ12-07	No	No	No	Pass

Notes:

1. SQS and CSL Biological Criteria for each bioassay are included in WAC 173-204-320.

CSL = Cleanup Screening Level
M = mortality
MIG = mean individual growth rate
N = normal counts
NA = not applicable
R = reference sediment
SQS = Sediment Quality Standard
T = test sediment
WAC = Washington Administrative Code

Table 5-6
Summary of Valid Historical Core Sampling Data

		Location ID	**HC-VC-85**	**HC-VC-85**
		Sample ID	**HC-VC-85-S1**	**HC-VC-85-S2**
		Sample Date	**09/13/1996**	**09/13/1996**
		Sample Depth	**0 - 4.5 ft**	**4.7 - 7.1 ft**
		Sample Type	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**		
Conventional Parameters (pct)				
Moisture, percent	--	--	**57**	**41**
Total organic carbon	--	--	**4.2**	**13**
Grain Size (pct)				
Gravel	--	--	**0**	**0**
Sand	--	--	**10**	**69**
Silt	--	--	**65**	**22**
Clay	--	--	**25**	**9**
Total Fines (silt + clay)	--	--	**90**	**31**
Metals (mg/kg)				
Arsenic	57	93	**9.9**	**4.7**
Cadmium	5.1	6.7	**1.4**	0.86 U
Chromium	260	270	**69**	**24**
Copper	390	390	**66**	**28**
Lead	450	530	**33**	**15**
Mercury	0.41	0.59	**0.88**	0.16 U
Silver	6.1	6.1	1.2 U	0.86 U
Zinc	410	960	**130**	**54**
Volatile Organics (mg/kg-OC)				
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	0.093 U	0.022 U
Semivolatile Organics (µg/kg)				
2,4-Dimethylphenol	29	29	**38 J**	**610 J**
2-Methylphenol (o-Cresol)	63	63	**23 J**	**400 J**
4-Methylphenol (p-Cresol)	670	670	**200 J**	**1500 J**
Benzoic acid	650	650	**200 J**	**47 J**
Benzyl alcohol	57	73	**4.8 J**	**4.4 J**

Table 5-6
Summary of Valid Historical Core Sampling Data

		Location ID	**HC-VC-85**	**HC-VC-85**
		Sample ID	**HC-VC-85-S1**	**HC-VC-85-S2**
		Sample Date	**09/13/1996**	**09/13/1996**
		Sample Depth	**0 - 4.5 ft**	**4.7 - 7.1 ft**
		Sample Type	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**		
Pentachlorophenol	360	690	**9.8 J**	**28 J**
Phenol	420	1200	**280 J**	**370 J**
Semivolatile Organics (mg/kg-OC)				
1,2,4-Trichlorobenzene	0.81	1.8	0.857 UJ[1]	0.2 UJ
1,2-Dichlorobenzene	2.3	2.3	1 UJ	**0.054 J**
1,4-Dichlorobenzene	3.1	9	0.905 UJ	**0.077 J**
bis(2-Ethylhexyl)phthalate	47	78	**50 J**	**1.231 J**
Butylbenzyl phthalate	4.9	64	**1.714 J**	0.4 UJ
Dibenzofuran	15	58	**3.81 J**	**4.692 J**
Diethyl phthalate	61	110	2.214 UJ	**0.231 J**
Dimethyl phthalate	53	53	**0.5 J**	**0.415 J**
Di-n-butyl phthalate	220	1700	**0.857 J**	**0.146 J**
Di-n-octyl phthalate	58	4500	**2.619 J**	0.369 UJ
Hexachlorobenzene	0.38	2.3	**0.167**	0.022 U
n-Nitrosodiphenylamine	11	11	**0.548 J**	**0.923 J**
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)				
2-Methylnaphthalene	38	64	**5 J**	**7.692 J**
Acenaphthene	16	57	**1.881 J**	**1.846 J**
Acenaphthylene	66	66	**0.81 J**	**1.308 J**
Anthracene	220	1200	**3.333 J**	**2.154 J**
Benzo(a)anthracene	110	270	**6.667 J**	**1.692 J**
Benzo(a)pyrene	99	210	**5 J**	**1.231 J**
Benzo(g,h,i)perylene	31	78	**5.476 J**	**0.754 J**
Chrysene	110	460	**10.238 J**	**2.077 J**
Dibenzo(a,h)anthracene	12	33	**1.929 J**	0.4 UJ
Fluoranthene	160	1200	**13.095 J**	**5.846 J**
Fluorene	23	79	**2.857 J**	**3 J**

Table 5-6
Summary of Valid Historical Core Sampling Data

Analytes		Location ID	HC-VC-85	HC-VC-85
		Sample ID	HC-VC-85-S1	HC-VC-85-S2
		Sample Date	09/13/1996	09/13/1996
		Sample Depth	0 - 4.5 ft	4.7 - 7.1 ft
		Sample Type	N	N
	SMS SCO	SMS CSL		
Indeno(1,2,3-c,d)pyrene	34	88	**4.286 J**	**0.585 J**
Naphthalene	99	170	**6.429 J**	**9.231 J**
Phenanthrene	100	480	**8.095 J**	**7.615 J**
Pyrene	1000	1400	**20.476 J**	**3.308 J**
Total Benzofluoranthenes (b,j,k) (U = 0)	230	450	**12.143 J**	**3.846 J**
Total HPAH (SMS) (U = 0)	960	5300	**79.31 J**	**19.338 J**
Total LPAH (SMS) (U = 0)	370	780	**23.405 J**	**25.154 J**
PCB Aroclors (mg/kg-OC)				
Aroclor 1016	--	--	2.857 U	0.654 U
Aroclor 1221	--	--	2.857 U	0.654 U
Aroclor 1232	--	--	2.857 U	0.654 U
Aroclor 1242	--	--	2.857 U	0.654 U
Aroclor 1248	--	--	2.857 U	0.654 U
Aroclor 1254	--	--	2.857 U	0.654 U
Aroclor 1260	--	--	2.857 U	0.654 U
Total PCB Aroclors (SMS Marine 2013) (U = 0)	12	65	2.857 U	0.654 U

Table 5-6
Summary of Valid Historical Core Sampling Data

Notes:

🟨 Detected concentration is greater than SMS SCO.

🟩 Detected concentration is greater than SMS CSL.

Bold = Detected result

1. Non-detected concentration is above one or more identified screening levels.

J = Estimated value

N = normal field sample

U = Compound analyzed, but not detected above detection limit

UJ = Compound analyzed, but not detected above estimated detection limit

-- = Results or values not reported or not applicable

µg/kg = microgram per kilogram

CSL = Cleanup Screening Level

ft = feet

HPAH = high-molecular weight polycyclic aromatic hydrocarbon

LPAH = low-molecular weight polycyclic aromatic hydrocarbon

mg/kg = milligram per kilogram

mg/kg-OC = milligram per kilogram organic carbon normalized

ng/kg = nanogram per kilogram

PCB = polychlorinated biphenyls

pct = percent

SCO = Sediment Cleanup Objective

SMS = Sediment Management Standards

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.

Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.

Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

					DMMU	DMMU3	DMMU4A	DMMU4B	DMMU5	DMMU6
					Location ID	IJ-C3-S1-COMP	IJ-C4-S1-COMP	IJ-C4-S2-COMP	IJ-C5-S1-COMP	IJ-C6-S1-COMP
					Sample ID	IJ-C3-S1	IJ-C4-S1	IJ-C4-S2	IJ-C5-S1	IJ-C6-S1
					Sample Date	06/13/2006	06/15/2006	06/15/2006	06/15/2006	06/14/2006
					Composite	(IJ-18, IJ-19, IJ-20, IJ-21)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-22, IJ-23, IJ-24, IJ-25)	(IJ-26, IJ-27, IJ-28, IJ-29)
					Sample Type	N	N	N	N	N
Analytes	SMS SCO	SMS CSL	DMMP SL	DMMP BT	DMMP ML					
Conventional Parameters (mg/kg)										
Ammonia	--	--	--	--	--	**62.2**	**50.9**	**41.6**	**91.2**	**82.7**
Sulfide	--	--	--	--	--	**2000 J**	**160 J**	**310 J**	**3400 J**	**680 J**
Conventional Parameters (pct)										
Moisture, percent	--	--	--	--	--	**49.1**	**53**	**41**	**52.8**	**47.1**
Total organic carbon	--	--	--	--	--	**2.98**	**7.08**	**2.45**	**3.22**	**7.03**
Total solids	--	--	--	--	--	**48.4**	**57.5**	**48.5**	**47.7**	**51.3**
Total solids (preserved)	--	--	--	--	--	**65.5**	**67.9**	**44.4**	**41.8**	**60.8**
Total volatile solids	--	--	--	--	--	**7.75**	**23.76**	**10.11**	**6.73**	**19.33**
Conventional Parameters (su)										
pH	--	--	--	--	--	**7.99**	**8.02**	**7.88**	**7.94**	**7.91**
Grain Size (pct)										
Total Gravel	--	--	--	--	--	**2.1**	**1.1**	**5.1**	**3.1**	**9.9**
Total Sand	--	--	--	--	--	**15.5**	**29.5**	**43.8**	**22.7**	**33.1**
Total Silt	--	--	--	--	--	**47.1**	**39.3**	**30.5**	**44.4**	**33**
Total Fines (silt + clay)	--	--	--	--	--	**82.5**	**69.3**	**51.3**	**74.2**	**57.1**
Total Clay	--	--	--	--	--	**35.4**	**30**	**20.8**	**29.8**	**24.1**
Metals (mg/kg)										
Antimony			150		200	**-- R**	**-- R**	**-- R**	**-- R**	**-- R**
Arsenic	57	93	57	507.1	700	**10**	**10**	8 U	10 U	10 U
Cadmium	5.1	6.7	5.1	11.3	14	**0.6**	**0.6**	**0.4**	**0.7**	**0.9**
Chromium	260	270	260	260	--	**68.3**	**60**	**44.4**	**68**	**55**
Copper	390	390	390	1027	1300	**62.3**	**55.9**	**44.2**	**61.8**	**59**
Lead	450	530	450	975	1200	**22**	**26**	**25**	**27**	**66**
Mercury	0.41	0.59	0.41	1.5	2.3	**0.7**	**0.43**	**0.54**	**0.74**	**1**
Nickel	--	--	140	370	370	**108**	**223**	**97**	**106**	**94**
Silver	6.1	6.1	6.1	6.1	8.4	0.6 U	0.6 U	0.5 U	0.7 U	0.6 U
Zinc	410	960	410	2783	3800	**128 J**	**113 J**	**80.1 J**	**131 J**	**134 J**
Organometallic Compounds (porewater) (µg/L)										
Butyltin (ion)	--	--	--	--	--	0.075 U	0.065 U	0.13 U	0.073 U	0.086 U
Dibutyltin (ion)	--	--	--	--	--	0.029 U	0.029 U	0.029 U	0.029 U	0.029 U
Tributyltin (ion)	--	--	0.15	0.15	--	0.13 U	**0.028 J**	0.12 U	0.084 U	**0.022 J**
Organometallic Compounds (µg/kg)										
Butyltin (ion)	--	--	--	--	--	4.1 UJ	4.1 UJ	4 UJ	3.9 UJ	4 UJ
Dibutyltin (ion)	--	--	--	--	--	5.8 U	**14**	5.7 U	5.6 U	5.7 U
Tributyltin (ion)	--	--	73	73	--	**6.8**	**9.1**	3.8 U	**6.4**	**14**
Volatile Organics (µg/kg)										

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

					DMMU	DMMU3	DMMU4A	DMMU4B	DMMU5	DMMU6
					Location ID	IJ-C3-S1-COMP	IJ-C4-S1-COMP	IJ-C4-S2-COMP	IJ-C5-S1-COMP	IJ-C6-S1-COMP
					Sample ID	IJ-C3-S1	IJ-C4-S1	IJ-C4-S2	IJ-C5-S1	IJ-C6-S1
					Sample Date	06/13/2006	06/15/2006	06/15/2006	06/15/2006	06/14/2006
					Composite	(IJ-18, IJ-19, IJ-20, IJ-21)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-22, IJ-23, IJ-24, IJ-25)	(IJ-26, IJ-27, IJ-28, IJ-29)
					Sample Type	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**DMMP SL**	**DMMP BT**	**DMMP ML**					
Ethylbenzene	--	--	--	--	--	2.2 U	1.6 U	1.4 U	2.2 U	--
m,p-Xylene	--	--	--	--	--	2.2 U	1.6 U	1.4 U	2.2 U	--
o-Xylene	--	--	--	--	--	2.2 U	1.6 U	1.4 U	2.2 U	--
Tetrachloroethene (PCE)	--	--	--	--	--	2.2 U	1.6 U	1.4 U	2.2 U	1.7 U
Trichloroethene (TCE)	--	--	--	--	--	2.2 U	1.6 U	1.4 U	2.2 U	1.7 U
Semivolatile Organics (µg/kg)										
1,2,4-Trichlorobenzene			31		64	20 U	20 U	20 U	20 U	20 U
1,2-Dichlorobenzene			35		110	20 U	20 U	20 U	20 U	20 U
1,3-Dichlorobenzene						20 U	20 U	20 U	20 U	20 U
1,4-Dichlorobenzene			110		120	20 U	20 U	20 U	20 U	20 U
2,4-Dimethylphenol	29	29	29		210	20 U	20 U	**28**	**12 J**	**54**
2-Methylphenol (o-Cresol)	63	63	63		77	20 U	20 U	20 U	20 U	**11 J**
4-Methylphenol (p-Cresol)	670	670	670		3600	**21**	**32**	**45**	**55**	**97**
Benzoic acid	650	650	650		760	200 U	200 U	200 U	200 U	200 U
Benzyl alcohol	57	73	57		870	20 U	20 U	20 U	20 U	20 U
bis(2-Ethylhexyl)phthalate			1300		8300	**460**	**420**	**110**	**690**	**12000**
Butylbenzyl phthalate			63		970	20 U	**20 J**	**12 J**	20 U	20 U
Dibenzofuran			540		1700	**19 J**	**30**	**48**	**39**	**74**
Diethyl phthalate			200		1200	20 U	20 U	20 U	20 U	20 U
Dimethyl phthalate			71		1400	20 U	**12 J**	20 U	20 U	**79**
Di-n-butyl phthalate			1400		5100	20 U	20 U	20 U	20 U	20 U
Di-n-octyl phthalate			6200		6200	20 U	20 U	20 U	**210**	**40**
Hexachlorobenzene			22	168	230	20 U	20 U	20 U	20 U	20 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)			11		270	20 U[1]	20 U[1]	20 U[1]	20 U[1]	20 U[1]
Hexachloroethane						20 U	20 U	20 U	20 U	20 U
n-Nitrosodiphenylamine			28		130	20 U	20 U	25 U	20 U	20 U
Pentachlorophenol	360	690	400	504	690	99 U	99 U	99 U	100 U	99 U
Phenol	420	1200	420		1200	20 U	20 U	**31**	20 U	20 U
Semivolatile Organics (mg/kg-OC)										
1,2,4-Trichlorobenzene	0.81	1.8				0.671 U	0.282 U	0.816 U[1]	0.621 U	0.284 U
1,2-Dichlorobenzene	2.3	2.3				0.671 U	0.282 U	0.816 U	0.621 U	0.284 U
1,4-Dichlorobenzene	3.1	9				0.671 U	0.282 U	0.816 U	0.621 U	0.284 U
bis(2-Ethylhexyl)phthalate	47	78				**15.436**	**5.932**	**4.49**	**21.429**	**170.697**
Butylbenzyl phthalate	4.9	64				0.671 U	**0.282 J**	**0.49 J**	0.621 U	0.284 U
Dibenzofuran	15	58				**0.638 J**	**0.424**	**1.959**	**1.211**	**1.053**
Diethyl phthalate	61	110				0.671 U	0.282 U	0.816 U	0.621 U	0.284 U
Dimethyl phthalate	53	53				0.671 U	**0.169 J**	0.816 U	0.621 U	**1.124**

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

					DMMU	**DMMU3**	**DMMU4A**	**DMMU4B**	**DMMU5**	**DMMU6**
					Location ID	**IJ-C3-S1-COMP**	**IJ-C4-S1-COMP**	**IJ-C4-S2-COMP**	**IJ-C5-S1-COMP**	**IJ-C6-S1-COMP**
					Sample ID	**IJ-C3-S1**	**IJ-C4-S1**	**IJ-C4-S2**	**IJ-C5-S1**	**IJ-C6-S1**
					Sample Date	**06/13/2006**	**06/15/2006**	**06/15/2006**	**06/15/2006**	**06/14/2006**
					Composite	**(IJ-18, IJ-19, IJ-20, IJ-21)**	**(IJ-30, IJ-31, IJ-32, IJ-33)**	**(IJ-30, IJ-31, IJ-32, IJ-33)**	**(IJ-22, IJ-23, IJ-24, IJ-25)**	**(IJ-26, IJ-27, IJ-28, IJ-29)**
					Sample Type	**N**	**N**	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**	**DMMP SL**	**DMMP BT**	**DMMP ML**					
Di-n-butyl phthalate	220	1700				0.671 U	0.282 U	0.816 U	0.621 U	0.284 U
Di-n-octyl phthalate	58	4500				0.671 U	0.282 U	0.816 U	**6.522**	**0.569**
Hexachlorobenzene	0.38	2.3				0.671 U[1]	0.282 U	0.816 U[1]	0.621 U[1]	0.284 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2				0.671 U	0.282 U	0.816 U	0.621 U	0.284 U
n-Nitrosodiphenylamine	11	11				0.671 U	0.282 U	1.02 U	0.621 U	0.284 U
Polycyclic Aromatic Hydrocarbons (µg/kg)										
2-Methylnaphthalene			670		1900	**20**	**33**	**67**	**33**	**69**
Acenaphthene			500		2000	**10 J**	**17 J**	**15 J**	**32**	**62**
Acenaphthylene			560		1300	20 U	**16 J**	20 U	20 U	**14 J**
Anthracene			960		13000	**26**	**55**	**32**	**69**	**83**
Benzo(a)anthracene			1300		5100	**65**	**160**	**56**	**160**	**170**
Benzo(a)pyrene			1600		3600	**49**	**150**	**44**	**110**	**110**
Benzo(b)fluoranthene						**81**	**190**	**44**	**120**	**150**
Benzo(g,h,i)perylene			670		3200	**33**	**97**	**30**	**60**	**48**
Benzo(k)fluoranthene						**44**	**160**	**51**	**100**	**99**
Chrysene			1400		21000	**110**	**270**	**79**	**200**	**250**
Dibenzo(a,h)anthracene			230		1900	20 U	**21**	20 U	**15 J**	**13 J**
Fluoranthene			1700	4600	30000	**120**	**310**	**150**	**320**	**500**
Fluorene			540		3600	**19 J**	**27**	**26**	**48**	**67**
Indeno(1,2,3-c,d)pyrene			600		4400	**30**	**95**	**26**	**59**	**48**
Naphthalene			2100		2400	**19 J**	**33**	**66**	**31**	**110**
Phenanthrene			1500		21000	**59**	**160**	**100**	**280**	**180**
Pyrene			2600	11980	16000	**180**	**420**	**150**	**400**	**560**
Total Benzofluoranthenes (b,j,k) (U = 0)			3200		9900	**125**	**350**	**95**	**220**	**249**
Total HPAH (DMMP) (U = 0)			12000		69000	**712**	**1873**	**630**	**1544 J**	**1948 J**
Total LPAH (DMMP) (U = 0)			5200		29000	**133 J**	**308 J**	**239 J**	**460**	**516 J**
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)										
2-Methylnaphthalene	38	64				**0.671**	**0.466**	**2.735**	**1.025**	**0.982**
Acenaphthene	16	57				**0.336 J**	**0.24 J**	**0.612 J**	**0.994**	**0.882**
Acenaphthylene	66	66				0.671 U	**0.226 J**	0.816 U	0.621 U	**0.199 J**
Anthracene	220	1200				**0.872**	**0.777**	**1.306**	**2.143**	**1.181**
Benzo(a)anthracene	110	270				**2.181**	**2.26**	**2.286**	**4.969**	**2.418**
Benzo(a)pyrene	99	210				**1.644**	**2.119**	**1.796**	**3.416**	**1.565**
Benzo(g,h,i)perylene	31	78				**1.107**	**1.37**	**1.224**	**1.863**	**0.683**
Chrysene	110	460				**3.691**	**3.814**	**3.224**	**6.211**	**3.556**
Dibenzo(a,h)anthracene	12	33				0.671 U	**0.297**	0.816 U	**0.466 J**	**0.185 J**
Fluoranthene	160	1200				**4.027**	**4.379**	**6.122**	**9.938**	**7.112**

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

					DMMU	DMMU3	DMMU4A	DMMU4B	DMMU5	DMMU6
					Location ID	IJ-C3-S1-COMP	IJ-C4-S1-COMP	IJ-C4-S2-COMP	IJ-C5-S1-COMP	IJ-C6-S1-COMP
					Sample ID	IJ-C3-S1	IJ-C4-S1	IJ-C4-S2	IJ-C5-S1	IJ-C6-S1
					Sample Date	06/13/2006	06/15/2006	06/15/2006	06/15/2006	06/14/2006
					Composite	(IJ-18, IJ-19, IJ-20, IJ-21)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-22, IJ-23, IJ-24, IJ-25)	(IJ-26, IJ-27, IJ-28, IJ-29)
					Sample Type	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**DMMP SL**	**DMMP BT**	**DMMP ML**					
Fluorene	23	79				**0.638 J**	**0.381**	**1.061**	**1.491**	**0.953**
Indeno(1,2,3-c,d)pyrene	34	88				**1.007**	**1.342**	**1.061**	**1.832**	**0.683**
Naphthalene	99	170				**0.638 J**	**0.466**	**2.694**	**0.963**	**1.565**
Phenanthrene	100	480				**1.98**	**2.26**	**4.082**	**8.696**	**2.56**
Pyrene	1000	1400				**6.04**	**5.932**	**6.122**	**12.422**	**7.966**
Total Benzofluoranthenes (b,j,k) (U = 0)	230	450				**4.195**	**4.944**	**3.878**	**6.832**	**3.542**
Total HPAH (SMS) (U = 0)	960	5300				**23.893**	**26.455**	**25.714**	**47.95 J**	**27.71 J**
Total LPAH (SMS) (U = 0)	370	780				**4.463 J**	**4.35 J**	**9.755 J**	**14.286**	**7.34 J**
Pesticides (µg/kg)										
4,4'-DDD (p,p'-DDD)			16			2 U	2 U	3 U	2.8 U	3.9 U
4,4'-DDE (p,p'-DDE)			9			2 U	2 U	2 U	4 U	3.9 U
4,4'-DDT (p,p'-DDT)			12			2 U	2 U	2 U	10 U	12 U
Aldrin			9.5			0.98 U	0.99 U	0.99 U	0.99 U	1.9 U
Chlordane, alpha- (cis-Chlordane)						0.98 U	0.99 U	0.99 U	0.99 U	1.9 U
Chlordane, gamma-						0.98 U	0.99 U	2.4 U	3.2 U	5 U
Dieldrin			1.9		1700	2 U[1]	2 U[1]	2 U[1]	2 U[1]	3.9 U[1]
Heptachlor			1.5		270	0.98 U	0.99 U	0.99 U	0.99 U	1.9 U[1]
Hexachlorocyclohexane, alpha (BHC)						0.98 U	0.99 U	0.99 U	0.99 U	1.9 U
Hexachlorocyclohexane, gamma- (BHC) (Lindane)						0.98 U	0.99 U	0.99 U	0.99 U	1.9 U
Sum 4,4 DDT, DDE, DDD (U = 0)				50	69	2 U	2 U	3 U	10 U	12 U
Total DMMP Chlordane (U = 0)			2.8	37		0.98 U	0.99 U	0.99 U	0.99 U	1.9 U
Dioxin Furans (ng/kg)										
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)						**1 J**	**1.1 J**	**1.4 J**	**1.4 J**	**1.4 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)						4.9 U	**5.7 J**	3.6 U	**5.8 J**	**5.4 J**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)						**9.6 J**	**10 J**	**5.9 J**	**10 J**	**7.1 J**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)						**32**	**35**	**27**	**41**	**39**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)						**17**	**18**	**13**	**20**	**15**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)						**830**	**820**	**880**	**950**	**1000**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)						**6000**	**6300**	**6200**	**6700**	**8900**
Total Tetrachlorodibenzo-p-dioxin (TCDD)						**150**	**160**	**46**	**160**	**76**
Total Pentachlorodibenzo-p-dioxin (PeCDD)						**210**	**250**	**83**	**280**	**120**
Total Hexachlorodibenzo-p-dioxin (HxCDD)						**600**	**620**	**530**	**870**	**610**
Total Heptachlorodibenzo-p-dioxin (HpCDD)						**3300**	**2900**	**4100**	**4400**	**4800**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)						**12 N**	**15 N**	**9.3 N**	**13 N**	**8.2 N**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)						3.1 U	3.7 U	2.8 U	4.3 U	**4.8 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)						3.5 U	3.9 U	3.2 U	4.5 U	**6.2 J**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)						**6 J**	**9.4 J**	**7.6 J**	**11**	**14**

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

					DMMU	DMMU3	DMMU4A	DMMU4B	DMMU5	DMMU6
					Location ID	IJ-C3-S1-COMP	IJ-C4-S1-COMP	IJ-C4-S2-COMP	IJ-C5-S1-COMP	IJ-C6-S1-COMP
					Sample ID	IJ-C3-S1	IJ-C4-S1	IJ-C4-S2	IJ-C5-S1	IJ-C6-S1
					Sample Date	06/13/2006	06/15/2006	06/15/2006	06/15/2006	06/14/2006
					Composite	(IJ-18, IJ-19, IJ-20, IJ-21)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-30, IJ-31, IJ-32, IJ-33)	(IJ-22, IJ-23, IJ-24, IJ-25)	(IJ-26, IJ-27, IJ-28, IJ-29)
					Sample Type	N	N	N	N	N
Analytes	SMS SCO	SMS CSL	DMMP SL	DMMP BT	DMMP ML					
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)						4.2 U	4.6 U	3.8 U	5.1 U	**6.8 J**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)						0.49 U	0.75 U	0.53 U	0.66 U	0.64 U
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)						3.7 U	3.6 U	3 U	4 U	**5.6 J**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)						**83**	**100**	**89**	**110**	**170**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)						**5.9 J**	**6.5 J**	**5.5 J**	**7.6 J**	**8.9 J**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)						**230**	**270**	**240**	**310**	**390**
Total Tetrachlorodibenzofuran (TCDF)						**50**	**55**	**44**	**56**	**61**
Total Pentachlorodibenzofuran (PeCDF)						**32**	**33**	**35**	**40**	**74**
Total Hexachlorodibenzofuran (HxCDF)						**120**	**150**	**130**	**170**	**260**
Total Heptachlorodibenzofuran (HpCDF)						**310**	**350**	**370**	**450**	**630**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)						**19.72 JN**	**26.78 JN**	**19.36 JN**	**29.48 JN**	**32.95 JN**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)						**23.16 JN**	**27.86 JN**	**22.05 JN**	**30.71 JN**	**32.98 JN**
PCB Aroclors (µg/kg)										
Aroclor 1016						20 U	20 U	20 U	20 U	39 U
Aroclor 1221						20 U	20 U	20 U	20 U	39 U
Aroclor 1232						20 U	20 U	20 U	20 U	39 U
Aroclor 1242						20 U	20 U	20 U	20 U	39 U
Aroclor 1248						20 U	20 U	20 U	47 U	39 U
Aroclor 1254						20 U	20 U	20 U	**64**	**89**
Aroclor 1260						20 U	20 U	20 U	20 U	39 U
Total DMMP PCB Aroclors (U = 0)			130		3100	20 U	20 U	20 U	**64**	**89**
PCB Aroclors (mg/kg-OC)										
Aroclor 1016						0.671 U	0.282 U	0.816 U	0.621 U	0.555 U
Aroclor 1221						0.671 U	0.282 U	0.816 U	0.621 U	0.555 U
Aroclor 1232						0.671 U	0.282 U	0.816 U	0.621 U	0.555 U
Aroclor 1242						0.671 U	0.282 U	0.816 U	0.621 U	0.555 U
Aroclor 1248						0.671 U	0.282 U	0.816 U	1.46 U	0.555 U
Aroclor 1254						0.671 U	0.282 U	0.816 U	**1.988**	**1.266**
Aroclor 1260						0.671 U	0.282 U	0.816 U	0.621 U	0.555 U
Total DMMP PCB Aroclors (U = 0)				38		0.671 U	0.282 U	0.816 U	**1.988**	**1.266**
Total PCB Aroclors (SMS Marine 2013) (U = 0)	12	65				0.671 U	0.282 U	0.816 U	**1.988**	**1.266**

Table 5-7
2005 DMMU Composite Samples Subsurface Sediment Chemical Testing Results

Notes:

🟨 Detected concentration is greater than SMS SCO.
🟩 Detected concentration is greater than SMS CSL.
🟪 Detected concentration is greater than the former DMMP SL.
🟦 Detected concentration is greater than DMMP BT.
🟧 Detected concentration is greater than DMMP ML.
Bold = Detected result

1. Non-detected concentration is above one or more identified screening levels.

J = Estimated value
N = Presumptive Evidence
R = Rejected
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
DMMU = Dredged Material Management Unit
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized
ML = maximum level
ng/kg = nanogram per kilogram
PCB = polychlorinated biphenyls
pct = percent
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEQ = toxic equivalents quotient

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.
Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.
Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
Data have been validated according to QA-2 protocols.
N = normal field sample

Table 5-8
USACE Samples for I&J Waterway Subsurface Sediment Chemical Testing Results

			Location ID	I-1	I-1	I-2	I-3	I-3	I-5	I-5	I-7
			Sample ID	I-1-DM	I-1-Z	I-2-A-Z	I-3-DM	I-3-Z	I-5-DM	I-5-Z	I-7-DM
			Sample Date	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/7/2011
			Sample Depth	0 - 4.6 feet	4.6 - 6.4 feet	3.3 - 5.1 feet	0 - 2.2 feet	2.2 - 3.8 feet	0 - 3.3 feet	3.3 - 5.3 feet	0 - 3.1 feet
			Sample Type	N	N	N	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**								
Conventional Parameters (mg/kg)											
Ammonia	--	--	--	**113**	**91.7 J**	**72.3 J**	**10.6**	--	**87.9**	--	**28.6**
Sulfide	--	--	--	**2650**	--	--	**1830**	--	**2320**	--	**1970**
Conventional Parameters (pct)											
Total organic carbon	--	--	--	**4.14**	**10.5 J**	**4.15 J**	**3.34**	--	**4.23**	--	**2.07**
Total solids	--	--	--	**48.3**	**59.6 J**	**51.3 J**	**57.6**	--	**46.7**	--	**49.7**
Total solids (preserved)	--	--	--	**45.4**	--	--	**53.9**	--	**46.3**	--	**48.5**
Total volatile solids	--	--	--	**9.06**	--	--	**6.52**	--	**11.15**	--	**6.84**
Grain Size (pct)											
Total Gravel	--	--	--	**0.2**	**0.7**	**0.4**	**2.9**	--	0.1 U	--	0.1 U
Total Sand	--	--	--	**13.3**	**38.5**	**18.9**	**34.4**	--	**17.1**	--	**4.8**
Total Silt	--	--	--	**46.6**	**38**	**44.6**	**34.4**	--	**48.1**	--	**56.6**
Total Fines (silt + clay)	--	--	--	**86.6**	**60.8**	**80.9**	**62.6**	--	**82.8**	--	**95.2**
Total Clay	--	--	--	**40**	**22.8**	**36.3**	**28.2**	--	**34.7**	--	**38.6**
Metals (mg/kg)											
Arsenic	57	93	--	--	8 U	9 U	--	--	--	--	--
Cadmium	5.1	6.7	--	--	**0.9**	**1.6**	--	--	--	--	--
Chromium	260	270	--	--	**48.1**	**88.1**	--	--	--	--	--
Copper	390	390	--	--	**54**	**64.3**	--	--	--	--	--
Lead	450	530	--	--	**30**	**40**	--	--	--	--	--
Mercury	0.41	0.59	--	--	**0.4 J**	**4.39 J**	--	--	--	--	--
Nickel[b]	--	--	--	--	**71**	**95**	--	--	--	--	--
Silver	6.1	6.1	--	--	0.5 U	0.6 U	--	--	--	--	--
Zinc	410	960	--	--	**96**	**125**	--	--	--	--	--
Semivolatile Organics (µg/kg)											
1,2,4-Trichlorobenzene	--	--	31	--	4.9 U	**3.1 J**	--	--	--	--	--
1,2-Dichlorobenzene	--	--	35	--	4.9 U	**3.1 J**	--	--	--	--	--
1,4-Dichlorobenzene	--	--	110	--	**2.7 J**	**5.2**	--	--	--	--	--
2,4-Dimethylphenol	29	29	--	--	**250 J**	**110 J**	--	--	--	--	--
2-Methylphenol (o-Cresol)	63	63	--	--	**120 J**	**42 J**	--	--	--	--	--
4-Methylphenol (p-Cresol)	670	670	--	--	**420**	**230**	--	--	--	--	--
Benzoic acid	650	650	--	--	390 U	380 U	--	--	--	--	--
Benzyl alcohol	57	73	--	--	20 U	19 U	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	1300	--	74 U	79 U	--	--	--	--	--
Butylbenzyl phthalate	--	--	63	--	**48**	**13**	--	--	--	--	--
Dibenzofuran	--	--	540	--	**190**	**84**	--	--	--	--	--
Diethyl phthalate	--	--	200	--	12 U	4.8 U	--	--	--	--	--

Table 5-8
USACE Samples for I&J Waterway Subsurface Sediment Chemical Testing Results

			Location ID	I-1	I-1	I-2	I-3	I-3	I-5	I-5	I-7
			Sample ID	I-1-DM	I-1-Z	I-2-A-Z	I-3-DM	I-3-Z	I-5-DM	I-5-Z	I-7-DM
			Sample Date	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/7/2011
			Sample Depth	0 - 4.6 feet	4.6 - 6.4 feet	3.3 - 5.1 feet	0 - 2.2 feet	2.2 - 3.8 feet	0 - 3.3 feet	3.3 - 5.3 feet	0 - 3.1 feet
			Sample Type	N	N	N	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**								
Dimethyl phthalate	--	--	71	--	**160**	**10**	--	--	--	--	--
Di-n-butyl phthalate	--	--	1400	--	20 U	19 U	--	--	--	--	--
Di-n-octyl phthalate	--	--	6200	--	20 U	19 U	--	--	--	--	--
Hexachlorobenzene	--	--	22	--	4.9 U	**6.3**	--	--	--	--	--
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	--	--	11	--	4.9 U	4.8 U	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	28	--	**36**	**12 J**	--	--	--	--	--
Pentachlorophenol	360	690	--	--	49 U	48 U	--	--	--	--	--
Phenol	420	1200	--	--	**120**	**59**	--	--	--	--	--
Polycyclic Aromatic Hydrocarbons (µg/kg)											
2-Methylnaphthalene	--	--	670	--	**300**	**130**	--	--	--	--	--
Acenaphthene	--	--	500	--	**64**	**27**	--	--	--	--	--
Acenaphthylene	--	--	1300	--	**33**	**12 J**	--	--	--	--	--
Anthracene	--	--	960	--	**100**	**55**	--	--	--	--	--
Benzo(a)anthracene	--	--	1300	--	**130**	**63**	--	--	--	--	--
Benzo(a)pyrene	--	--	1600	--	**78**	**41**	--	--	--	--	--
Benzo(b,j,k)fluoranthenes	--	--	--	--	**170**	**86**	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	670	--	**30**	**19**	--	--	--	--	--
Chrysene	--	--	1400	--	**180**	**69**	--	--	--	--	--
Dibenzo(a,h)anthracene	--	--	230	--	**9.8 J**	**6**	--	--	--	--	--
Fluoranthene	--	--	1700	--	**430**	**230**	--	--	--	--	--
Fluorene	--	--	540	--	**140 J**	**59 J**	--	--	--	--	--
Indeno(1,2,3-c,d)pyrene	--	--	600	--	**27**	**15 J**	--	--	--	--	--
Naphthalene	--	--	2100	--	**300**	**160**	--	--	--	--	--
Phenanthrene	--	--	1500	--	**340**	**120**	--	--	--	--	--
Pyrene	--	--	2600	--	**390**	**180**	--	--	--	--	--
Total HPAH (SMS) (U = 0)	--	--	12000	--	**1444.8 J**	**709 J**	--	--	--	--	--
Total LPAH (SMS) (U = 0)	--	--	5200	--	**977 J**	**433 J**	--	--	--	--	--
Total PAH (SMS) (U = 0)	--	--	--	--	**2421.8 J**	**1142 J**	--	--	--	--	--

Table 5-8
USACE Samples for I&J Waterway Subsurface Sediment Chemical Testing Results

			Location ID	I-1	I-1	I-2	I-3	I-3	I-5	I-5	I-7
			Sample ID	I-1-DM	I-1-Z	I-2-A-Z	I-3-DM	I-3-Z	I-5-DM	I-5-Z	I-7-DM
			Sample Date	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/7/2011
			Sample Depth	0 - 4.6 feet	4.6 - 6.4 feet	3.3 - 5.1 feet	0 - 2.2 feet	2.2 - 3.8 feet	0 - 3.3 feet	3.3 - 5.3 feet	0 - 3.1 feet
			Sample Type	N	N	N	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**								
Dioxin Furans (ng/kg)											
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**1.73**	**1.6**	**0.928 J**	**1.07**	**0.199 J**	**2.71**	**0.664 J**	**1.15**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**7.22 J**	**6.49 J**	**4.43**	**4.09 J**	**0.904 J**	**5.82 J**	**3.42 J**	**4.67 J**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**14.5**	**7.68**	**5.48**	**7.68**	**1.09 J**	**9.95**	**3.73**	**11.5**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**49 J**	**34.2 J**	**50.6**	**37.9 J**	**7.29 J**	**51.9 J**	**32.3 J**	**30.4 J**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**24.4 J**	**15.7 J**	**13.8**	**13.9 J**	**2.24 J**	**19.6 J**	**9.31 J**	**15.5 J**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**971 J**	**677**	**1410**	**815 J**	**153**	**1200 J**	**767**	**493 J**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	--	--	--	**7750 J**	**5790**	**15600**	**7250 J**	**1370**	**11100 J**	**7070**	**3830 J**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**339**	**157**	**41.4 J**	**180**	**12.4 J**	**227 J**	**40.2 J**	**457**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**394 J**	**172**	**65.1 J**	**211 J**	**15.1 J**	**260 J**	**53.5**	**485 J**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**705**	**378**	**340**	**415**	**53.6**	**548 J**	**236**	**692**
Total Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**2300 J**	**1550**	**2920**	**1620 J**	**325**	**2360 J**	**1490**	**983 J**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	--	--	--	**16.8**	**9.02**	**7.74**	**10.6**	**0.918 J**	**21.7 J**	**5.42**	**13.8**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**4.45 J**	**3.11**	**6.17**	**4.29 J**	**0.637 J**	**7.12**	**4.51**	**2.8 J**
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**4.73**	**4**	**5.98**	**4.01**	**0.828 J**	**5.88**	**3.92**	**2.73**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**13.9 J**	**11.1**	**24.9**	**14.8 J**	**3.06**	**23.3**	**15.4**	**7.27 J**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**6.58**	**5.99**	**7.53**	**5.23**	**1.28 J**	**7.54**	**5.45**	**3.08**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	--	--	--	**4.57 J**	**3.62**	**6.81**	**4.22 J**	**0.926 J**	**7.36**	**5.02**	**2.26 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**9.76 J**	**10 J**	**10.9**	**7.24 J**	**2.15 J**	**10.5 J**	**7.71 J**	**4.64 J**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	--	--	--	**145**	**153**	**248**	**137**	**46.7**	**213**	**160**	**77.9**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	--	--	--	**9.94**	**10.4 J**	**14.5**	**9.78**	**2.92 J**	**14.7**	**11.2 J**	**5.33**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	--	--	--	**381**	**445 J**	**873**	**395**	**140 J**	**615**	**486 J**	**251**
Total Tetrachlorodibenzofuran (TCDF)	--	--	--	**91.9 J**	**111 J**	**62 J**	**55 J**	**14.2 J**	**97 J**	**53.7 J**	**64.4 J**
Total Pentachlorodibenzofuran (PeCDF)	--	--	--	**113 J**	**170 J**	**133 J**	**83.2 J**	**28 J**	**125 J**	**101 J**	**54.5 J**
Total Hexachlorodibenzofuran (HxCDF)	--	--	--	**266**	**263 J**	**402**	**228 J**	**65.7 J**	**335**	**242 J**	**132**
Total Heptachlorodibenzofuran (HpCDF)	--	--	--	**505 J**	**575**	**985 J**	**510 J**	**160**	**825 J**	**611 J**	**307 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	--	--	--	**38.15 J**	**29.39 J**	**41.78 J**	**28.56 J**	**5.745 J**	**43.48 J**	**25.478 J**	**22.55 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	--	--	--	**38.15 J**	**29.39 J**	**41.78 J**	**28.56 J**	**5.745 J**	**43.48 J**	**25.478 J**	**22.55 J**

Table 5-8
USACE Samples for I&J Waterway Subsurface Sediment Chemical Testing Results

			Location ID	I-1	I-1	I-2	I-3	I-3	I-5	I-5	I-7
			Sample ID	I-1-DM	I-1-Z	I-2-A-Z	I-3-DM	I-3-Z	I-5-DM	I-5-Z	I-7-DM
			Sample Date	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/8/2011	9/7/2011
			Sample Depth	0 - 4.6 feet	4.6 - 6.4 feet	3.3 - 5.1 feet	0 - 2.2 feet	2.2 - 3.8 feet	0 - 3.3 feet	3.3 - 5.3 feet	0 - 3.1 feet
			Sample Type	N	N	N	N	N	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**								
PCB Aroclors (µg/kg)											
Aroclor 1016	--	--	--	--	19 U	20 U	--	--	--	--	--
Aroclor 1221	--	--	--	--	19 U	20 U	--	--	--	--	--
Aroclor 1232	--	--	--	--	19 U	20 U	--	--	--	--	--
Aroclor 1242	--	--	--	--	19 U	20 U	--	--	--	--	--
Aroclor 1248	--	--	--	--	**60**	**61**	--	--	--	--	--
Aroclor 1254	--	--	--	--	**48**	**65**	--	--	--	--	--
Aroclor 1260	--	--	--	--	**22**	**36**	--	--	--	--	--
Total PCB Aroclors (U = 0)	--	--	130	--	**130**	**162**	--	--	--	--	--

Notes:

🟨 Detected concentration is greater than SMS SCO.

🟩 Detected concentration is greater than SMS CSL.

🟦 Detected concentration is greater than PS LAET SL.

🟪 Detected concentration is greater than the former DMMP SL.[b]

Bold = Detected result

a. Only samples with TOC > 3.5% were screened against the PS LAET SL.
b. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.

J = Estimated value
N = normal field sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
-- Results or values not reported or not applicable

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
dw = dry weight
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
ML = maximum level
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
pct = percent
PS = Puget Sound Estuary Program
SCO = Sediment Cleanup Objective
SMS = Sediment Management Standards
SL = screening level
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient
USACE = U.S. Army Corps of Engineers

Results are reported in dry weight basis and as OC-normalized basis.
Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.
Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.
Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
Total PAH are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. 2-methylnapthalene is not included.
Benzo(j)fluoranthene is included in the total of benzo(b&k)fluoranthenes.
Dioxin TEQ values were calculated with 2005 World Health Organization (WHO) TEF values for mammals.
U.S. Environmental Protection Agency (USEPA) Stage 2B data validation was completed by Laboratory Data Consultants (LDC).

Table 5-9
2013 Subsurface Sediment Chemical and Physical Testing Results

			Location ID	**IJ13-VC-101**	**IJ13-VC-102**	**IJ13-VC-102**
			Sample ID	**IJ13-VC-101-2-3.9**	**IJ13-VC-102-2-4**	**IJ13-VC-102-4-5.4**
			Sample Date	**08/20/2013**	**08/20/2013**	**08/20/2013**
			Sample Depth	**2 - 3.9 ft**	**2 - 4 ft**	**4 - 5.4 ft**
			Sample Type	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET**[a]			
Conventional Parameters (pct)						
Plastic limit	--	--	--	**30.6**	**39.7**	**26.7**
Plasticity index	--	--	--	**15.4**	**22.9**	**13.8**
Liquid limit	--	--	--	**46**	**62.6**	**40.5**
Moisture (water) content	--	--	--	**58.38**	**75.01**	**46.94**
Total organic carbon	--	--	--	**7.58**	**20.1**	**5.6**
Total solids	--	--	--	**64.29**	**58.23**	**64.57**
Conventional Parameters (unitless)						
Atterberg classification	--	--	--	**-- ML**	**-- MH**	**-- ML**
Grain Size (pct)						
Total Gravel	--	--	--	**10.4**	**0.1**	**15.1**
Total Sand	--	--	--	**47**	**16.7**	**35.3**
Total Silt	--	--	--	**27**	**51.9**	**29.2**
Total Fines (silt + clay)	--	--	--	**42.6**	**83.2**	**49.5**
Total Clay	--	--	--	**15.6**	**31.3**	**20.3**
Metals (mg/kg)						
Arsenic	57	93	--	8 U	20 U	**9**
Cadmium	5.1	6.7	--	**0.7**	0.8 U	**0.4**
Chromium	260	270	--	**43.4 J**	**41 J**	**31.8 J**
Copper	390	390	--	**37.6**	**64.3**	**38**
Lead	450	530	--	**26**	**34**	**37**
Mercury	0.41	0.59	--	**0.09**	**0.29**	**0.15**
Nickel[b]	--	--	--	**41**	**53**	**37**
Silver	6.1	6.1	--	0.5 U	1 U	0.4 U
Zinc	410	960	--	**75**	**113**	**62**
Semivolatile Organics (μg/kg)						
1,2,4-Trichlorobenzene	--	--	31	4.9 U	14 U	4.8 U

Table 5-9
2013 Subsurface Sediment Chemical and Physical Testing Results

			Location ID	**IJ13-VC-101**	**IJ13-VC-102**	**IJ13-VC-102**
			Sample ID	**IJ13-VC-101-2-3.9**	**IJ13-VC-102-2-4**	**IJ13-VC-102-4-5.4**
			Sample Date	**08/20/2013**	**08/20/2013**	**08/20/2013**
			Sample Depth	**2 - 3.9 ft**	**2 - 4 ft**	**4 - 5.4 ft**
			Sample Type	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET[a]**			
1,2-Dichlorobenzene	--	--	35	4.9 U	**9.8 J**	4.8 U
1,4-Dichlorobenzene	--	--	110	**3.8 J**	**18**	**5.3**
2,4-Dimethylphenol	29	29	--	**210**	**1300**	**420**
2-Methylphenol (o-Cresol)	63	63	--	**140**	**620**	**160**
4-Methylphenol (p-Cresol)	670	670	--	**570**	**1900**	**510**
Benzoic acid	650	650	--	**140 J**	**740 J**	**190 J**
Benzyl alcohol	57	73	--	20 U	58 U[1]	19 U
bis(2-Ethylhexyl)phthalate	--	--	1300	**43 J**	**120 J**	**44 J**
Butylbenzyl phthalate	--	--	63	4.9 U	**60**	**29**
Dibenzofuran	--	--	540	**180**	**880**	**280**
Diethyl phthalate	--	--	200	26 U	58 U	21 U
Dimethyl phthalate	--	--	71	4.9 U	**510**	**150**
Di-n-butyl phthalate	--	--	1400	20 U	58 U	19 U
Di-n-octyl phthalate	--	--	6200	20 U	58 U	19 U
Hexachlorobenzene	--	--	22	4.9 U	14 U	4.8 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	--	--	11	4.9 U	14 U[1]	4.8 U
n-Nitrosodiphenylamine	--	--	28	4.9 U	14 U	4.8 U
Pentachlorophenol	360	690	--	20 UJ	**41 J**	19 UJ
Phenol	420	1200	--	**230**	**680**	**200**
Polycyclic Aromatic Hydrocarbons (µg/kg)						
2-Methylnaphthalene	--	--	670	**290**	**1600**	**430**
Acenaphthene	--	--	500	**99**	**200**	**74**
Acenaphthylene	--	--	1300	**110**	**230**	**140**
Anthracene	--	--	960	**96**	**370**	**140**
Benzo(a)anthracene	--	--	1300	**84**	**250**	**94**
Benzo(a)pyrene	--	--	1600	**85 J**	**240**	**93**
Benzo(b,j,k)fluoranthenes	--	--	--	**130 J**	**400**	**160**

Table 5-9
2013 Subsurface Sediment Chemical and Physical Testing Results

			Location ID	**IJ13-VC-101**	**IJ13-VC-102**	**IJ13-VC-102**
			Sample ID	**IJ13-VC-101-2-3.9**	**IJ13-VC-102-2-4**	**IJ13-VC-102-4-5.4**
			Sample Date	**08/20/2013**	**08/20/2013**	**08/20/2013**
			Sample Depth	**2 - 3.9 ft**	**2 - 4 ft**	**4 - 5.4 ft**
			Sample Type	**N**	**N**	**N**
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET**[a]			
Benzo(g,h,i)perylene	--	--	670	**81 J**	**120**	**59**
Chrysene	--	--	1400	**110 J**	**330**	**130**
Dibenzo(a,h)anthracene	--	--	230	**9.7 J**	**36**	4.8 U
Fluoranthene	--	--	1700	**280 J**	**930**	**390**
Fluorene	--	--	540	**120**	**390**	**140**
Indeno(1,2,3-c,d)pyrene	--	--	600	**52 J**	**87**	**38**
Naphthalene	--	--	2100	**790 J**	**2400**	**1000**
Phenanthrene	--	--	1500	**470 J**	**1400**	**630**
Pyrene	--	--	2600	**330 J**	**900**	**440**
Total Benzofluoranthenes (b,j,k) (U = 0)	--	--	3200	**130 J**	**400**	**160**
Total HPAH (SMS) (U = 0)	--	--	12000	**1161.7 J**	**3293**	**1404**
Total LPAH (SMS) (U = 0)	--	--	5200	**1685 J**	**4990**	**2124**
Total PAH (SMS) (U = 0)	--	--	--	**2846.7 J**	**8283**	**3528**
Dioxin Furans (ng/kg)						
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**0.79 J**	**2.08**	**0.96 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**2.99**	**10.9**	**4.07**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**1.99**	**6.61**	**2.43**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**6.53 J**	**30.4 J**	**8.46 J**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**3.57**	**12.3**	**4.44**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**87.6**	**331**	**92**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	--	--	--	**662**	**2230**	**519**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	--	**92.9 J**	**169**	**101 J**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	--	**92.3 J**	**203**	**86.7**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	--	**154 J**	**360 J**	**134 J**
Total Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	--	**238**	**949**	**239**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	--	--	--	**3.02**	**10.4**	**3.01**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**2.15 J**	**4.18 J**	**1.95 J**

Table 5-9
2013 Subsurface Sediment Chemical and Physical Testing Results

			Location ID	IJ13-VC-101	IJ13-VC-102	IJ13-VC-102
			Sample ID	IJ13-VC-101-2-3.9	IJ13-VC-102-2-4	IJ13-VC-102-4-5.4
			Sample Date	08/20/2013	08/20/2013	08/20/2013
			Sample Depth	2 - 3.9 ft	2 - 4 ft	4 - 5.4 ft
			Sample Type	N	N	N
Analytes	**SMS SCO**	**SMS CSL**	**PS LAET**[a]			
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	--	**2.4**	**7.42**	**2.31 J**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**3.67**	**10.3**	**3.26**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**2.58**	**8.96**	**2.97**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	--	--	--	**0.748 J**	**3.63 J**	**0.845 J**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	--	**2.28**	**9.07**	**2.65**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	--	--	--	**40.8**	**287**	**58.6**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	--	--	--	**1.69**	**8.11**	**2.1**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	--	--	--	**67.3**	**407**	**95.6**
Total Tetrachlorodibenzofuran (TCDF)	--	--	--	**59.3 J**	**191 J**	**66.5 J**
Total Pentachlorodibenzofuran (PeCDF)	--	--	--	**71.1 J**	**360 J**	**88 J**
Total Hexachlorodibenzofuran (HxCDF)	--	--	--	**61.1 J**	**346 J**	**76 J**
Total Heptachlorodibenzofuran (HpCDF)	--	--	--	**109**	**747 J**	**152 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	--	--	--	**8.523 J**	**31.55 J**	**10.299 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	--	--	--	**8.523 J**	**31.55 J**	**10.299 J**
PCB Aroclors (µg/kg)						
Aroclor 1016	--	--	--	20 U	19 U	19 U
Aroclor 1221	--	--	--	20 U	19 U	19 U
Aroclor 1232	--	--	--	20 U	19 U	19 U
Aroclor 1242	--	--	--	20 U	19 U	19 U
Aroclor 1248	--	--	--	20 U	19 U	19 U
Aroclor 1254	--	--	--	**44**	19 U	19 U
Aroclor 1260	--	--	--	20 U	24 U	19 U
Total PCB Aroclors (U = 0)	--	--	130	**44**	24 U	19 U

Table 5-9

2013 Subsurface Sediment Chemical and Physical Testing Results

Notes:

🟨 Detected concentration is greater than SMS SCO.
🟩 Detected concentration is greater than SMS CSL.
🟦 Detected concentration is greater than LAET SL when TOC > 3.5%.
🟪 Detected concentration is greater than the former DMMP SL.[b]
Bold = Detected result

1. Non-detected concentration is above one or more identified screening levels.
a. Only samples with TOC > 3.5% were screened against the PS LAET SL.
b. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw.

J = Estimated value
N = normal field sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
-- = Results or values not reported or not applicable

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
dw = dry weight
ft = feet
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LAET = lowest apparent effects threshold
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
ML = maximum level
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
pct = percent
PS = Puget Sound Estuary Program
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient

Results are reported in dry weight basis and as OC-normalized basis.

Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest limit value is reported as the sum.

Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.

Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Total PAH are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. 2-methylnapthalene is not included.

Benzo(j)fluoranthene is included in the total of benzo(b&k)fluoranthenes.

Dioxin TEQ values were calculated with 2005 World Health Organization (WHO) TEF values for mammals.

U.S. Environmental Protection Agency (USEPA) Stage 2B data validation was completed by Laboratory Data Consultants (LDC).

Table 6-1
2012 Storm Drain Solids Chemical and Physical Testing Results

		Location ID	**CB-002**
		Sample ID	**CB-002-06222012**
		Sample Date	**6/22/2012**
		Sample Depth	**0-10 cm**
		Sample Type	**N**
	SMS SCO	**SMS CSL**	
Conventional Parameters (mg/kg)			
Ammonia	--	--	**2.15**
Sulfide	--	--	**1.7**
Conventional Parameters (pct)			
Total organic carbon	--	--	**0.833**
Total solids	--	--	**85.7**
Total solids (preserved)	--	--	**87.5**
Grain Size (pct)			
Total Gravel	--	--	**59.2**
Total Sand	--	--	**32.9**
Total Silt	--	--	**6.5**
Total Fines (silt + clay)	--	--	**7.9**
Total Clay	--	--	**1.4**
Metals (mg/kg)			
Arsenic	57	93	10 U
Cadmium	5.1	6.7	0.6 U
Chromium	260	270	**38 J**
Copper	390	390	**34.4 J**
Lead	450	530	**18**
Mercury	0.41	0.59	**0.04 J**
Nickel[a]	--	--	**826**
Silver	6.1	6.1	0.8 U
Zinc	410	960	**98**
Semivolatile Organics (µg/kg)			
1,2,4-Trichlorobenzene	0.81	1.8	0.552 U
1,2-Dichlorobenzene	2.3	2.3	0.552 U
1,4-Dichlorobenzene	3.1	9	0.552 U
2,4-Dimethylphenol	29	29	18 UJ
2-Methylphenol (o-Cresol)	63	63	4.6 U
4-Methylphenol (p-Cresol)	670	670	37 U
Benzoic acid	650	650	370 U
Benzyl alcohol	57	73	18 U
Hexachlorobutadiene (Hexachloro-1,3-butadiene)	3.9	6.2	0.552 U
Pentachlorophenol	360	690	46 U
Phenol	420	1200	18 U
Semivolatile Organics (mg/kg-OC)			
Bis(2-ethylhexyl)phthalate	47	78	6.122 U
Butylbenzyl phthalate	4.9	64	**18.007**
Dibenzofuran	15	58	2.161 U
Diethyl phthalate	61	110	1.681 U

Table 6-1
2012 Storm Drain Solids Chemical and Physical Testing Results

		Location ID	**CB-002**
		Sample ID	**CB-002-06222012**
		Sample Date	**6/22/2012**
		Sample Depth	**0-10 cm**
		Sample Type	**N**
	SMS SCO	**SMS CSL**	
Dimethyl phthalate	53	53	**1.801**
Di-n-butyl phthalate	220	1700	2.161 U
Di-n-octyl phthalate	58	4500	2.161 U
Hexachlorobenzene	0.38	2.3	0.144 U[b]
N-Nitrosodiphenylamine	11	11	**0.432 J**
Polycyclic Aromatic Hydrocarbons (mg/kg-OC)			
2-Methylnaphthalene	38	64	**3.481**
Acenaphthene	16	57	2.161 U
Acenaphthylene	66	66	2.161 U
Anthracene	220	1200	2.161 U
Benzo(a)anthracene	110	270	**1.116 J**
Benzo(a)pyrene	99	210	**1.321 J**
Benzo(b,j,k)fluoranthenes	230	450	**3.001**
Benzo(g,h,i)perylene	31	78	**2.521**
Chrysene	110	460	**2.641**
Dibenzo(a,h)anthracene	12	33	**0.612**
Fluoranthene	160	1200	**3.481**
Fluorene	23	79	2.161 U
Indeno(1,2,3-c,d)pyrene	34	88	2.161 U
Naphthalene	99	170	**3.361**
Phenanthrene	100	480	**3.962**
Pyrene	1000	1400	**3.721**
Total Benzofluoranthenes (b,j,k) (U = 0)	230	450	**3.001**
Total HPAH (SMS) (U = 0)	960	5300	**18.415 J**
Total LPAH (SMS) (U = 0)	370	780	**7.323**
Total PAH (SMS) (U = 0)	--	--	**25.738 J**
Dioxin Furans (ng/kg)			
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	**0.744 J**
1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	**4.36**
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	**3.29**
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	**8.57**
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	**5.92**
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	**95.9**
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin (OCDD)	--	--	**611**
Total Tetrachlorodibenzo-p-dioxin (TCDD)	--	--	**42.2 J**
Total Pentachlorodibenzo-p-dioxin (PeCDD)	--	--	**55.7**
Total Hexachlorodibenzo-p-dioxin (HxCDD)	--	--	**85 J**
Total Heptachlorodibenzo-p-dioxin (HpCDD)	--	--	**174**
2,3,7,8-Tetrachlorodibenzofuran (TCDF)	--	--	**3.75**
1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	**4.78**

Table 6-1
2012 Storm Drain Solids Chemical and Physical Testing Results

		Location ID	**CB-002**
		Sample ID	**CB-002-06222012**
		Sample Date	**6/22/2012**
		Sample Depth	**0-10 cm**
		Sample Type	**N**
	SMS SCO	**SMS CSL**	
2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	--	--	**5.82**
1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	**9.55**
1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	**6.71**
1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	--	--	**2.05**
2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	--	--	**6.61**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	--	--	**35.5**
1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	--	--	**4.15**
1,2,3,4,6,7,8,9-Octachlorodibenzofuran (OCDF)	--	--	**50.8**
Total Tetrachlorodibenzofuran (TCDF)	--	--	**67.7 J**
Total Pentachlorodibenzofuran (PeCDF)	--	--	**85.1 J**
Total Hexachlorodibenzofuran (HxCDF)	--	--	**80.7 J**
Total Heptachlorodibenzofuran (HpCDF)	--	--	**77.5**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 0)	--	--	**13.2 J**
Total Dioxin/Furan TEQ 2005 (Mammal) (U = 1/2)	--	--	**13.2 J**
PCB Aroclors (mg/kg-OC)			
Aroclor 1016	--	--	2.281 U
Aroclor 1221	--	--	2.281 U
Aroclor 1232	--	--	2.281 U
Aroclor 1242	--	--	2.281 U
Aroclor 1248	--	--	2.281 U
Aroclor 1254	--	--	2.281 U
Aroclor 1260	--	--	2.281 U
Total PCB Aroclors (U = 0)	12	65	2.281 U

Table 6-1
2012 Storm Drain Solids Chemical and Physical Testing Results

Notes:

🟨 Detected concentration is greater than SMS SCO.
🟩 Detected concentration is greater than SMS CSL.
🟪 Detected concentration is greater than the former DMMP SL.[a]
Bold = Detected result

a. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.
b. Hexachlorobenzene was reported to the MDL.

J = Estimated value
N = normal field sample
U = Compound analyzed, but not detected above detection limit
UJ = Compound analyzed, but not detected above estimated detection limit
-- Results or values not reported or not applicable

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
cm = centimeter
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
dw = dry weight
HPAH = high-molecular-weight polycyclic aromatic hydrocarbon
LPAH = low-molecular-weight polycyclic aromatic hydrocarbon
MDL = method detection limit
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized
ML = maximum level
ng/kg = nanogram per kilogram
PAH = polycyclic aromatic hydrocarbons
PCB = polychlorinated biphenyls
pct = percent
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEF = toxic equivalency factor
TEQ = toxic equivalents quotient

USEPA Stage 2B data validation was completed by Laboratory Data Consultants (LDC).
Results are reported in dry weight basis and as OC-normalized basis.
Totals are calculated as the sum of all detected results (U=0). If all results are not detected, the highest method detection limit value is reported as the sum.
Total LPAH (Low PAH) are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene. 2-methylnapthalene is not included in the sum of LPAHs.
Total HPAH (High PAH) are the total of fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.
Total PAH are the total of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene. 2-methylnapthalene is not included.
Benzo(j)fluoranthene is included in the total of benzo(b&k)fluoranthenes.
Dioxin TEQ values were calculated with 2005 World Health Organization (WHO) TEF values for mammals.

Table 6-2
Select COCs at Co-located I&J Surface Sediment Chemical Concentrations

Co-located Sample Groups		Total Organic Carbon	Nickel (mg/kg)	Bis(2-ethylhexyl)phthalate		Bis(2-ethylhexyl)phthalate		Phenol (µg/kg)		Total cPAH TEQ	
Sample ID	Sample Collection Year[1]	(pct)		(mg/kg-OC)		(µg/kg)				(U = 1/2) (µg/kg)	
HC-SS-45	1996	**3.4**	NA	**13**		**450**		**1500**		**201**	**J**
AN-SS-45	1998	**2.8**	NA	**50**		**1,400**		40	U	**360**	
IJW-SS-03	2005/2006	**2.5**	**117**	**16**		**400**		99	U	**245**	
IJ12-08a	2012	**3.8**	**113**	2.7	U	100	U	**27**		**92**	**J**
IJ12-58a	2012	**4.3**	**120**	3.7	U	160	U	**39**		**178**	
OG-11	2000	**3.0**	**47**	**933**	D	**28,000**	**D**	20	U	**566**	
IJW-SS-06	2005/2006	**2.1**	**57**	**393**		**8,400**		59	U	**2,475**	
HC-SS-47	1996	**4.0**	NA	**700**		**28,000**		**460**		**1,047**	
AN-SS-47	1998	**4.2**	NA	**476**		**19,992**		280	UG	**686**	
IJW-SS-12	2005/2006	**3.9**	**152**	**14**		**540**		58	U	**512**	
IJ12-04	2012	**2.1**	**116**	**15**	**J**	**320**	**J**	**140**		**705**	**J**
IJW-SS-09	2005/2006	**2.0**	**192**	**7.5**		**150**		59	U	**149**	
IJ12-02	2012	**2.5**	**148**	4.1	U	100	U	**18**	**J**	**89**	
IJW-SS-07	2005/2006	**2.5**	**174**	**10**		**250**		59	U	**143**	
IJ12-03	2012	**2.9**	**140**	3.4	U	100	U	**34**		**113**	
OG-09	2000	**2.9**	NA	**110**	**D**	**3,200**	**D**	**50**	**M**	**233**	
IJW-SS-13	2005/2006	**2.5**	**133**	**12**		**290**		59	U	**62**	
IJ12-05	2012	**3.1**	**137**	**16**		**500**		**17**	**J**	**71**	**J**
IJW-SS-05	2005/2006	**2.2**	**125**	**5.8**		**130**		60	U	**100**	
IJ12-06	2012	**2.6**	**126**	2.8	U	71	U	**22**		**57**	

Notes:

🟨 Detected concentration is greater than SMS SCO.

🟩 Detected concentration is greater than SMS CSL.

🟪 Detected concentration is greater than the former DMMP SL.[a]

D = indicates value reported in diluted sample

J = estimated value

M = indicates estimated value of analyte found and confirmed by analyst but with low spectral match

U = Compound analyzed, but not detected above detection limit

NA = Not analyzed

a. The former DMMP SL and BT/ML for nickel is 140 mg/kg dw and 370 mg/kg dw, respectively.

1. Years indicated correspond to the following investigations:
   1996 = Hart Crowser (1997). Surface sediment sample data included in the Work Plan (RETEC 2005) and Appendix C.
   1998 = Anchor Environmental (1998). Surface sediment sample data included in the Work Plan (RETEC 2005) and Appendix C.
   2000 = ThermoRetec (2000). All surface sediment chemical testing results inlcuded in Appendix C.
   2005/2006 = RETEC (2006). All chemical testing results included in Table 5-1a.
   2012 = Anchor QEA (2013). All chemical testing results included in Table 5-2.

µg/kg = microgram per kilogram
BT = Bioaccumulation Trigger
COC = constituent of concern
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
DMMP = Dredged Material Management Program
dw = dry weight
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized
ML = maximum level
pct = percent
SCO = Sediment Cleanup Objective
SL = screening level
SMS = Sediment Management Standards
TEQ = toxic equivalents quotient

Table 6-3

Summary of Estimated Sedimentation Rates from 2000 Whatcom Waterway RI/FS[1]

Natural Recovery Core Number	Sedimentation Rate in cm/yr				
	Pb-210 Decay	Onset of Cs-137 (1950)	Peak of Cs-137 (1967)	Peak of Mercury (1970)	Average Sedimentation Rate
HC-NR-100	1.4	1.69	1.43	1.54	1.52
HC-NR-101	1.06	1.99	1.41	1.61	1.52
HC-NR-102	2.07	1.52	1.52	1.98	1.77
Overall Average Sedimentation Rate					1.6

Notes:

1. Table from the Whatcom Waterway 2000 RI/FS Table 9-1 (Hart Crowser 2000)

cm/yr = centimeters per year

Cs-137 = cesium 137

Pb-210 = lead 210

RI/FS = Remedial Investigation/Feasibility Study

Table 6-4

Summary of Average Net Sedimentation, Gross Sedimentation, and Resusupension Rates from the 2000 Whatcom Waterway RI/FS[1]

Natural Recovery Core Number	Average Estimated Net Sedimentation Rate in cm/yr	Estimated Gross Sedimentation Rate in cm/yr	Calculated Resuspension Rate in Percent
HC-NR-100, HC-ST-100	1.52	7.85	81
HC-NR-101, HC-ST-101	1.52	8.45	82

Notes:

1. Table from the Whatcom Waterway 2000 RI/FS Table 9-1 (Hart Crowser 2000)

cm/yr = centimeters per year

RI/FS = Remedial Investigation/Feasibility Study

Table 6-5

10-Year Recovery Projections of Mercury Concentration from the 2000 Whatcom Waterway RI/FS[1]

Natural Recovery Core Number	Maximum Sample Interval Used in Regression (in cm)	Number of Samples Used in Regression	Regression R2 Value	Standard Error	Average Net Sedimentation Rate (in cm/yr)	Sediment Mercury Concentration in mg/kg	
						Year 1995	Year 2005 (+/- Standard Error)
HC-NR-100	-44.2	11	0.59	0.05944	1.52	1.3	0.80 (+/- 0.12)
HC-NR-101	-41.6	12	0.68	0.0751	1.52	1.7	1.12 (+/- 0.15)
HC-NR-102	-45.6	13	0.81	0.05679	1.77	0.34	0.23 (+/- 0.11)

Notes:

1. Table from the Whatcom Waterway 2000 RI/FS Table 9-1 (Hart Crowser 2000)

cm/yr = centimeters per year

mg/kg = milligram per kilogram

RI/FS = Remedial Investigation/Feasibility Study

Table 8-1
Cleanup Standards

	Screening Level						Preliminary Cleanup Level[a]	Horizontal Scale of Application	Vertical Point of Compliance
	Carbon Normalized Screening Level			Dry-weight Screening Level					
Analyte	SCO	CSL	Unit	SCO	CSL	Unit			
Nickel	n/a	n/a	n/a	140	140	mg/kg	SCO	Point-based	Upper 12 cm of sediment
Total cPAH TEQ	n/a	n/a	n/a	61	610	µg/kg	70 µg/kg (Preliminary Regional Background)[b]	Area-weighted average	Upper 12 cm of sediment
Total cPAH TEQ	n/a	n/a	n/a	110	1,100	µg/kg	SCO	Area-weighted average in intertidal areas	Upper 45 cm of sediment
2-Methylnaphthalene	38	64	mg/kg OC	670	670	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Acenaphthene	16	57	mg/kg OC	500	500	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Anthracene	220	1,200	mg/kg OC	960	960	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Benzo(a)anthracene	110	270	mg/kg OC	1,300	1,600	µg/kg	SCO	Point-based	Upper 12 cm of sediment
bis(2-Ethylhexyl)phthalate	47	78	mg/kg OC	1,300	3,100	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Chrysene	110	460	mg/kg OC	1,400	2,800	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Dibenzo(a,h)anthracene	12	33	mg/kg OC	230	230	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Dibenzofuran	15	58	mg/kg OC	540	540	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Dimethyl phthalate	53	53	mg/kg OC	71	160	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Fluoranthene	160	1,200	mg/kg OC	1,700	2,500	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Fluorene	23	79	mg/kg OC	540	540	µg/kg	SCO	Point-based	Upper 12 cm of sediment
n-Nitrosodiphenylamine	11	11	mg/kg OC	28	40	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Phenanthrene	100	480	mg/kg OC	1,500	1,500	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Pyrene	1,000	1,400	mg/kg OC	2,600	3,300	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Total HPAH	960	5,300	mg/kg OC	12,000	17,000	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Total LPAH	370	780	mg/kg OC	5,200	5,200	µg/kg	SCO	Point-based	Upper 12 cm of sediment
2,4-Dimethylphenol	n/a	n/a	n/a	29	29	µg/kg	SCO	Point-based	Upper 12 cm of sediment
2-Methylphenol (o-Cresol)	n/a	n/a	n/a	63	63	µg/kg	SCO	Point-based	Upper 12 cm of sediment
4-Methylphenol (p-Cresol)	n/a	n/a	n/a	670	670	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Benzoic acid	n/a	n/a	n/a	650	650	µg/kg	SCO	Point-based	Upper 12 cm of sediment
Benzyl alcohol	n/a	n/a	n/a	57	73	µg/kg	SCO	Point-based	Upper 12 cm of sediment

Notes:

a. The SCO is the carbon normalized value when total organic carbon is within the range of 0.5% to 3.5%.

b. The cleanup level has been adjusted upwards from the SCO to the preliminary regional background concentration. See Section 8.2.3.

µg/kg = microgram per kilogram
cm = centimeter
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
HPAH = high-molecular weight polycyclic aromatic hydrocarbon
LPAH = low-molecular weight polycyclic aromatic hydrocarbon
mg/kg = milligram per kilogram
mg/kg-OC = milligram per kilogram organic carbon normalized
n/a = not applicable
SCO = Sediment Quality Objective
TEQ = toxic equivalent quotient

Table 9-1
Site Units

Site Unit	Physical Factors			Land Use and Navigation	Natural Resources	Contaminant Distribution	
	Water Depths	Infrastructure	Sediment Type			Surface Sediment	Subsurface Sediment
Navigation Channel West	-16 ft MLLW to -12 ft MLLW	None	Fine sediments	Used by Bornstein and USCG vessels. Authorized at -18 ft MLLW.	Subtidal area	Bioassay exceedances. Interpolated cPAH exceedance (from sample in berthing area).	Elevated mercury, 2,4-dimethylphenol, 2-methylphenol phthalates, and n-nitrosodiphenylamine
Navigation Channel East	-14 ft MLLW to MLLW	None	Fine sediments	Used by Bornstein and USCG vessels. Authorized at -18 ft MLLW.	Subtidal area	Elevated nickel and bioassay exceedances	
Coast Guard	-13 ft MLLW to MLLW	USCG dock	Fine sediments	Used by USCG vessels. Includes area designated as federal navigation channel.	Subtidal area	Elevated nickel and bioassay exceedance	
Coast Guard Bank	-10 ft MLLW to approximately MLLW at upper limits	USCG dock	Fine sediments; Rubble and riprap shoreline along Bellwether shoreline	None	Shallow water habitat along shoreline used by juvenile salmonids	No data; nearby data indicate elevated nickel and bioassay exceedances	
Berthing Area	-16 ft MLLW to -10 ft MLLW at face of Bornstein dock	None	Fine sediments	Used for berthing by fishing vessels	Subtidal area	Elevated PAHs, bis(2-ethylhexyl)phthalate, dibenzofuran, and bioassay exceedance	Elevated mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol
Dock	-10 ft MLLW at face of Bornstein dock; Approximately +1 ft MLLW at shoreline bulkhead	Bornstein dock; Bornstein bulkhead	Fine sediments; Rubble shoreline along Bornstein bulkhead	Used for vessel berthing and seafood processing	Shallow water habitat along shoreline used by juvenile salmonids	Elevated PAHs, 2,4-dimethylphenol, benzyl alcohol, dibenzofuran, and bis(2-ethylhexyl)phthalate	Elevated mercury, phthalates, methylphenols, phenol, benzoic acid, dibenzofuran, and PAHs
Floating Dock	-10 ft MLLW at face of Bornstein dock; Approximately +1 ft MLLW at shoreline bulkhead	Bornstein float; Bornstein bulkhead	Fine sediments; Rubble shoreline along Bornstein bulkhead	Used for berthing by fishing vessels	Shallow water habitat along shoreline used by juvenile salmonids	Elevated nickel, PAHs, and bioassay exceedance	Elevated mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol
South Bank	-11 ft MLLW at navigation channel; Approximately +1 ft MLLW at shoreline bulkhead	"Northern bulkhead"	Fine sediments; Rubble shoreline along bulkhead	None	Shallow water habitat along shoreline used by juvenile salmonids	Elevated nickel, PAHs, and bioassay exceedance	Elevated mercury, bis(2-ethylhexyl)phthalate, and 2,4-dimethylphenol
Head of Waterway	MLLW to approximately +4 ft MLLW at upper limits	"Northern bulkhead"	Fine sediments; Rubble shoreline along bulkhead and eastern shoreline (head)	Future kayak launch and public access. Includes small area designated as federal navigation channel.	Shallow water and intertidal habitat used by juvenile salmonids	Elevated nickel, PAHs, and bioassay exceedance	Elevated nickel, mercury, 2,4-dimethyl phenol, 2-methylphenol, 4-methylphenol, and bis(2-ethylhexyl)phthalate.

Notes:

Contaminant distribution compared to action levels

Subsurface sediment based on historical cores and DMMP core composites

cPAH = carcinogenic polycyclic aromatic hydrocarbon

DMMP = Dredged Material Management Program

ft = feet

MLLW = mean lower low water

PAH = polycyclic aromatic hydrocarbon

USCG = U.S. Coast Guard

Table 10-1
Technology Screening by Site Unit

Site Unit	Monitored Natural Recovery	Enhanced Natural Recovery	Capping	Removal
Navigation Channel West	Retained	Eliminated	Eliminated	Retained
Navigation Channel East	Retained	Eliminated	Eliminated	Retained
Coast Guard	Retained	Eliminated	Eliminated	Retained (structures moved during construction)
Coast Guard Bank	Retained	Eliminated	Eliminated	Retained
Berthing Area	Eliminated	Eliminated	Eliminated	Retained
Dock	Eliminated	Eliminated	Retained with sheetpile toe wall	Retained (with dock and bulkhead replacement)
Floating Dock	Eliminated	Eliminated	Retained with sheetpile toe wall	Retained (structure moved during construction, bulkhead replacement)
South Bank	Retained	Retained	Eliminated	Retained (bulkhead replacement)
Head of Waterway	Eliminated	Eliminated	Retained	Retained (bulkhead replacement)

Table 11-1
Remedial Alternative Technology Assignments

Site Unit	Area (acres)	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Navigation Channel West	0.72	MNR	MNR	Removal	Removal	Removal	Removal
Navigation Channel East	0.41	MNR	MNR	MNR	MNR	Removal	Removal
Coast Guard	0.28	MNR	MNR	MNR	MNR	Removal	Removal
Coast Guard Bank	0.15	MNR	MNR	MNR	MNR	Removal	Removal
Berthing Area	0.24	Removal	Removal	Removal	Removal	Removal	Removal
Dock	0.17	Cap with sheetpile toe wall	Cap with sheetpile toe wall	Cap with sheetpile toe wall	Removal with dock and bulkhead replacement	Cap with sheetpile toe wall	Removal with dock and bulkhead modifications
Floating Dock	0.14	Cap with sheetpile toe wall	Cap with sheetpile toe wall	Cap with sheetpile toe wall	Removal with bulkhead replacement	Cap with sheetpile toe wall	Removal with bulkhead replacement
South Bank	0.33	MNR	ENR	ENR	ENR	Removal	Removal
Head of Waterway	0.66	Cap	Cap	Cap	Cap	Cap	Removal

Notes:

ENR = Enhanced Natural Recovery

MNR = Monitored Natural Recovery

Table 11-2

Remedial Alternative Areas, Volumes, Costs, and Construction Time Frames

Parameter	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Areas (acres)						
Removal	0.2	0.2	1.0	1.3	2.1	3.1
Capping	1.0	1.0	1.0	0.7	1.0	0.0
Enhanced Natural Recovery	0.0	0.3	0.3	0.3	0.0	0.0
Monitored Natural Recovery	1.9	1.6	0.8	0.8	0.0	0.0
Volumes (cubic yards)						
Total Removal	5,563	5,563	14,964	18,144	30,093	39,101
Total Placement	5,835	6,374	7,535	7,034	8,882	5,994
Construction Timeframe (days)						
Construction Time	37	38	52	68	84	110
Cost ($ millions)						
Cost	$5.4	$5.5	$7.7	$12.6	$13.5	$20.6

Table 12-1
Performance of Remedial Alternative Compared to Cleanup Standards

Exposure Pathway	Parameter	Cleanup Standard	Area	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Protection of Human Health				*Estimated SWAC following construction (µg TEQ/kg dw)* [a]					
Protection of human health for seafood consumption	cPAHs	70 µg TEQ/kg; SWAC of home range; upper 12 cm	I&J Remediation Area[b] Baseline = 399 µg TEQ/kg dw	165	117	61	61	15	15
		70 µg TEQ/kg; SWAC of home range; upper 12 cm	Crab and fish home range[c] Baseline = 44 µg TEQ/kg dw	44	44	44	44	44	44
Protection of human health for direct contact		110 µg TEQ/kg; SWAC of intertidal; upper 12 cm	Intertidal[d] Baseline = 445 µg TEQ/kg dw	15	15	15	15	15	15
Protection of the Benthic Community				*Point sample locations remediated* [e]					
Protection of the Benthic Community	SMS Chemicals[f]	SCO; points concentrations; upper 12 cm	I&J Remediation Area[b]	All points remediated post-construction					
	Biological Criteria			All points remediated within 10 years post-construction[g]				All points remediated post-construction	
	Nickel			All points remediated within 10 years post-construction[h]				All points remediated post-construction	

Notes:

🟨 = anticipated to achieve cleanup standard within 10 years following construction

🟩 = cleanup standard achieved immediately following construction

Concentrations of co-occurring contaminants, including dioxins/furans, mercury, and total PCBs, will achieve SMS requirements following construction.

a. Post-construction SWACs for cPAHs are calculated assuming that remediation areas have a post-construction concentration of 15 µg TEQ/kg dw (based on natural background). Although low concentrations may be present as a temporary condition, the site is expected to equilibrate to regional background concentrations over the long term due to diffuse sources (e.g., stormwater). See Appendix H.

b. The I&J Waterway remediation area is approximately 3.1 acres.

c. The crab and fish home range is assumed to include I&J Waterway and adjacent areas (approximately 2,500 acres).

d. The intertidal area is approximately 0.7 acre in the Head of Waterway unit.

e. The points achieving the benthic SCO following construction were estimated by assuming that all locations with dredging, capping, or enhanced natural recovery achieve cleanup standards, and point in monitored natural recovery areas remain at baseline conditions. This is a conservative assumption because natural recovery is ongoing, and surface sediment conditions are expected to improve over baseline conditions prior to construction.

f. Includes all chemicals in SMS Table III (WAC 173-204-562); does not include nickel.

g. As discussed in Sections 5.2.2 and 6.2.2 and shown in Figure 5-2, the adverse biological effects of I&J Waterway sediment on benthic organisms have reduced over time; 2005/2006 sampling resulted in multiple CSL exceedances, and 2012 sampling results indicated no CSL exceedances (SCO exceedances only). This trend forms that basis for the predictions for Alternatives 1 through 4, which use monitored natural recovery in marginally impacted areas of the waterway.

h. As discussed in Section 6.6.2 and presented in Table 6-2, the surface sediment chemical concentrations of nickel have reduced over time, forming the basis for the predictions for Alternatives 1 through 4, which use monitored natural recovery in marginally impacted areas of the waterway.

µg/kg = microgram per kilogram
cm = centimeter
cPAH = carcinogenic polycyclic aromatic hydrocarbon
CSL = Cleanup Screening Level
dw = dry weight
PCB = polychlorinated biphenyl
PQL = practical quantitation limit
SCO = Sediment Cleanup Objective
SMS = Sediment Management Standards
SWAC = spatially weighted area concentration
TEQ = toxic equivalents quotient
WAC = Washington Administrative Code

Table 12-2
Disproportionate Cost Analysis

Criterion	Weighting	Washington Administrative Code (WAC) Language	Considerations for Site-Specific Evaluation		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Protectiveness	30%	*Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and offsite risks resulting from implementing the alternative, and improvement of the overall environmental quality.*	Protection of Human Health - Seafood Consumption	Performance	Monitored Natural Recovery (MNR) used in marginally impacted areas of the Site. Alternatives achieve cleanup standards in the fish and crab home range following construction, and are predicted to achieve cleanup standards in the Site within 10 years following construction.		Alternatives achieve cleanup standards following construction.			
				Score	4	4	5	5	5	5
			Protection of Human Health - Direct Contact	Performance	Alternatives achieve cleanup standards following construction.					
				Score	5	5	5	5	5	5
			Protection of the Environment - Benthic Community	Performance	MNR used in marginally impacted areas of the Site. Alternatives achieve cleanup standards within 10 years following construction.				Alternatives achieve cleanup standards following construction.	
				Score	4	4	4	4	5	5
			Total	**Score**	**4.3**	**4.3**	**4.7**	**4.7**	**5.0**	**5.0**
Permanence	20%	*The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.*	Certainty and Reliability the Alternative will not Result in Future Releases to the Biological Active Zone	Removal of impacted sediments from likely disturbance areas	Sediments remain in navigation areas and under-dock areas.	Sediments remain in navigation areas and under-dock areas.	Sediments removed from likely disturbance areas, but remain under dock.	Sediments removed from likely disturbance areas.	Sediments removed from all navigation areas, but remain under dock.	Sediments removed from all navigation and under dock areas.
				Score	**1**	**1**	**3**	**4**	**4**	**5**
				Removal of potential ongoing sources	Capping of Dock/Floating Dock units.	Capping of Dock/Floating Dock units.	Capping of Dock/Floating Dock units.	Removal of dock and bulkhead in Dock/Floating Dock units.	Capping of Dock/Floating Dock units and partial bulkhead removal in South Bank Unit.	Removal of dock in Dock/Floating Dock units and all bulkheads.
				Score	**1**	**1**	**1**	**3**	**2**	**4**
			Total	**Score**	**1.0**	**1.0**	**2.0**	**3.5**	**3.0**	**4.5**

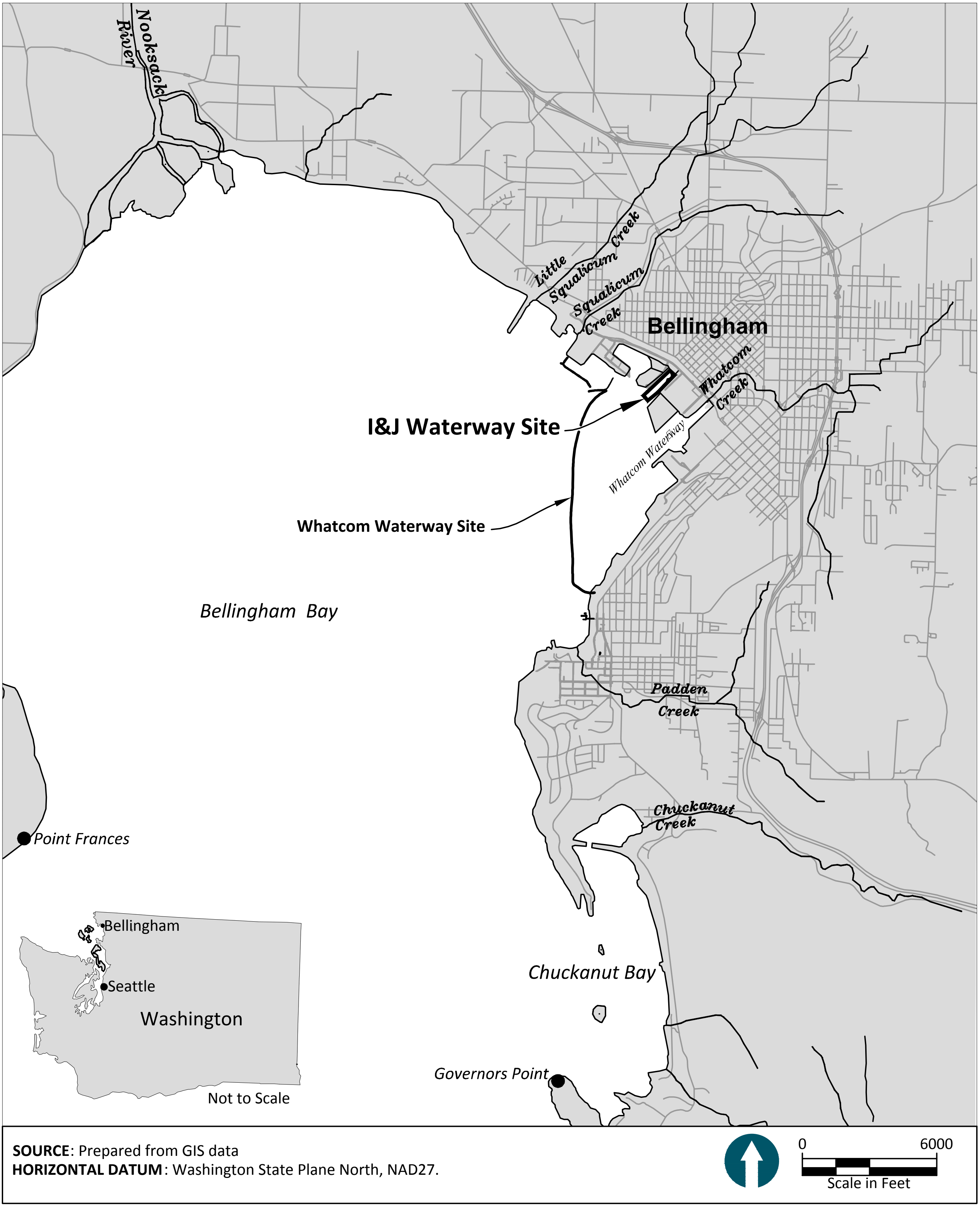
Table 12-2
Disproportionate Cost Analysis

<table>
<tr><th>Criterion</th><th>Weighting</th><th>Washington Administrative Code (WAC) Language</th><th colspan="2">Considerations for Site-Specific Evaluation</th><th>Alternative 1</th><th>Alternative 2</th><th>Alternative 3</th><th>Alternative 4</th><th>Alternative 5</th><th>Alternative 6</th></tr>
<tr><td rowspan="11">Effectiveness over the Long Term</td><td rowspan="11">20%</td><td rowspan="11"><i>When assessing the relative degree of long-term effectiveness of cleanup action components, the following types of components may be used as a guide, in descending order:
(i) Source controls in combination with other cleanup technologies;
(ii) Beneficial reuse of the sediments;
(iii) Treatment to immobilize, destroy, or detoxify contaminants;
(iv) Dredging and disposal in an upland engineered facility that minimizes subsequent releases and exposures to contaminants;
(v) Dredging and disposal in a nearshore, in-water, confined aquatic disposal facility;
(vi) Containment of contaminated sediments in-place with an engineered cap;
(vii) Dredging and disposal at an open water disposal site approved by applicable state and federal agencies;
(viii) Enhanced natural recovery;
(ix) Monitored natural recovery; and
(x) Institutional controls and monitoring.</i></td><td>Remedial Technologies</td><td>Characteristics</td><td colspan="6">Remedial Technology by Area</td></tr>
<tr><td>Berthing Area Unit</td><td rowspan="2">Likely Disturbance Area; Highest Concentration Areas</td><td colspan="6">Dredging</td></tr>
<tr><td>Dock and Floating Dock Units</td><td colspan="3">Capping</td><td>Dredging</td><td>Capping</td><td>Dredging</td></tr>
<tr><td>Navigation Channel West Unit</td><td>Likely Disturbance Area; Lower Concentration Area</td><td colspan="2">MNR</td><td colspan="4">Dredging</td></tr>
<tr><td>Coast Guard and Navigation Channel East Units</td><td rowspan="3">Low Disturbance Area; Lower Concentration Areas</td><td colspan="4">MNR</td><td colspan="2">Dredging</td></tr>
<tr><td>South Bank Unit</td><td>MNR</td><td colspan="3">ENR</td><td colspan="2">Dredging</td></tr>
<tr><td>Head of Waterway Unit</td><td colspan="5">Capping</td><td>Dredging</td></tr>
<tr><td>Remedial Technologies</td><td>Score</td><td>1</td><td>2</td><td>3</td><td>4</td><td>3</td><td>5</td></tr>
<tr><td rowspan="2">Source Control</td><td>Performance</td><td>Capping of Dock/Floating Dock units.</td><td>Capping of Dock/Floating Dock units.</td><td>Capping of Dock/Floating Dock units.</td><td>Removal of dock and bulkhead in Dock/Floating Dock units.</td><td>Capping of Dock/Floating Dock units and partial bulkhead removal in South Bank Unit.</td><td>Removal of dock in Dock/Floating Dock units and all bulkheads.</td></tr>
<tr><td>Score</td><td>1</td><td>1</td><td>1</td><td>3</td><td>2</td><td>4</td></tr>
<tr><td>Total</td><td>Score</td><td>1.0</td><td>1.5</td><td>2.0</td><td>3.5</td><td>2.5</td><td>4.5</td></tr>
<tr><td rowspan="5">Management of Short-term Risk</td><td rowspan="5">10%</td><td rowspan="5"><i>The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.</i></td><td rowspan="2">Risk to Human Health and Safety and Risks to Environment During Construction (Proportional to Construction Time)</td><td>Construction Time (days)</td><td>37</td><td>38</td><td>52</td><td>68</td><td>84</td><td>110</td></tr>
<tr><td>Score</td><td>5</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td rowspan="2">Site Risks and Risks of Recontamination During Restoration Time</td><td>Time to Achieve Cleanup Standards</td><td colspan="3">MNR within 10 years. Capping under dock has elevated recontamination risk.</td><td>MNR within 10 years; Dock area recontamination risk reduced by removal.</td><td>Short restoration time-frame, but capping under dock has elevated recontamination risk.</td><td>Short restoration time-frame.</td></tr>
<tr><td>Score</td><td>2.0</td><td>2.0</td><td>3.0</td><td>4.0</td><td>4.0</td><td>5.0</td></tr>
<tr><td>Total</td><td>Score</td><td>3.5</td><td>3.5</td><td>3.5</td><td>3.5</td><td>3.0</td><td>3.0</td></tr>
</table>

Table 12-2
Disproportionate Cost Analysis

Criterion	Weighting	Washington Administrative Code (WAC) Language	Considerations for Site-Specific Evaluation		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Technical and Administrative Implementability	10%	*Technical and administrative implementability. Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary offsite facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions.*	Technical feasibility to implement	Performance	Concerns about structural integrity of dock and bulkhead during construction (dredging, wall placement, cap placement); risks of damage and/or contractor claims.			Complex project but utilizes standard construction methods.	Same as Alt 1-3.	Complex project but utilizes standard construction methods.
				Score	**2**	**2**	**2**	**4**	**2**	**4**
			Feasibility to maintain over long-term	Performance	Requires long-term performance of under-dock capping with sheet-pile toe-wall. Future toe-wall replacement not included in remedy.			Potential future Olivine bulkhead maintenance or replacement.	Same as Alt 1-3.	Least long-term maintenance of the alternatives.
				Score	**2**	**2**	**2**	**4**	**2**	**5**
			Permitting and Regulatory Implementability	Performance	MNR in Navigation Channel - West Unit could be impacted by future maintaince dredging. Requires maintenance and potential future replacement of toe-wall and underdock cap. Fender system may be moved waterward to accommodate sheetpile.		Same as Alt 1-2, but without MNR in the Navigation Channel - West Unit.	Retains some MNR (in navigation channel), but no toe-wall and no under-dock cap issues.	Same as Alt 3.	Fewer long term permitting and regulatory concerns.
				Score	**1**	**1**	**2**	**3**	**2**	**5**
			Total	**Score**	**1.7**	**1.7**	**2.0**	**3.7**	**2.0**	**4.7**
Consideration of Public Concerns	10%	*Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.*	Consistency with land use, protection of users, habitat restoration, and permanently improve the environment	Performance	Consistent with land use, protects users, restores habitat. Minimal removal of contaminated sediment or potential ongoing sources.		Consistent with land use, protects users, restores habitat. Moderate removal of contaminated sediment; minimal removal of potential ongoing sources.	Consistent with land use, protects users, restores habitat. Moderate removal of contaminated sediment; removes potential ongoing sources.	Consistent with land use, protects users, restores habitat. Moderate removal of contaminated sediment; minimal removal of potential ongoing sources.	Consistent with land use, protects users, restores habitat. Maximum removal of contaminated sediment and potential ongoing sources.
			Total	**Score**	**1**	**1**	**2**	**3.5**	**3**	**4.5**
Total Weighted Benefits					**2.3**	**2.4**	**3.0**	**3.9**	**3.4**	**4.5**
Cost					**$5.4**	**$5.5**	**$7.7**	**$12.6**	**$13.5**	**$20.6**

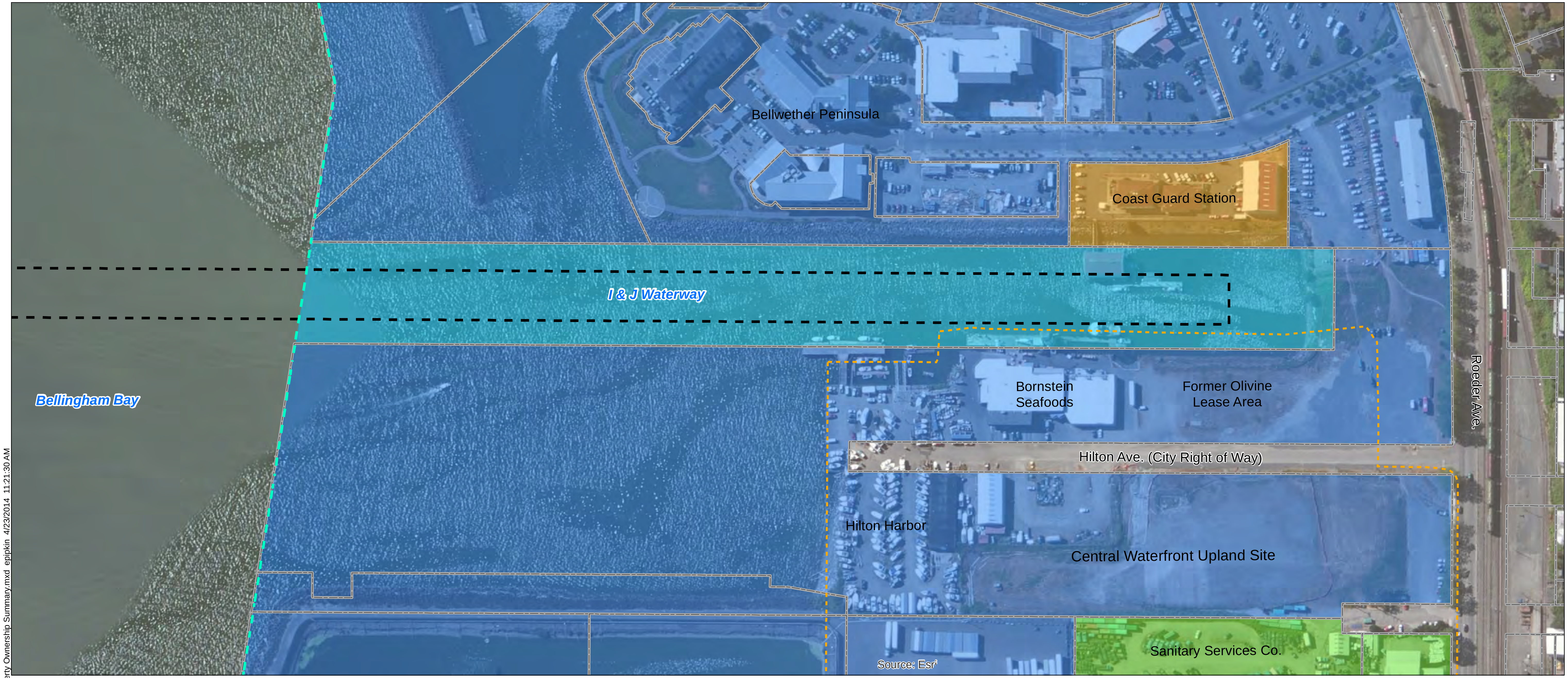
FIGURES



SOURCE: Prepared from GIS data
HORIZONTAL DATUM: Washington State Plane North, NAD27.

Apr 23, 2014 10:49am epipkin R:\Jobs\090007-01_I&J_Waterway\Maps\2013_04\Vicinity Map CAD.dwg 2-1

Figure 2-1
Site Location
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



Source: Esri

LEGEND

- Inner Harbor Line
- Federal Navigation Channel (Authorized to -18 Feet MLLW)
- Whatcom County Tax Parcel

Parcel Owner

- Port of Bellingham
- Sanitary Services Co.
- U.S.A.
- State Owned
- Central Waterfront Site Boundary

NOTES:

1. Parcel data provided by City of Bellingham.
2. Harbor line provided by Washington Department of Natural Resources.
3. Land use adjacent to south shoreline zoned Industrial/Mixed Use.
4. Land use adjacent to north shoreline zoned Commercial.

Feet

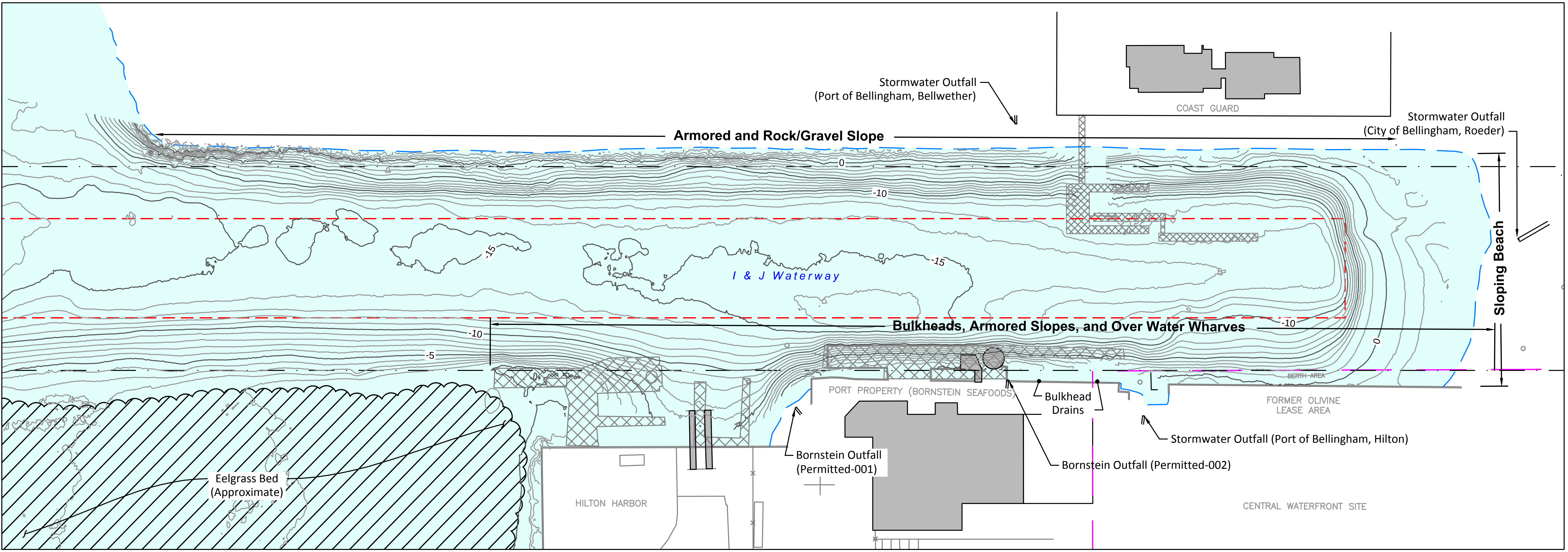
0 100 200 300 400

R:\Jobs\090007-01_I&J_Waterway\Maps\2013_04\Property Ownership Summary.mxd epipkin 4/23/2014 11:21:30 AM

ANCHOR QEA

Figure 2-2

Summary of Property Ownership and Land Use
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



LEGEND:

▨	Docks or Piers (Over Water Structures)
■	Existing Structures
▧	Eelgrass Bed (Boundary Approximate)
— —	Federal Channel Boundary
— —	Existing Shoreline
— —	Central Waterfront Site Boundary
— · —	I&J Waterway Boundary
—-10—	Bathymetric Contour (1-foot interval)

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE:

1. Bathymetric survey from eTrac dated April 5, 2012.

Figure 3-1
Site Bathymetry and Shoreline Features
Draft RI/FS Study Report
I&J Waterway Site
Port of Bellingham

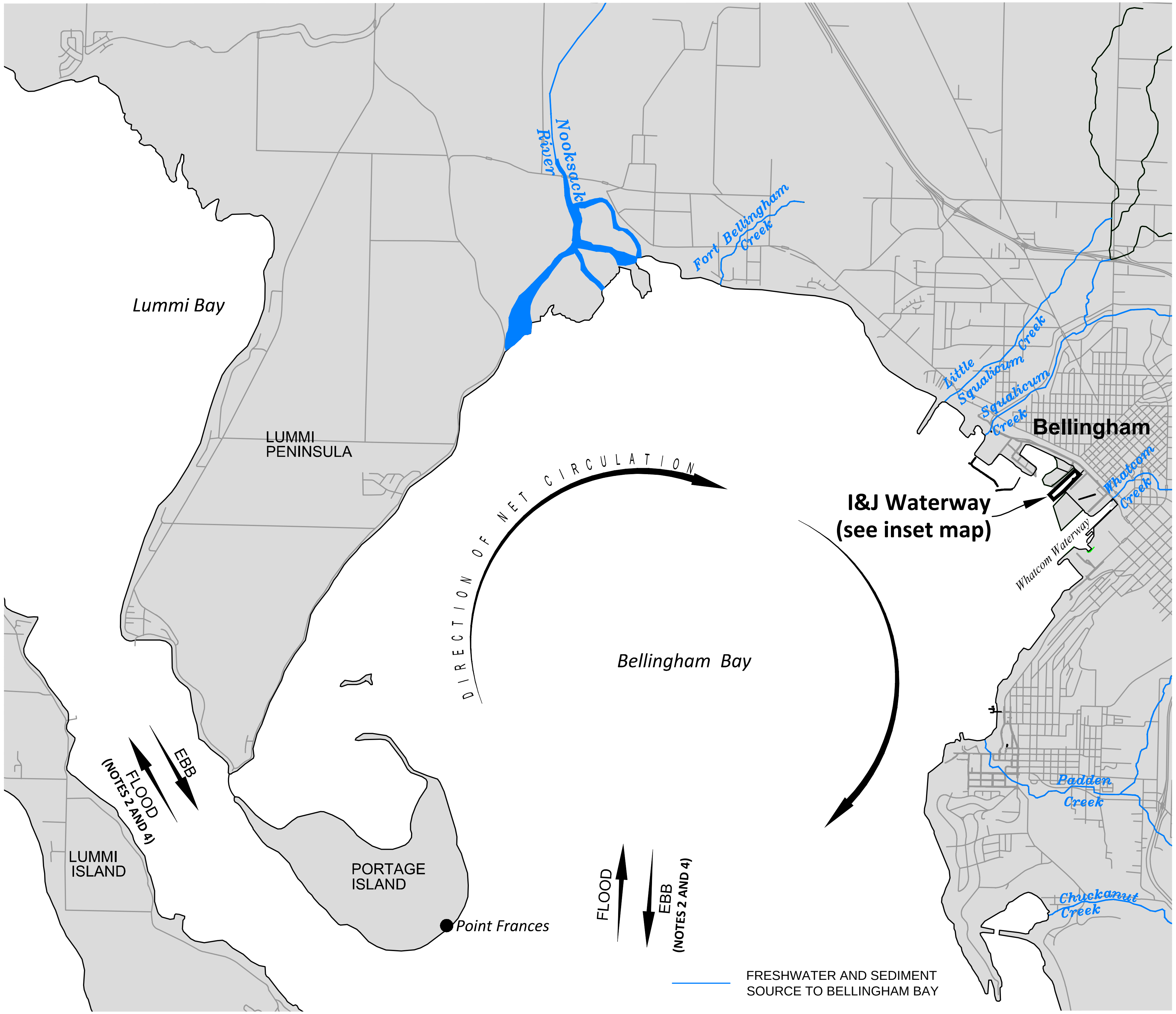
Operational Areas in I&J Waterway

Operational Area	Type of Maneuvers	Type of Vessels	Approximate Depth (ft MLLW)
A	Transit in Channel	All	-15
B	Docking	Recreational	-5 to -10
C	Transit in Channel, Turning and Docking	USCG and Bornstein	-5 to -15
D	Turning and Docking	USCG	-5 to -14
E	None	N/A	-5 to -15

I&J Waterway Inset Map

NOTES:

1. Aerial photo from Google Earth, July 26, 2011.
2. Tide and current directions shown are approximate.
3. Vessel operational areas are described in Section 6.3.3.
4. Maximum tidal fluctuation is 13.9 feet.



0 1
Scale in Miles

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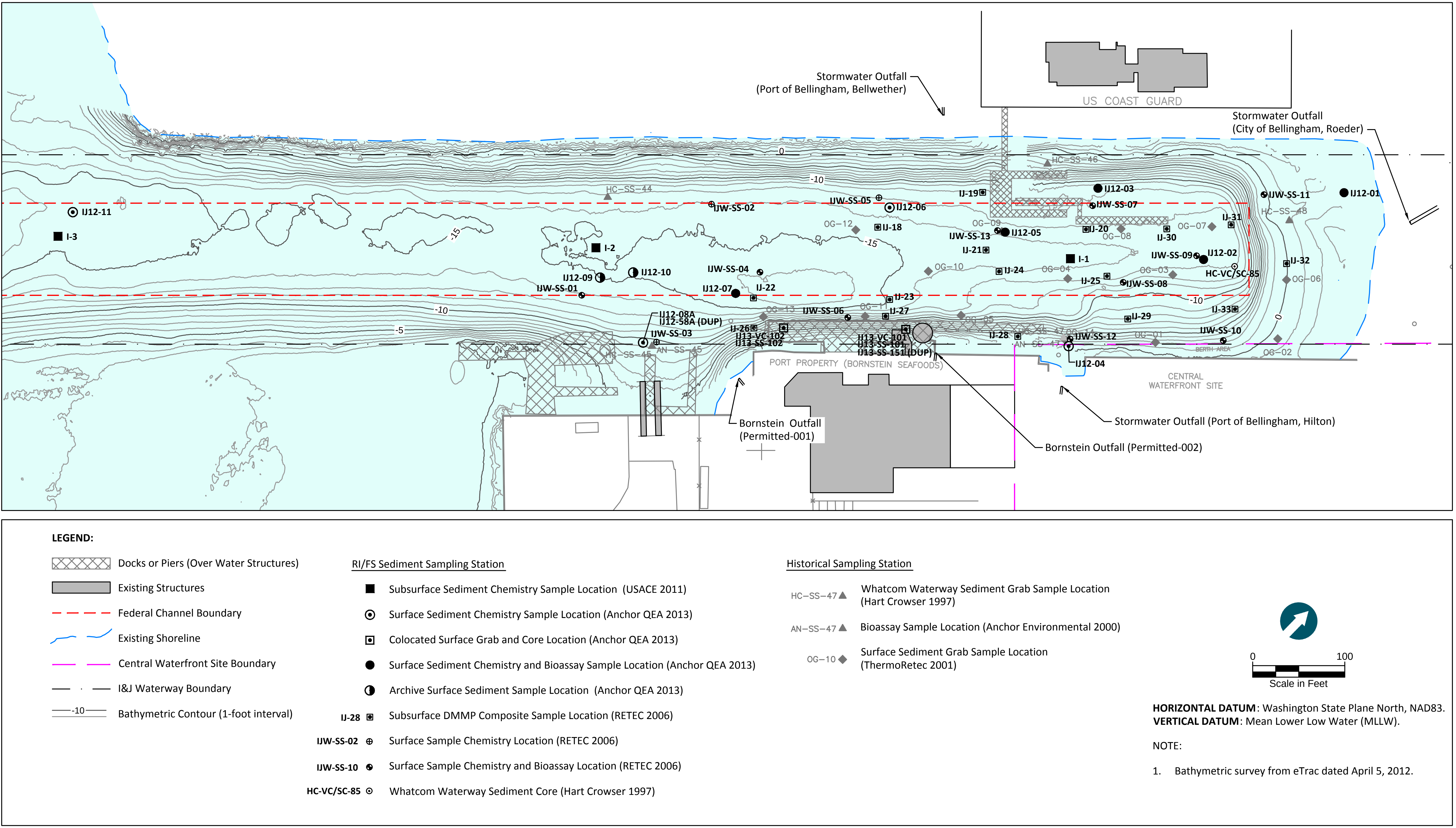
Figure 3-2
Physical Processes in I & J Waterway and Vicinity
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

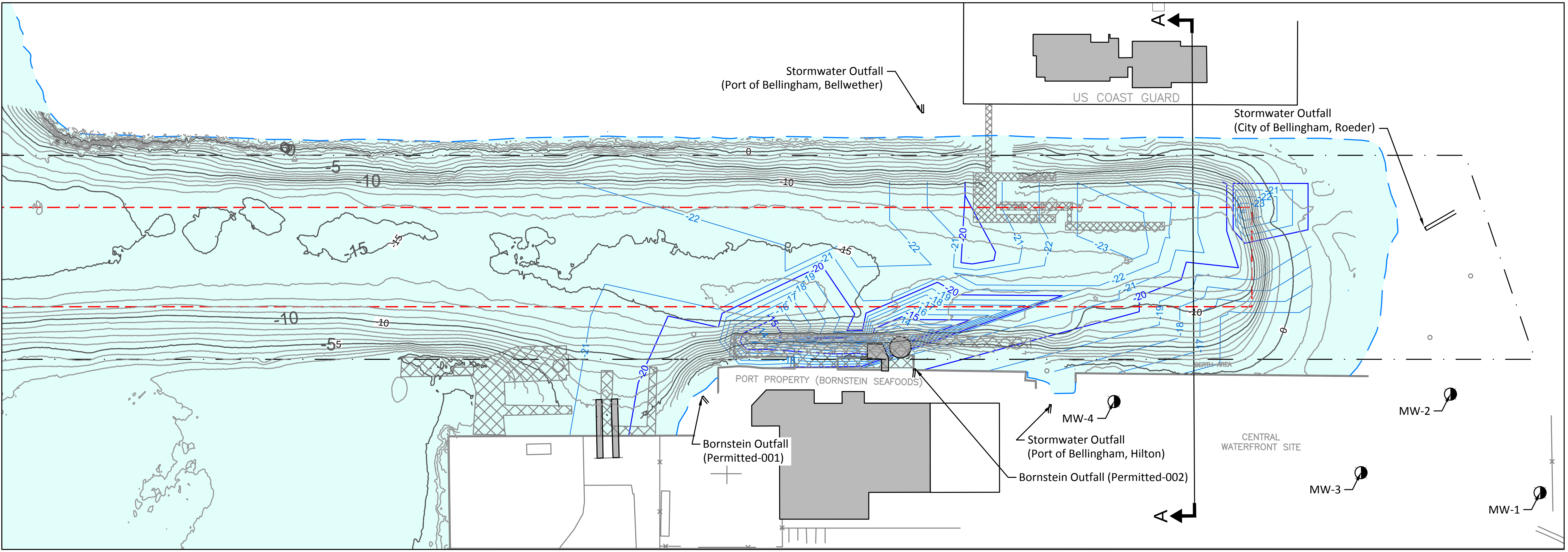


HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE:

1. Bathymetric survey from eTrac dated April 5, 2012.

Figure 3-3
RI/FS Sediment Sampling Locations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



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LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ■ Existing Structures
- – – – Federal Channel Boundary
- – – – Existing Shoreline
- – – – Central Waterfront Site Boundary
- — · — I&J Waterway Boundary
- —-10— Bathymetric Contour (1-foot interval)
- —-20— Clay Surface Contour (1-foot interval)
- ◑ Central Waterfront Monitoring Well Location

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:

1. Bathymetric survey from eTrac dated April 5, 2012.
2. Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

Figure 3-4
Elevation of Native Clay Layer
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

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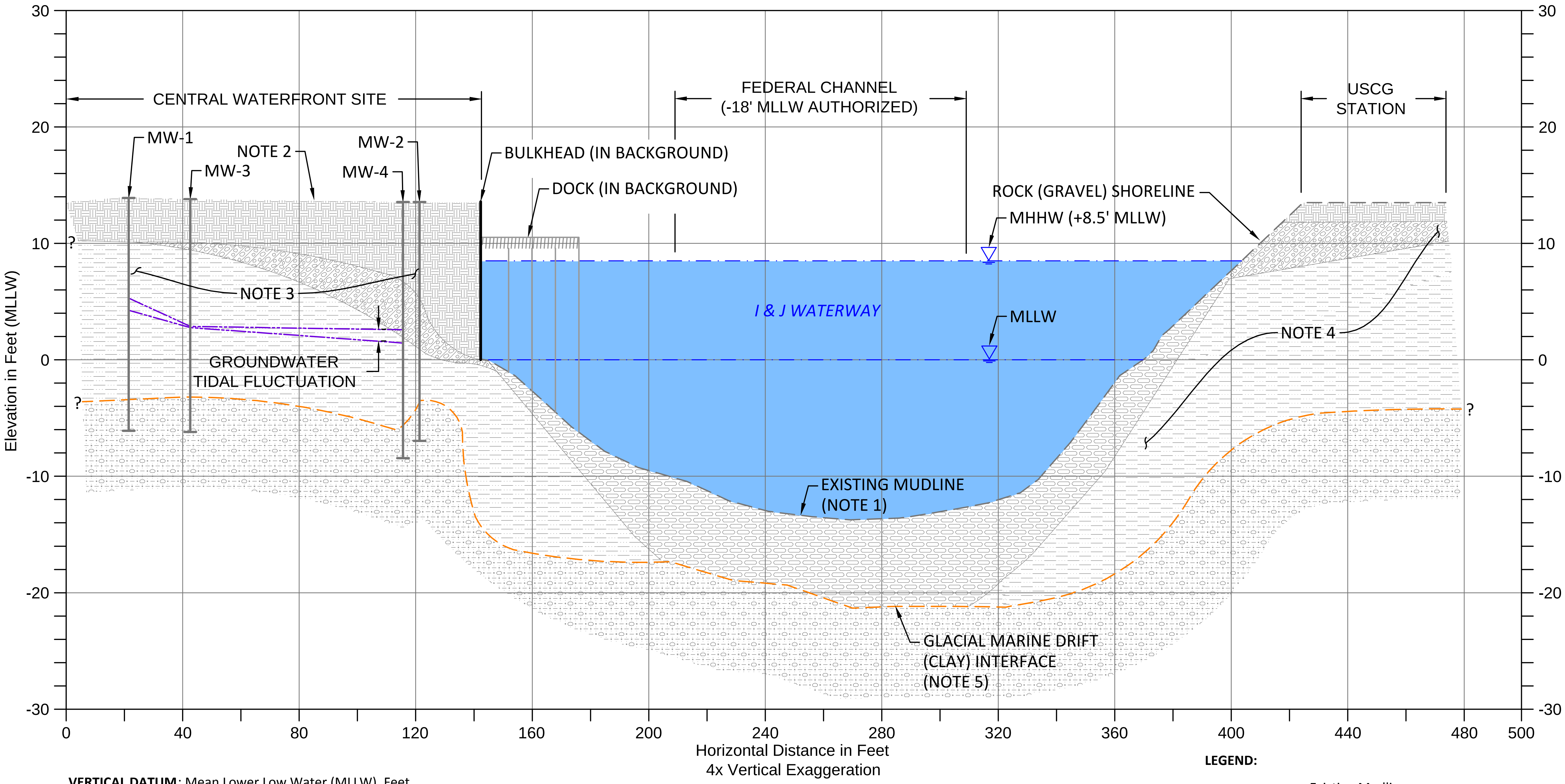

VERTICAL DATUM: Mean Lower Low Water (MLLW), Feet.

NOTE:

1. Bathymetric survey from eTrac dated April 5, 2012.
2. Upland survey conducted by Walker Associates (2004).
3. Upland boring data from Harding Lawson Associates. Soil, Sediment, and Groundwater Investigation prepared for U.S. Coast Guard (1995).
4. North upland geologic conditions inferred based on vicinity geology and known historical land use.
5. Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

Scale in Feet
0 40 80

0 10 20
Vertical Scale in Feet (MLLW)
Vertical Exaggeration x 4

LEGEND:

— — — —	Existing Mudline
— — — —	Glacial Marine Drift (Clay) Interface
▨	Fill (Various Grain Size)
▨	Fill (Sand/Silty Sand)
▨	Recent Deposits (Soft Silt)
▨	Post Glacial Fluvial Deposits (Sand/Silty Sand)
▨	Glacial Marine Drift (Stiff Clay)

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Figure 3-5
Conceptual Geologic Cross Section
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

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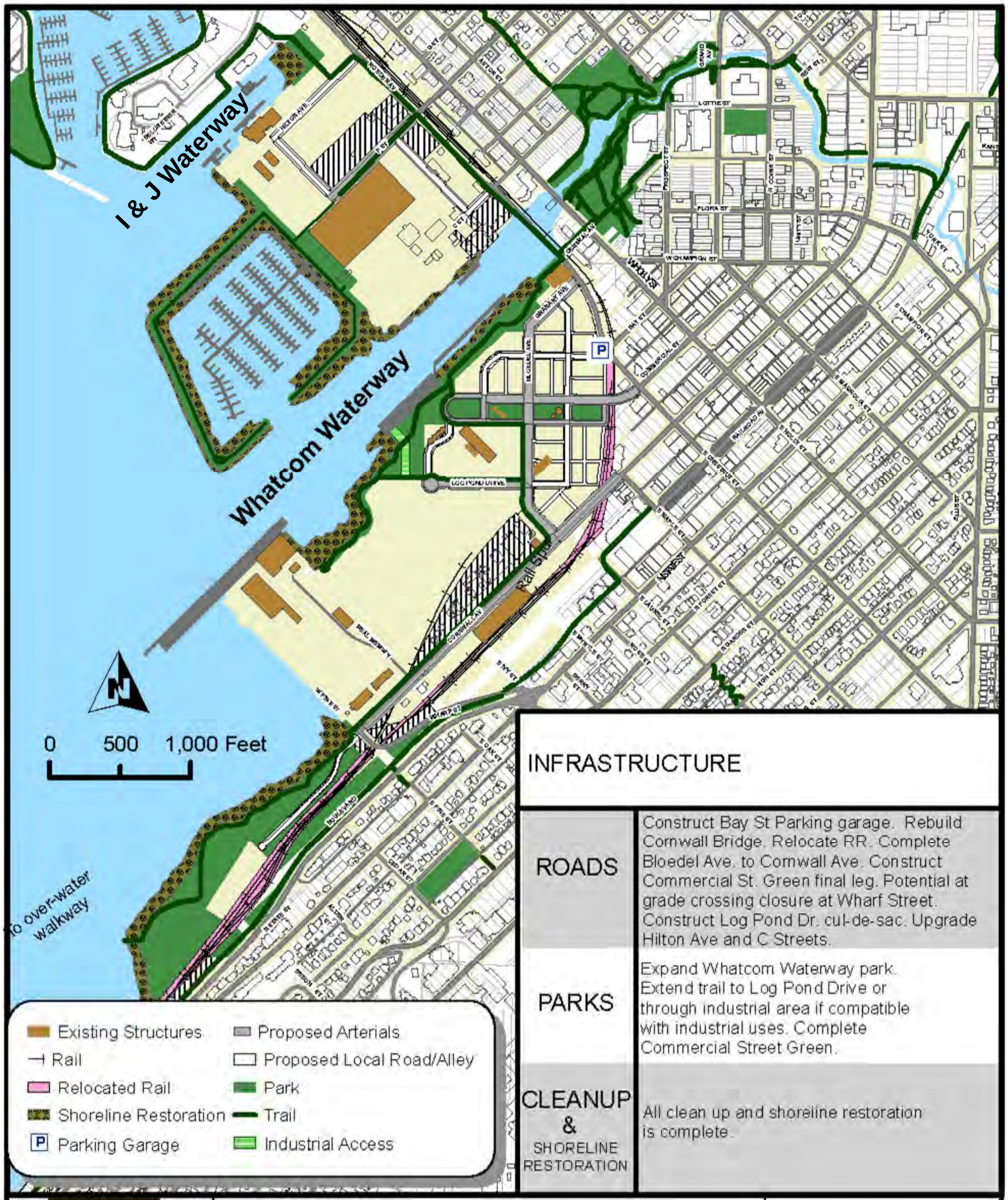


INFRASTRUCTURE	
ROADS	Construct Bay St Parking garage. Rebuild Cornwall Bridge. Relocate RR. Complete Bloedel Ave. to Cornwall Ave. Construct Commercial St. Green final leg. Potential at grade crossing closure at Wharf Street. Construct Log Pond Dr. cul-de-sac. Upgrade Hilton Ave and C Streets.
PARKS	Expand Whatcom Waterway park. Extend trail to Log Pond Drive or through industrial area if compatible with industrial uses. Complete Commercial Street Green.
CLEANUP & SHORELINE RESTORATION	All clean up and shoreline restoration is complete.

the waterfront district

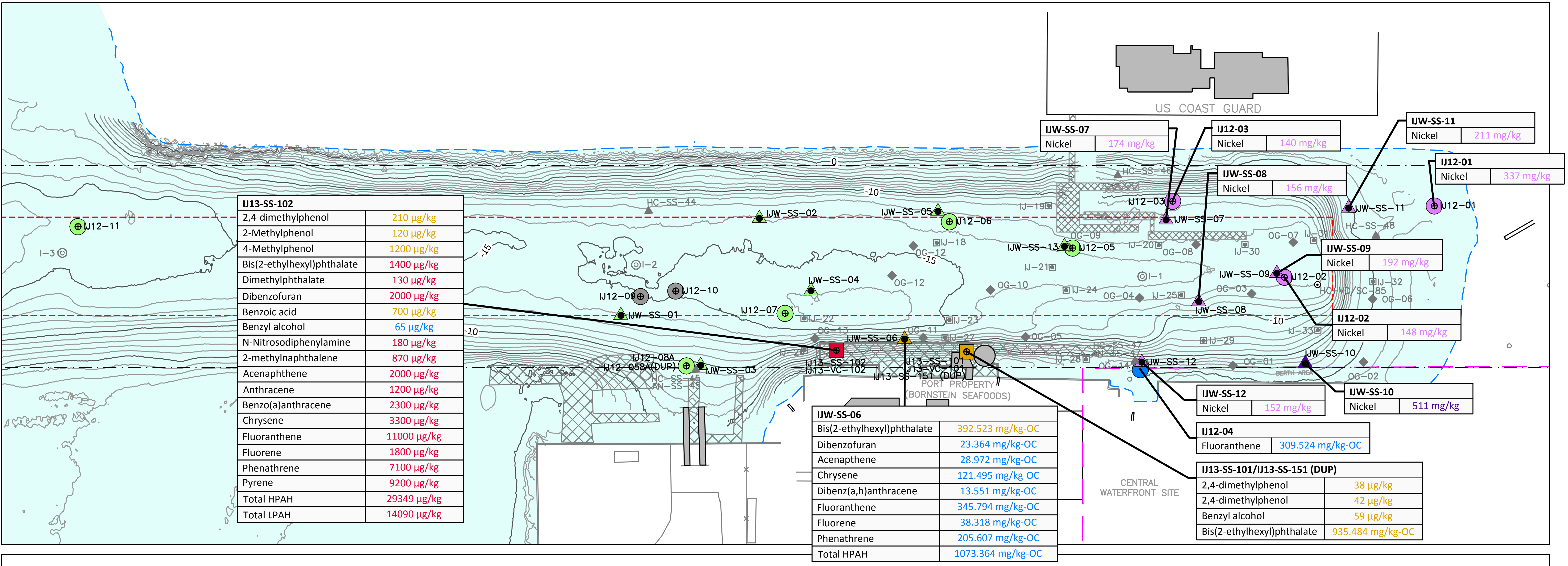
PHASE 5
Rail Relocation & Full Buildout of Downtown Area

The Waterfront District Facilities Agreement
12/14/2012

ANCHOR QEA

SOURCE:
Waterfront Phasing Map: Phase 5, City of Bellingham, acquired from: http://www.cob.org/documents/planning/waterfront/2012-12-17-phase-5-map.pdf. Accessed: 2/17/14.

Figure 3-6
Waterfront Phasing Map
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



IJ13-SS-102	
2,4-dimethylphenol	210 µg/kg
2-Methylphenol	120 µg/kg
4-Methylphenol	1200 µg/kg
Bis(2-ethylhexyl)phthalate	1400 µg/kg
Dimethylphthalate	130 µg/kg
Dibenzofuran	2000 µg/kg
Benzoic acid	700 µg/kg
Benzyl alcohol	65 µg/kg
N-Nitrosodiphenylamine	180 µg/kg
2-methylnaphthalene	870 µg/kg
Acenaphthene	2000 µg/kg
Anthracene	1200 µg/kg
Benzo(a)anthracene	2300 µg/kg
Chrysene	3300 µg/kg
Fluoranthene	11000 µg/kg
Fluorene	1800 µg/kg
Phenathrene	7100 µg/kg
Pyrene	9200 µg/kg
Total HPAH	29349 µg/kg
Total LPAH	14090 µg/kg

IJW-SS-06	
Bis(2-ethylhexyl)phthalate	392.523 mg/kg-OC
Dibenzofuran	23.364 mg/kg-OC
Acenaphthene	28.972 mg/kg-OC
Chrysene	121.495 mg/kg-OC
Dibenz(a,h)anthracene	13.551 mg/kg-OC
Fluoranthene	345.794 mg/kg-OC
Fluorene	38.318 mg/kg-OC
Phenathrene	205.607 mg/kg-OC
Total HPAH	1073.364 mg/kg-OC

IJW-SS-07	
Nickel	174 mg/kg

IJ12-03	
Nickel	140 mg/kg

IJW-SS-11	
Nickel	211 mg/kg

IJ12-01	
Nickel	337 mg/kg

IJW-SS-08	
Nickel	156 mg/kg

IJW-SS-09	
Nickel	192 mg/kg

IJ12-02	
Nickel	148 mg/kg

IJW-SS-12	
Nickel	152 mg/kg

IJW-SS-10	
Nickel	511 mg/kg

IJ12-04	
Fluoranthene	309.524 mg/kg-OC

IJ13-SS-101/IJ13-SS-151 (DUP)	
2,4-dimethylphenol	38 µg/kg
2,4-dimethylphenol	42 µg/kg
Benzyl alcohol	59 µg/kg
Bis(2-ethylhexyl)phthalate	935.484 mg/kg-OC

LEGEND:

▨	Docks or Piers (Over Water Structures)
▭	Existing Structures
- - -	Existing Shoreline
—-10—	Bathymetric Contour (1 foot interval)
— —	Central Waterfront Site Boundary
— · — · —	I & J Waterway Boundary
- - - - -	Federal Channel Boundary
——	Site Unit

2012/2013 RI/FS and Historic Sediment Sampling Station

HC–SS–47 ▲	Whatcom Waterway Sediment Grab Sample Location (Hart Crowser 1997)
HC–VC/SC–85 ⊙	Whatcom Waterway Sediment Core Location (Hart Crowser 1997)
AN–SS–47 ▲	Bioassay Sample Location (Anchor 2000)
OG–10 ◆	Surface Sediment Grab Sample Location (ThermoRetec 2001)
IJ–28 ▣	Subsurface DMMP Composite Sample Location (RETEC 2006)
IJW–SS–02 ●	Surface Sample Location (RETEC 2006)
I–2 ◎	Subsurface Sample Location (USACE 2011)
IJ12–10 ⊕	Surface Sediment Sample Location (Anchor QEA 2013)

Benthic Chemical Criteria

2005/2006	2012	2013	
▲	●	■	No Exceedances
▲	●	■	SCO Exceedances
▲	●	■	CSL Exceedances
		■	LAET Exceedances
▲	●		Nickel > 140 mg/kg (Former DMMP Screening Level)
▲	●		Nickel > 370 mg/kg (Former DMMP Bioaccumulation Trigger)
▲	●		Archived

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:
1. CSL = Cleanup Screening Level.
2. LAET = Lowest Apparent Effect Threshold.
3. SCO = Sediment Cleanup Objective.
4. IJ12-08A is IJ12-08 alternative sample location.
5. Bathymetric survey from eTrac dated April 5, 2012.

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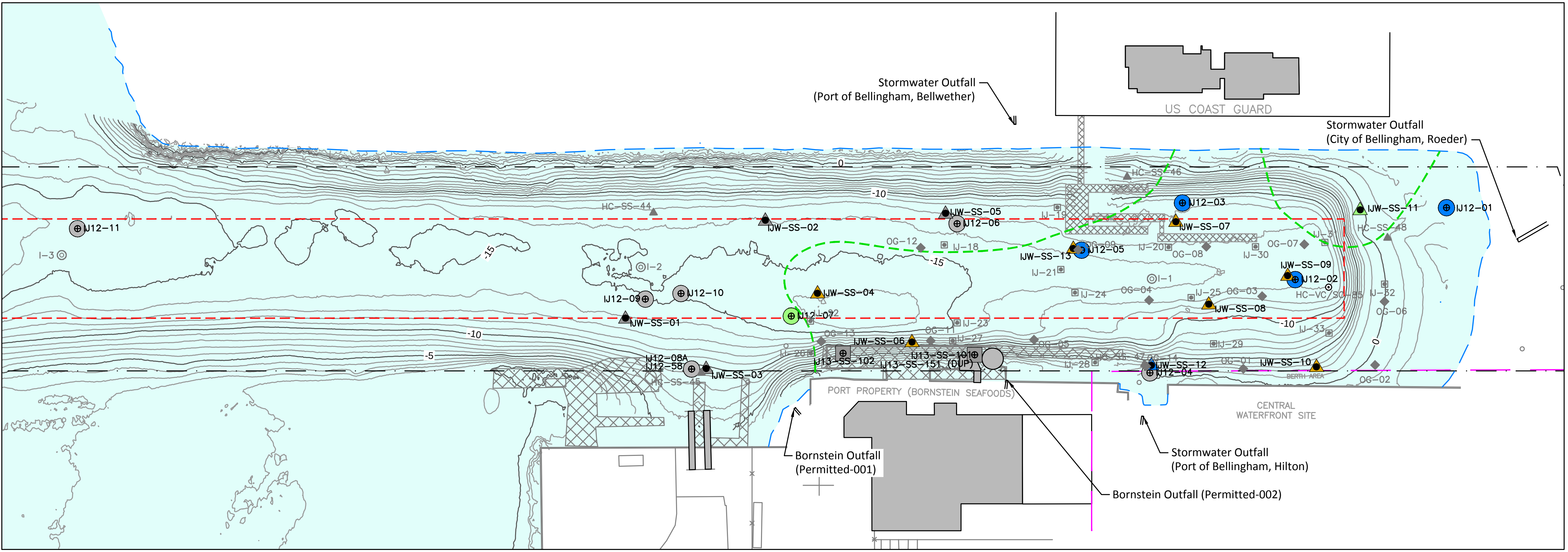
Figure 5-1
Exceedances of Benthic Chemical Criteria in Surface Sediment 2005/2006 and 2012/2013
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ▬ Existing Structures
- Existing Shoreline
- —-10— Bathymetric Contour (1-foot interval)
- Central Waterfront Site Boundary
- I&J Waterway Boundary
- Federal Channel Boundary
- Area Above Benthic Biological SMS Criteria

RI/FS and Historic Sediment Sampling Station

- HC-SS-47 ▲ Whatcom Waterway Sediment Grab Sample Location (Hart Crowser 1997)
- HC-VC/SC-85 ⊙ Whatcom Waterway Sediment Core (Hart Crowser 1997)
- AN-SS-47 ▲ Bioassay Sample Location (Anchor 2000)
- OG-10 ◆ Surface Sediment Grab Sample Location (ThermoRetec 2001)
- IJ-28 ▣ Subsurface DMMP Composite Sample Location (RETEC 2006)
- IJW-SS-02 ● Surface Sample Location (RETEC 2006)
- I-2 ◎ Subsurface Sample Location (USACE 2011)
- IJ12-10 ⊕ Surface Sediment Sample Location (Anchor QEA 2013)

Biological Effects Criteria

2005/2006	2012	2013	
▲	●		No Exceedances
▲	●		SCO Exceedances
▲	●		CSL Exceedances
▲	●	■	Not Tested

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:
1. CSL = Cleanup Screening Level.
2. SCO = Sediment Cleanup Objective.
3. Samples were compared to Carr Inlet reference CR-023.
4. IJ12-08A is IJ12-08 alternative sample location.
5. Bathymetric survey from eTrac dated April 5, 2012.

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Figure 5-2
Exceedances of Benthic Biological Criteria in Surface Sediment 2005/2006 and 2012/2013
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

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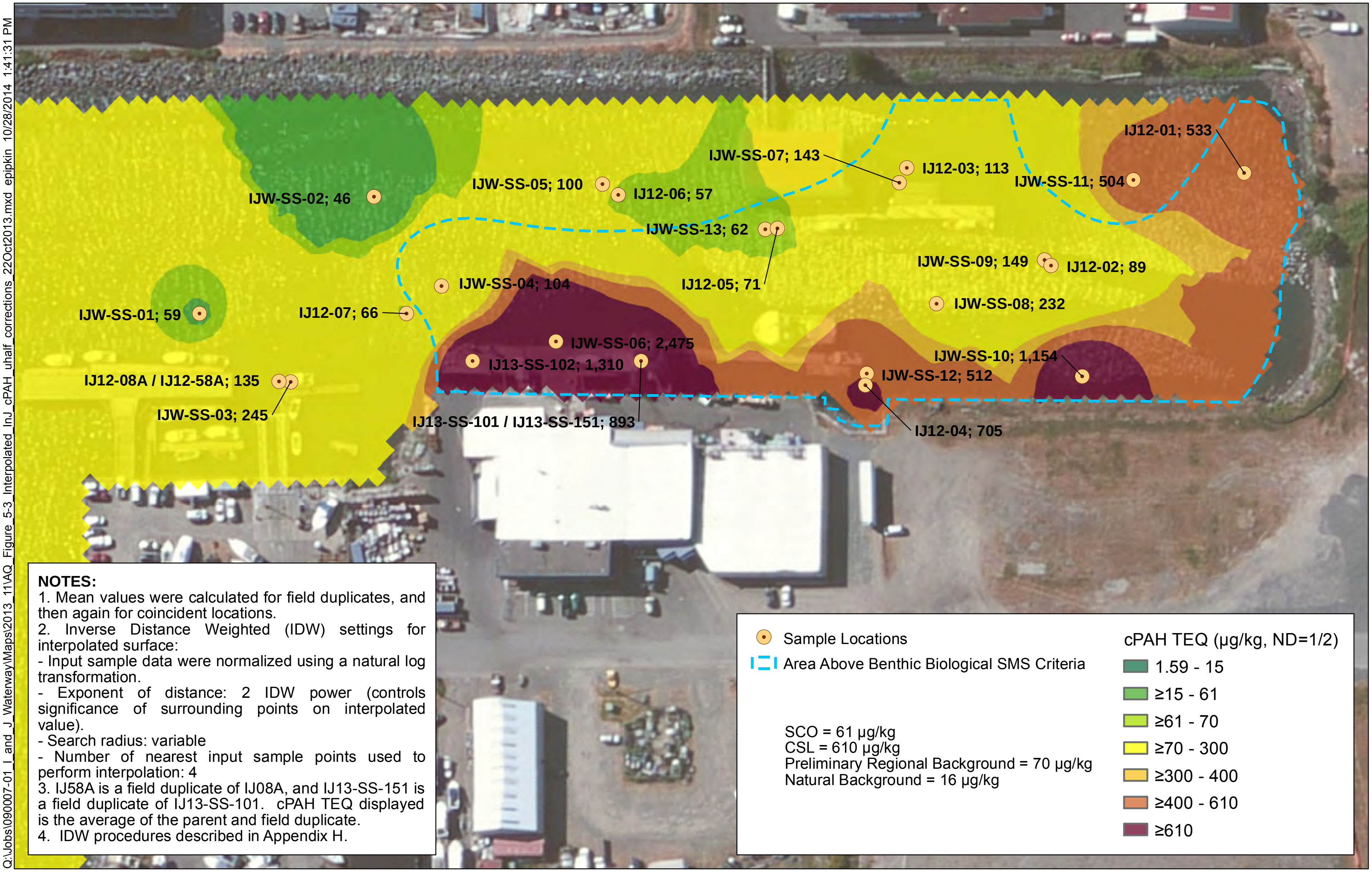

NOTES:

1. Mean values were calculated for field duplicates, and then again for coincident locations.
2. Inverse Distance Weighted (IDW) settings for interpolated surface:
- Input sample data were normalized using a natural log transformation.
- Exponent of distance: 2 IDW power (controls significance of surrounding points on interpolated value).
- Search radius: variable
- Number of nearest input sample points used to perform interpolation: 4
3. IJ58A is a field duplicate of IJ08A, and IJ13-SS-151 is a field duplicate of IJ13-SS-101. cPAH TEQ displayed is the average of the parent and field duplicate.
4. IDW procedures described in Appendix H.

● Sample Locations

▭ Area Above Benthic Biological SMS Criteria

SCO = 61 µg/kg
CSL = 610 µg/kg
Preliminary Regional Background = 70 µg/kg
Natural Background = 16 µg/kg

cPAH TEQ (µg/kg, ND=1/2)

🟩	1.59 - 15
🟩	≥15 - 61
🟩	≥61 - 70
🟨	≥70 - 300
🟨	≥300 - 400
🟧	≥400 - 610
🟥	≥610

Q:\Jobs\090007-01 I and J Waterway\Maps\2013 11\AQ Figure 5-3 Interpolated InJ cPAH uhalf corrections 22Oct2013.mxd epipkin 10/28/2014 1:41:31 PM

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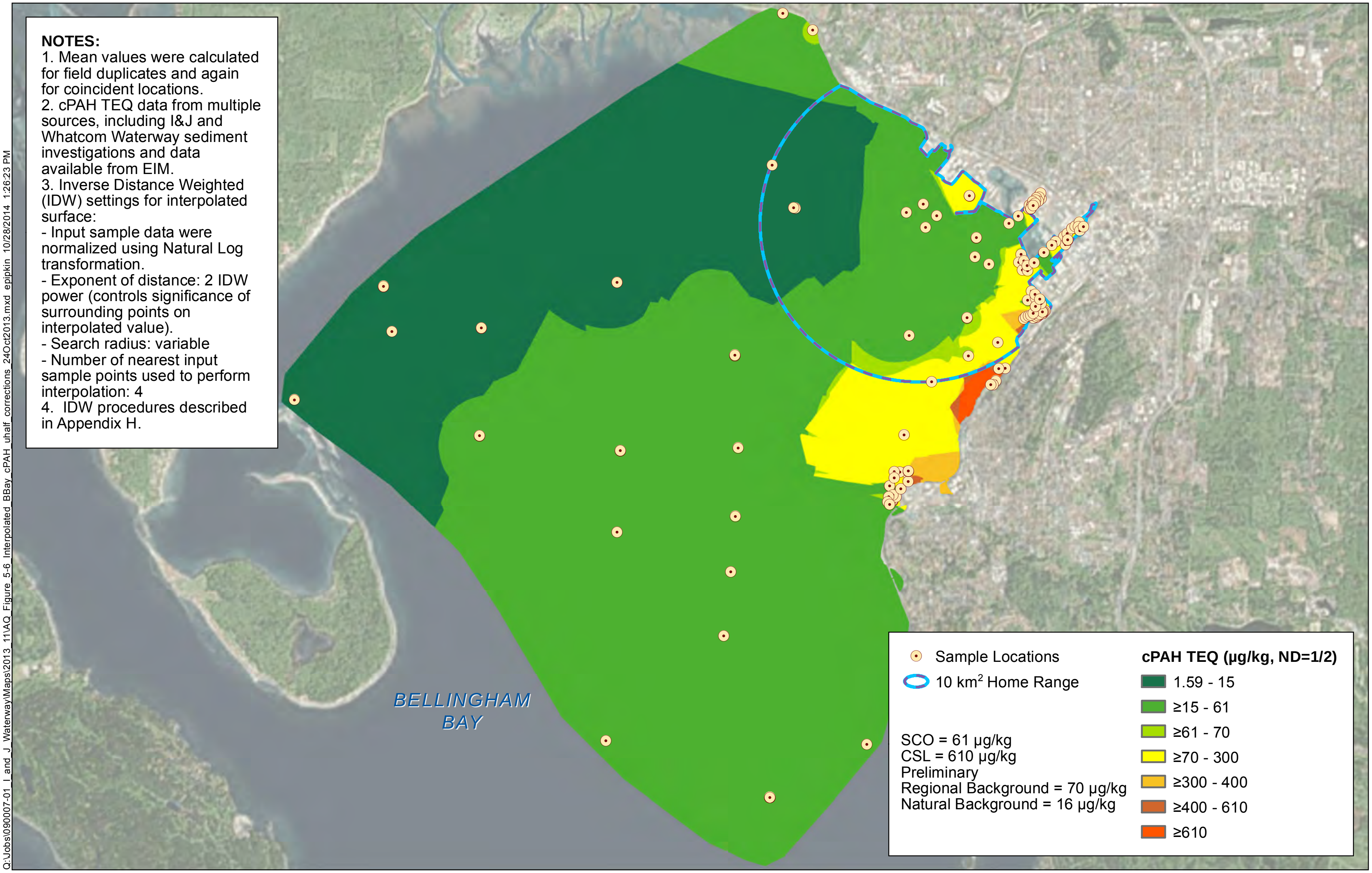
Figure 5-3

Interpolated I&J Waterway Surface Sediment cPAH TEQ Concentrations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



NOTES:
1. Mean values were calculated for field duplicates and again for coincident locations.
2. cPAH TEQ data from multiple sources, including I&J and Whatcom Waterway sediment investigations and data available from EIM.
3. Inverse Distance Weighted (IDW) settings for interpolated surface:
- Input sample data were normalized using Natural Log transformation.
- Exponent of distance: 2 IDW power (controls significance of surrounding points on interpolated value).
- Search radius: variable
- Number of nearest input sample points used to perform interpolation: 4
4. IDW procedures described in Appendix H.

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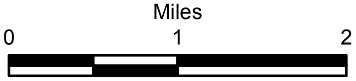
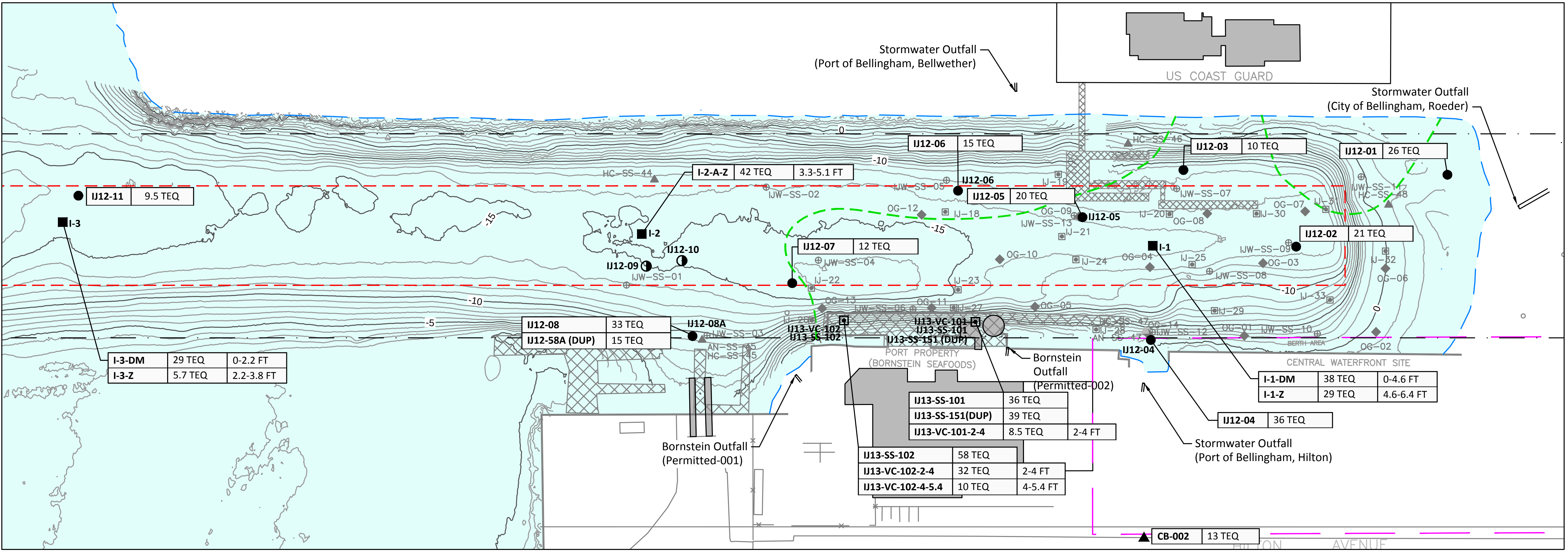


Figure 5-4

Interpolated Bellingham Bay Surface Sediment cPAH TEQ Concentrations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ▬ Existing Structures
- — — Federal Channel Boundary
- — — Existing Shoreline
- — — Central Waterfront Site Boundary
- — · — I&J Waterway Boundary
- —-10— Bathymetric Contour (1-foot interval)
- — — Area Above SMS Criteria

RI/FS Sampling Station with Dioxin/Furan TEQ

- ■ Subsurface Sediment Sample Location (USACE 2011)
- ● Surface Sediment Sample Location (Anchor QEA 2013)
- ⊡ Colocated Surface Grab and Core Location (Anchor QEA 2013)
- ◑ Archive Surface Sediment Sample Location (Anchor QEA 2013)
- ▲ Storm Drain Solid Sample Location (Anchor QEA 2013)

Historic Sampling Station

- HC–SS–47 ▲ Whatcom Waterway Sediment Grab Sample Location (Hart Crowser 1997)
- AN–SS–47 ▲ Bioassay Sample Location (Anchor Environmental 2000)
- OG–10 ◆ Surface Sediment Grab Sample Location (ThermoRetec 2001)
- IJ–28 ⊡ Subsurface DMMP Composite Sample Location (RETEC 2006)
- IJW–SS–02 ⊕ Surface Sample Location (RETEC 2006)

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:

1. Bathymetric survey from eTrac dated April 5, 2012.
2. Dioxin/Furan concentrations shown as Total Dioxin Furan TEQ 2005 (Mammal) (U=1/2) ng/kg.

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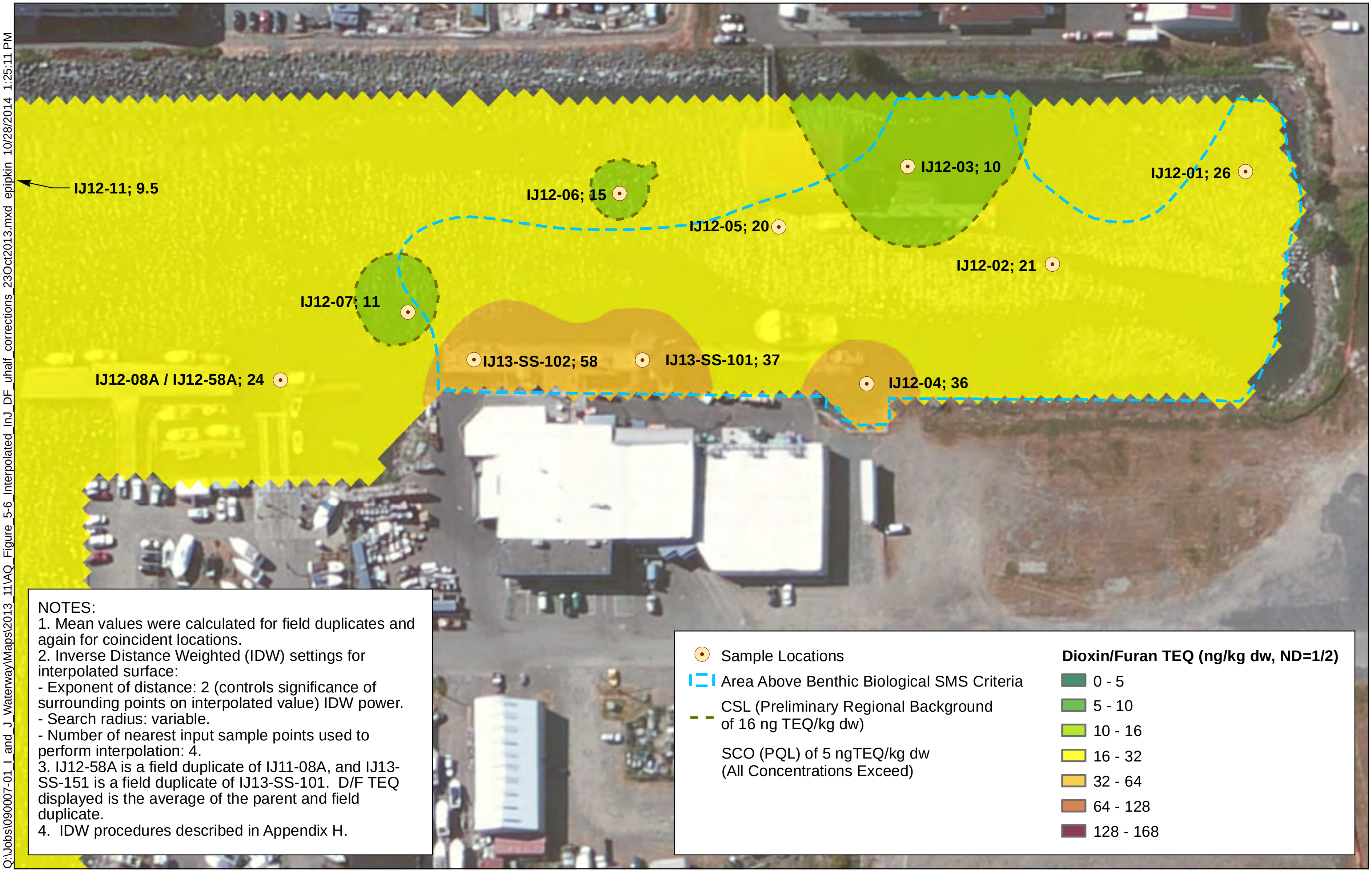
Figure 5-5
Surface Sediment and Storm Drain Solid Dioxin/Furan TEQ Concentrations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



NOTES:
1. Mean values were calculated for field duplicates and again for coincident locations.
2. Inverse Distance Weighted (IDW) settings for interpolated surface:
- Exponent of distance: 2 (controls significance of surrounding points on interpolated value) IDW power.
- Search radius: variable.
- Number of nearest input sample points used to perform interpolation: 4.
3. IJ12-58A is a field duplicate of IJ11-08A, and IJ13-SS-151 is a field duplicate of IJ13-SS-101. D/F TEQ displayed is the average of the parent and field duplicate.
4. IDW procedures described in Appendix H.

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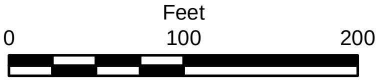

Figure 5-6

Interpolated I&J Waterway Surface Sediment Dioxin/Furan TEQ Concentrations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

Q:\Jobs\090007-01 I and J Waterway\Maps\2013 11\AQ Figure 5-6 Interpolated InJ DF uhalf corrections 23Oct2013.mxd epipkin 10/28/2014 1:25:11 PM

Q:\Jobs\090007-01 I and J Waterway\Maps\2013 10\AQ Figure 5-7 Interpolated BBay DF uhalf corrections 23Oct2013.mxd epipkin 10/28/2014 1:27:56 PM

NOTES:

1. Mean values were calculated for field duplicates and again for coincident locations.
2. Dioxin/Furan TEQ data sources:
   - I&J Waterway 2013
   - I&J Waterway 2012
   - Whatcom Waterway Pre-Remedial Design Investigation
   - Dioxins and Furans in Surface Sediments of Bellingham Bay
   - DNR Dioxin Study
   - Bellingham Bay Creosote Piling and Structure Removal Evaluation, Hart Crowser Sediment Investigation.
3. Inverse Distance Weighted (IDW) settings for interpolated surface:
   - Input sample data were normalized using Natural Log transformation
   - Exponent of distance: 2 (controls significance of surrounding points on interpolated value) IDW power
   - Search radius: variable
   - Number of nearest input sample points used to perform interpolation: 4
4. IDW procedures described in Appendix H.

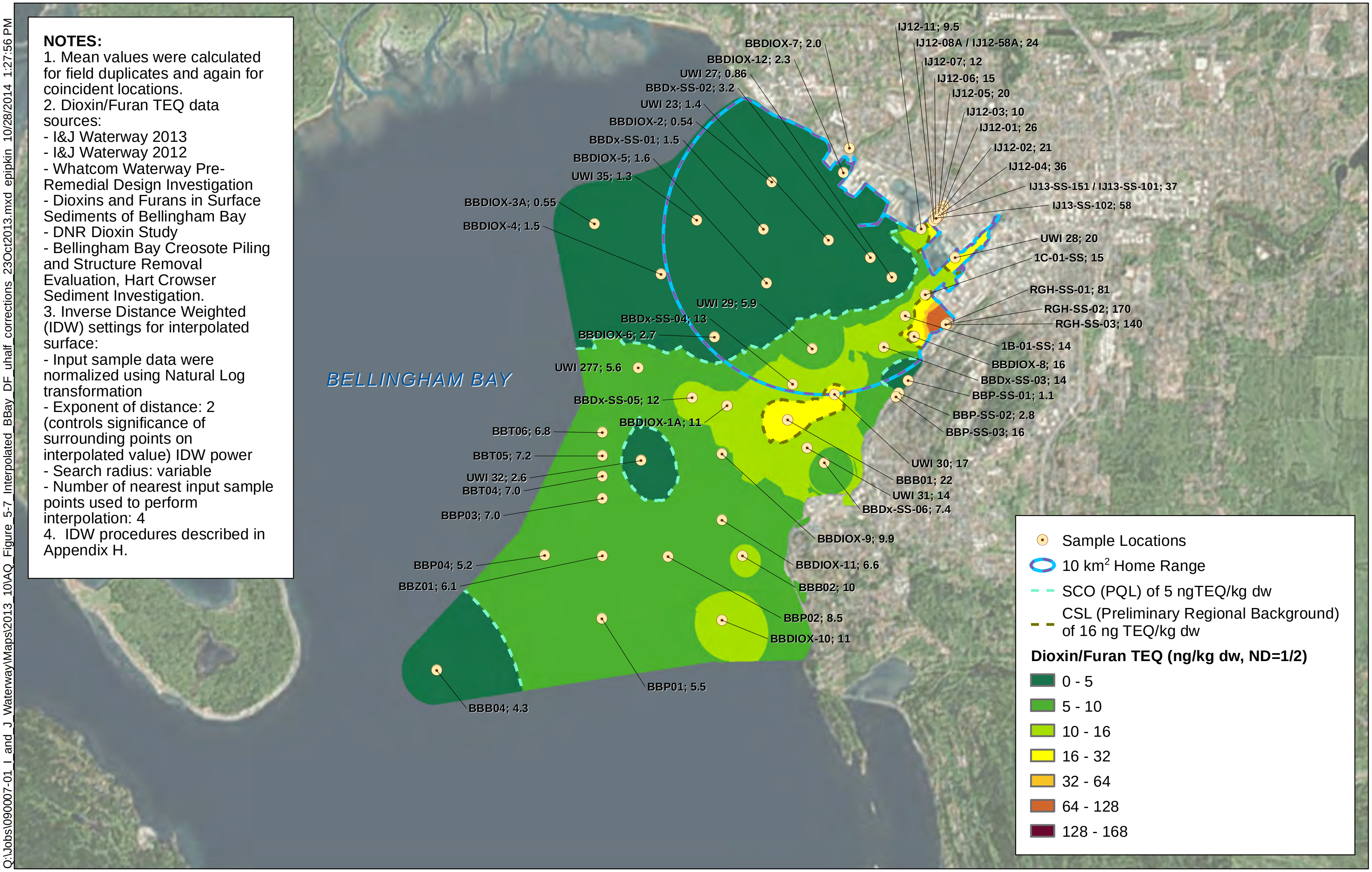

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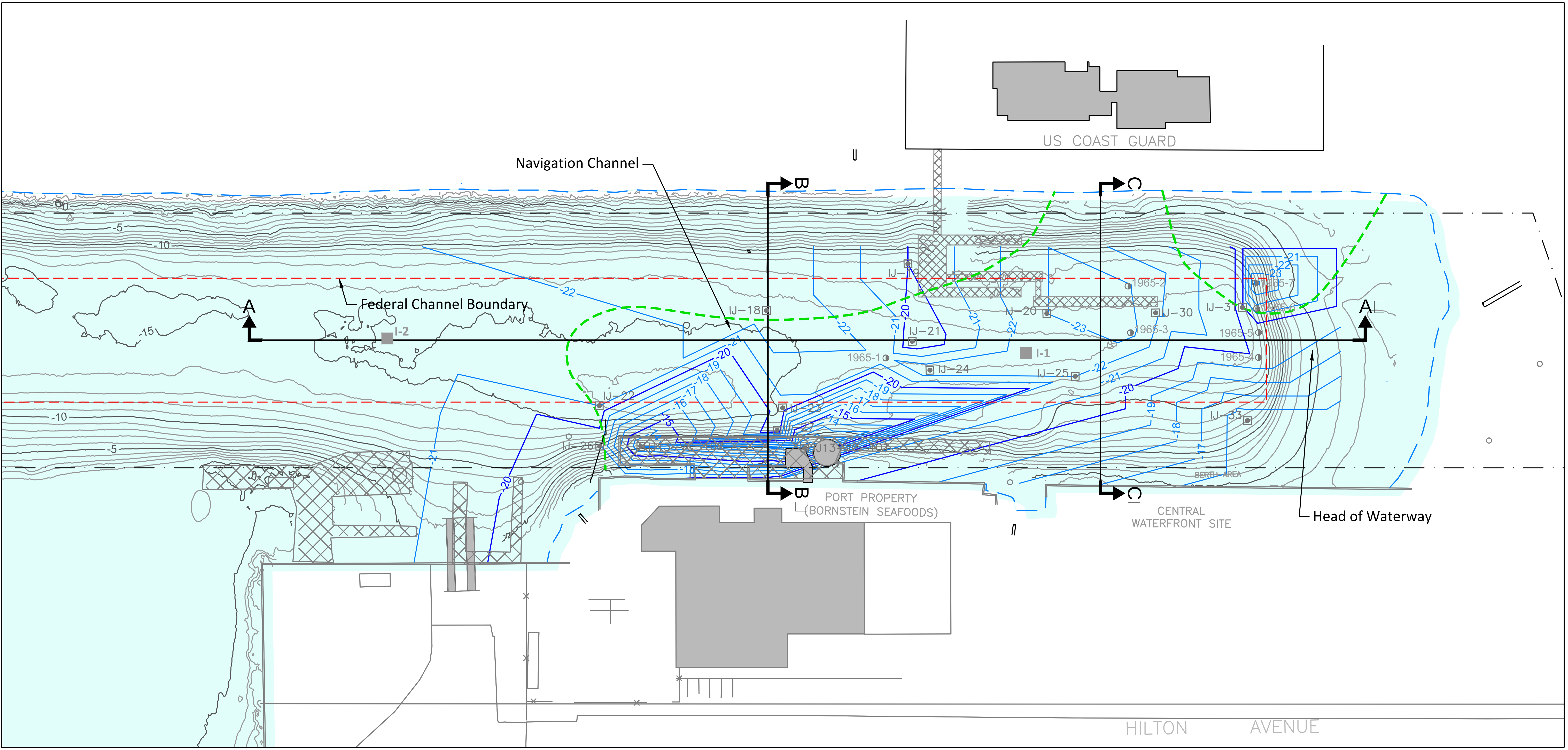
Figure 5-7

Interpolated Bellingham Bay Surface Sediment Dioxin/Furan TEQ Concentrations
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).
NOTE: Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ▩ Existing Structures
- Federal Channel Boundary
- Existing Shoreline
- Central Waterfront Site Boundary
- I&J Waterway Boundary
- Area Above SMS Criteria
- Existing Contours (1' and 5')
- Clay Surface Contours (1' and 5')

Sample Station Used in Clay Surface Interpolation

- ■ Subsurface Sediment Chemistry Sample Location (USACE 2011)
- ▣ Colocated Surface Grab and Core Location (Anchor QEA 2013)
- ◑ Historical Sample Station

0 80
Scale in Feet

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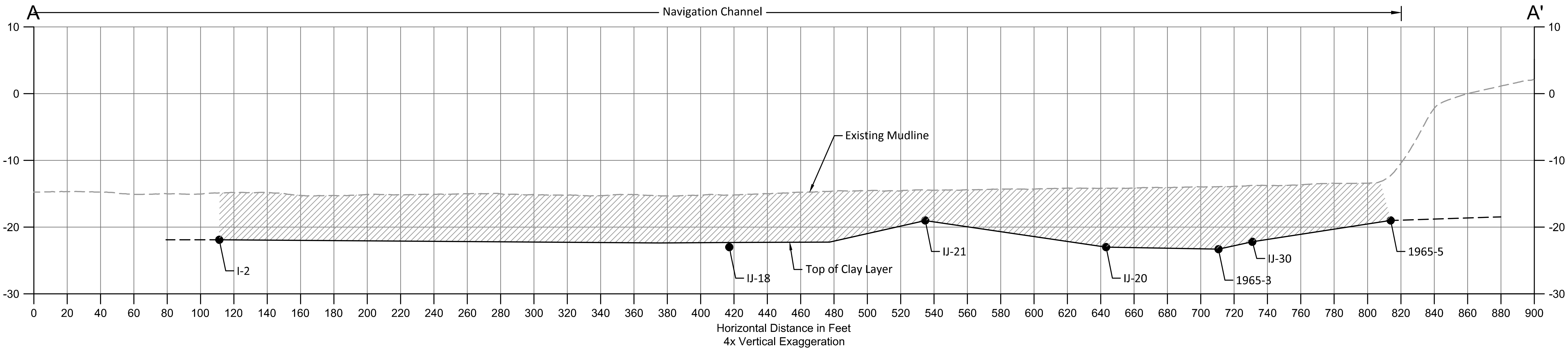
Figure 5-8
Interpolated Elevation of Clay Layer
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE: Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

LEGEND:

- – – – Existing Mudline
- —— Interpolated Top of Clay layer
- ▨ Sediment Above Native Clay
- ● Core Location

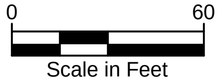


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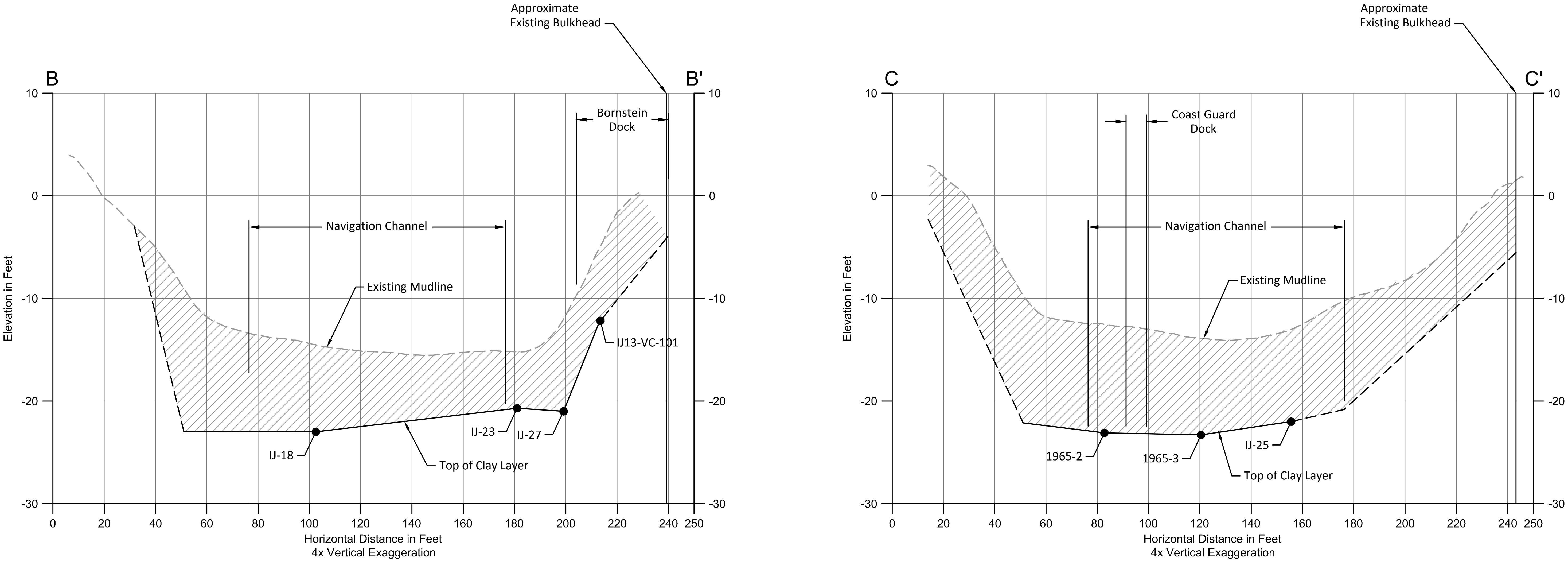
Figure 5-9

Cross Section A-A' Interpolated Elevation of Clay Layer
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE: Clay elevations developed based on cores collected in 2006 and 2011 and original post-dredge bathymetric surveys from 1966.

LEGEND:

– – –	Existing Mudline
───	Interpolated Top of Clay layer
▨	Sediment Above Native Clay
●	Core Location

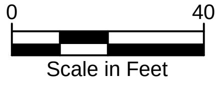


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Figure 5-10
Cross Sections B-B' and C-C' Interpolated Elevation of Clay Layer
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Storm Drain Features

- ▣ Sampled Catch Basin
- ▽ Surveyed Storm Drain
- ▣ Surveyed Catch Basin
- ▣ Other Catch Basin
- ⊕ Outfall
- ⊕ Bornstein Outfall (Permitted)
- ⊕ Outfall - Unknown Drainage Area

- —— Main
- -·-· Estimated Stormwater Pipe Location

NOTES:
1. Storm drain features from City of Bellingham GIS, site observations along bulkhead of Bornstein property, and supporting documents submitted for modification of industrial stormwater permit.
2. Bornstein permitted outfalls shown are from General Permit for Industrial Stormwater No.WAR000679. May, 2011.

Feet
0 60 120 180 240

R:\Jobs\090007-01_I&J_Waterway\Maps\2013_04\IJ_Stormwater_Drains.mxd epipkin 6/3/2014 4:19:00 PM

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Figure 6-1
I&J Waterway Stormwater Catch Basins
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

Apr 23, 2014 2:59pm epipkin R:\Jobs\090007-01_I&J_Waterway\Maps\2014_02\6-2 Natural Recovery Cores.dwg Figure 6-2

SOURCE: Drawing prepared from Figure 3-4, RETEC 2006a.

NOTE: Sediment traps HC-ST-100 and HC-ST-101 are co-located with HC-NR-100 and HC-NR-101, respectively.

Figure 6-2
Natural Recovery Cores
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

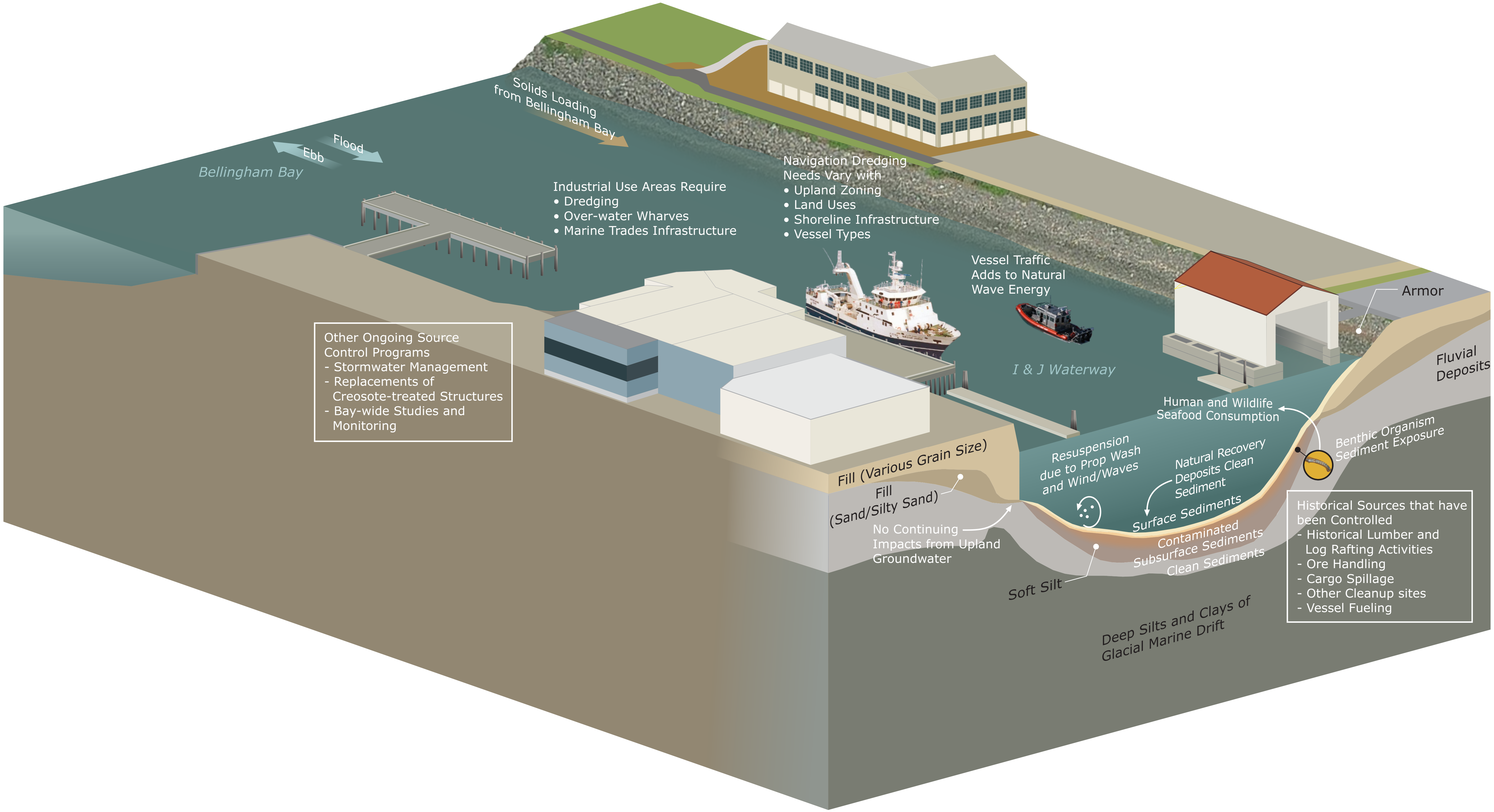

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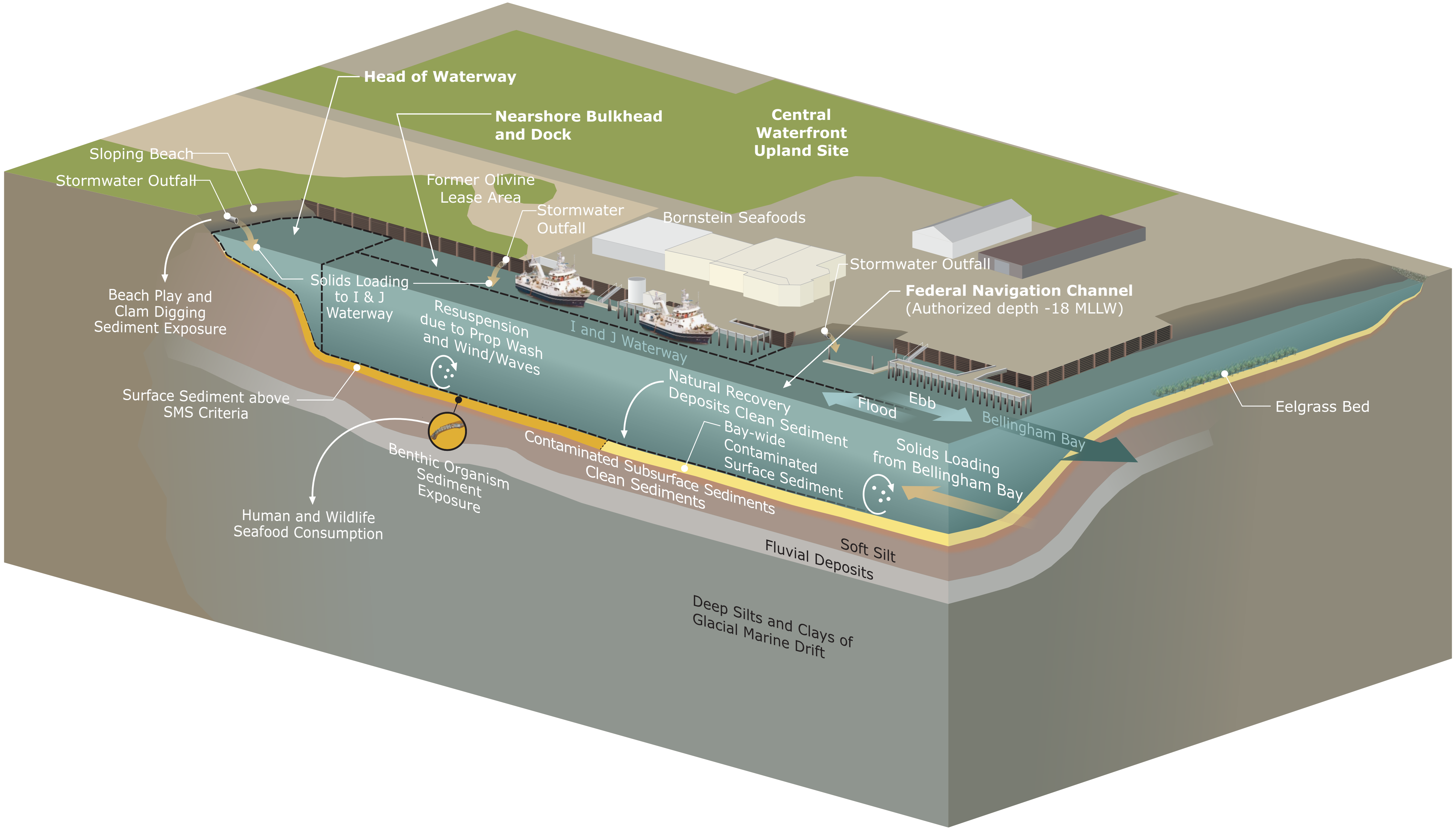
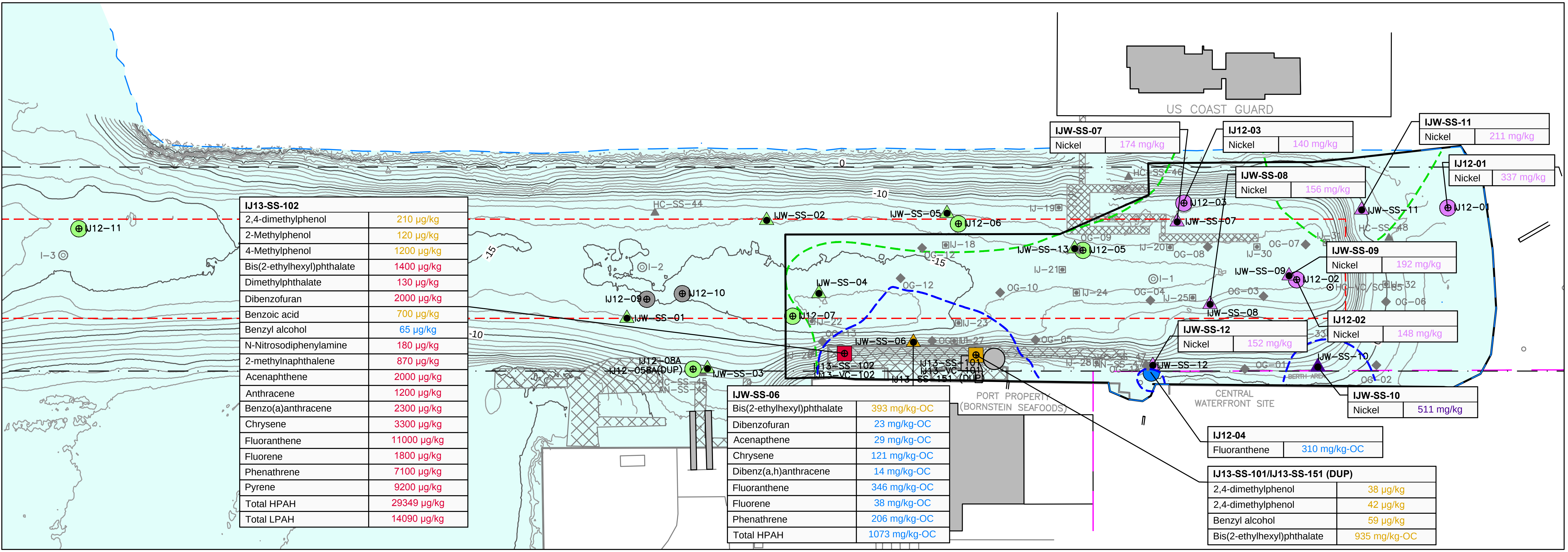
Figure 7-1
Conceptual Site Model - Part 1 of 2
Waterway Conceptual Cross Section and Northern Shoreline
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham



6/4/2014 heriksen T:/CAD/Projects/0007-Port of Bellingham/I&J Waterway RI-FS/Corel/00007-RP-002.cdr

Figure 7-2
Conceptual Site Model - Part 2 of 2
Waterway Conceptual Cross Section and Northern Shoreline
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham



IJ13-SS-102	
2,4-dimethylphenol	210 µg/kg
2-Methylphenol	120 µg/kg
4-Methylphenol	1200 µg/kg
Bis(2-ethylhexyl)phthalate	1400 µg/kg
Dimethylphthalate	130 µg/kg
Dibenzofuran	2000 µg/kg
Benzoic acid	700 µg/kg
Benzyl alcohol	65 µg/kg
N-Nitrosodiphenylamine	180 µg/kg
2-methylnaphthalene	870 µg/kg
Acenaphthene	2000 µg/kg
Anthracene	1200 µg/kg
Benzo(a)anthracene	2300 µg/kg
Chrysene	3300 µg/kg
Fluoranthene	11000 µg/kg
Fluorene	1800 µg/kg
Phenathrene	7100 µg/kg
Pyrene	9200 µg/kg
Total HPAH	29349 µg/kg
Total LPAH	14090 µg/kg

IJW-SS-06	
Bis(2-ethylhexyl)phthalate	393 mg/kg-OC
Dibenzofuran	23 mg/kg-OC
Acenapthene	29 mg/kg-OC
Chrysene	121 mg/kg-OC
Dibenz(a,h)anthracene	14 mg/kg-OC
Fluoranthene	346 mg/kg-OC
Fluorene	38 mg/kg-OC
Phenathrene	206 mg/kg-OC
Total HPAH	1073 mg/kg-OC

IJW-SS-07	
Nickel	174 mg/kg

IJ12-03	
Nickel	140 mg/kg

IJW-SS-11	
Nickel	211 mg/kg

IJ12-01	
Nickel	337 mg/kg

IJW-SS-08	
Nickel	156 mg/kg

IJW-SS-09	
Nickel	192 mg/kg

IJW-SS-12	
Nickel	152 mg/kg

IJ12-02	
Nickel	148 mg/kg

IJW-SS-10	
Nickel	511 mg/kg

IJ12-04	
Fluoranthene	310 mg/kg-OC

IJ13-SS-101/IJ13-SS-151 (DUP)	
2,4-dimethylphenol	38 µg/kg
2,4-dimethylphenol	42 µg/kg
Benzyl alcohol	59 µg/kg
Bis(2-ethylhexyl)phthalate	935 mg/kg-OC

LEGEND:

▨	Docks or Piers (Over Water Structures)
▬	Existing Structures
– –	Existing Shoreline
—-10—	Bathymetric Contour (1-foot interval)
— —	Central Waterfront Site Boundary
— · —	I & J Waterway Boundary
- - -	Federal Channel Boundary
- - -	Area Above Benthic Biological Criteria
- - -	Area Above cPAH Action Level (610 µg/kg)
——	Cleanup Footprint

2012/2013 RI/FS and Historic Sediment Sampling Station

HC–SS–47 ▲	Whatcom Waterway Sediment Grab Sample Location (Hart Crowser 1997)
HC–VC/SC–85 ⊙	Whatcom Waterway Sediment Core Location (Hart Crowser 1997)
AN–SS–47 ▲	Bioassay Sample Location (Anchor 2000)
OG–10 ◆	Surface Sediment Grab Sample Location (ThermoRetec 2001)
IJ–28 ▣	Subsurface DMMP Composite Sample Location (RETEC 2006)
IJW–SS–02 ●	Surface Sample Location (RETEC 2006)
I–2 ◎	Subsurface Sample Location (USACE 2011)
IJ12–10 ⊕	Surface Sediment Sample Location (Anchor QEA 2013)

Benthic Chemical Criteria

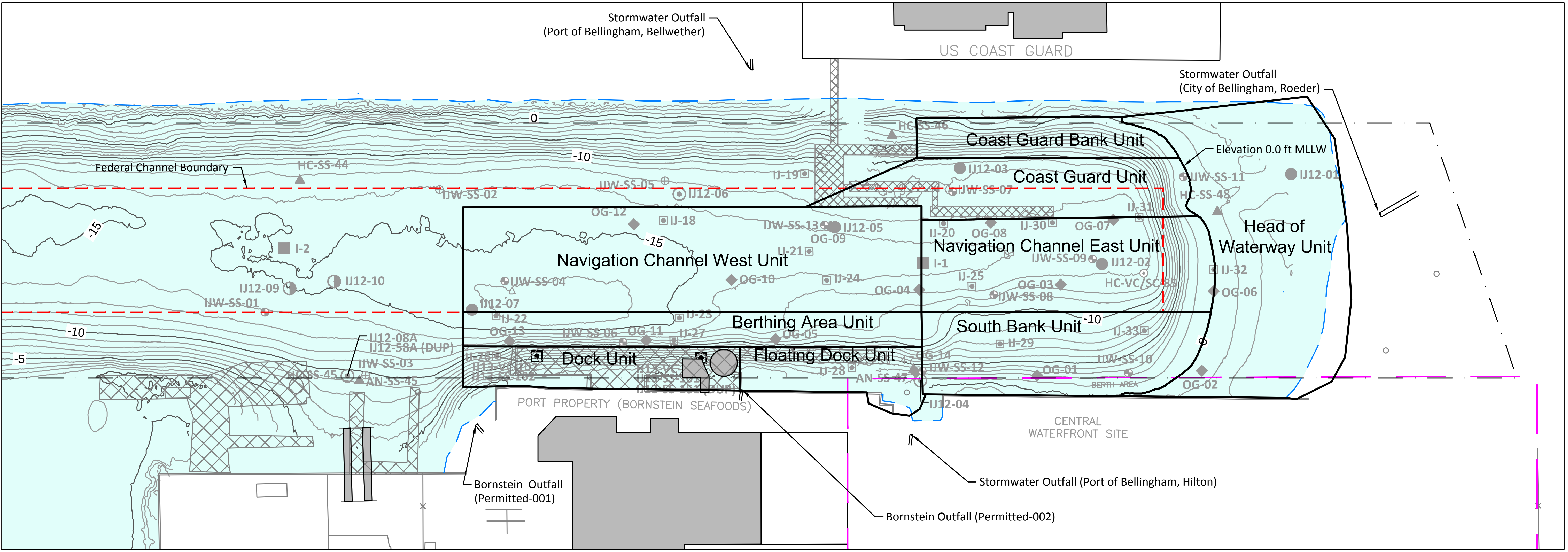
2005/2006	2012	2013	
△	○	■	No Exceedances
▲	●	■	SCO Exceedances
▲	●	■	CSL Exceedances
		■	LAET Exceedances
△	○		Nickel > 140 mg/kg (Former DMMP Screening Level)
▲	●		Nickel > 370 mg/kg (Former DMMP Bioaccumulation Trigger)
▲	●		Archived

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTES:
1. CSL = Cleanup Screening Level.
2. LAET = Lowest Apparent Effect Threshold
3. SCO = Sediment Cleanup Objective.
4. IJ12-08A is IJ12-08 alternative sample location.
5. cPAH concentrations are shown on Figure 5-3.
6. Bathymetric survey from eTrac dated April 5, 2012.

Figure 8-1
Remediation Footprint and Surface Sediment Chemical Exceedances
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



LEGEND:

▨	Docks or Piers (Over Water Structures)
▬	Existing Structures
— — —	Federal Channel Boundary
— — —	Existing Shoreline
— — —	Central Waterfront Site Boundary
— · —	I&J Waterway Boundary
—-10—	Bathymetric Contour (1-foot interval)

RI/FS Sediment Sampling Station

■	Subsurface Sediment Chemistry Sample Location (USACE 2011)
⊙	Surface Sediment Chemistry Sample Location (Anchor QEA 2013)
▣	Colocated Surface Grab and Core Location (Anchor QEA 2013)
●	Surface Sediment Chemistry and Bioassay Sample Location (Anchor QEA 2013)
◑	Archive Surface Sediment Sample Location (Anchor QEA 2013)
IJ-28 ▣	Subsurface DMMP Composite Sample Location (RETEC 2006)
IJW-SS-02 ⊕	Surface Sample Chemistry Location (RETEC 2006)
IJW-SS-10 ⊕	Surface Sample Chemistry and Bioassay Location (RETEC 2006)
HC-VC/SC-85 ⊙	Whatcom Waterway Sediment Core (Hart Crowser 1997)

Historical Sampling Station

HC–SS–47 ▲	Whatcom Waterway Sediment Grab Sample Location (Hart Crowser 1997)
AN–SS–47 ▲	Bioassay Sample Location (Anchor Environmental 2000)
OG–10 ◆	Surface Sediment Grab Sample Location (ThermoRetec 2001)

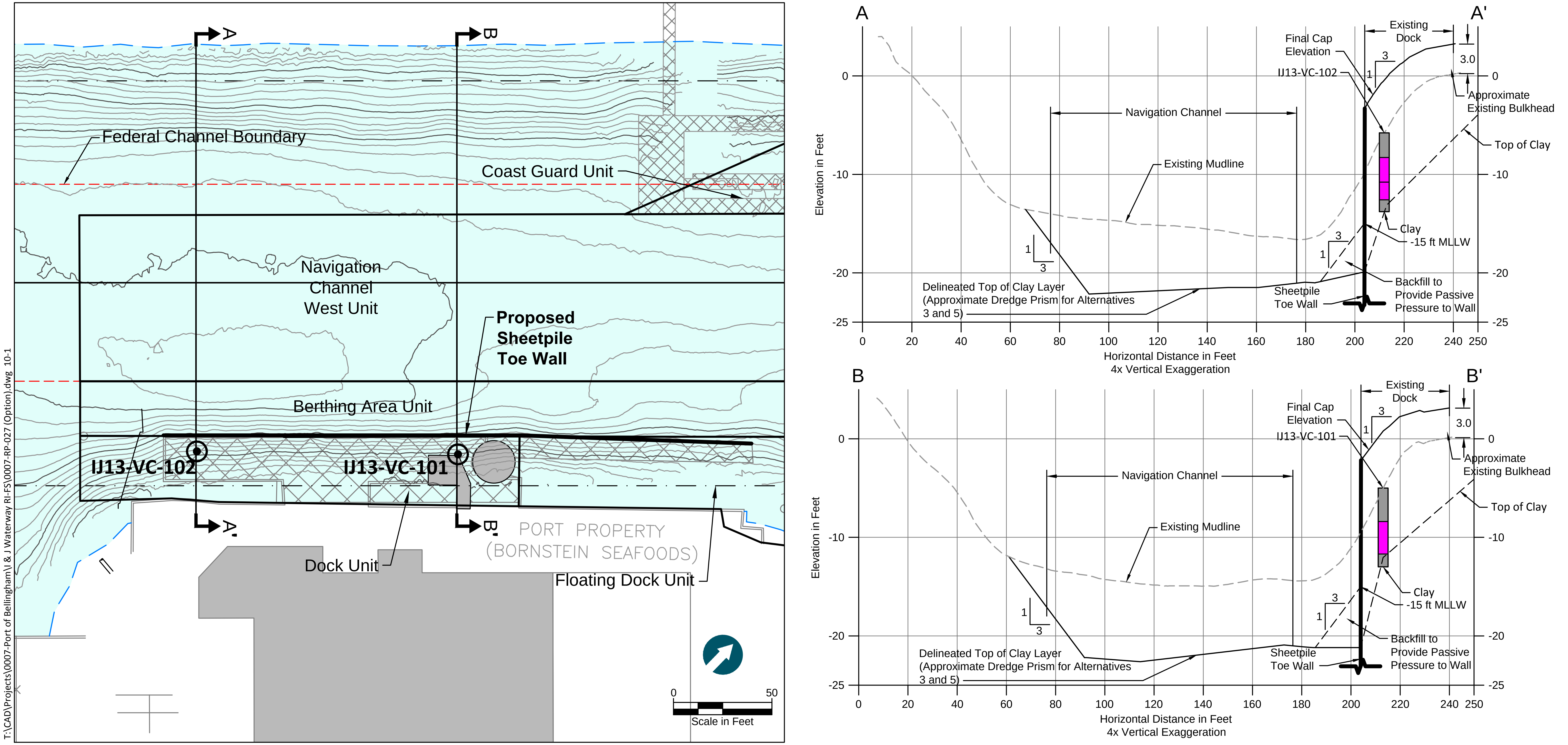
0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

NOTE:

1. Bathymetric survey from eTrac dated April 5, 2012.

Figure 9-1
Site Units
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).
NOTE: Under dock capping applicable to Alternatives 1, 2, 3, and 5.

LEGEND:
- ▨ Docks or Piers (Over Water Structures)
- ▒ Existing Structures
- Federal Channel Boundary
- Existing Shoreline
- I&J Waterway Boundary
- Existing Contours (1' and 5')
- Proposed Site Unit
- Existing Mudline
- Inferred Bathymetry
- Final Dredge Elevation
- ▒ Not Analyzed
- ▒ > CSL (Benthic)

0 40
Scale in Feet

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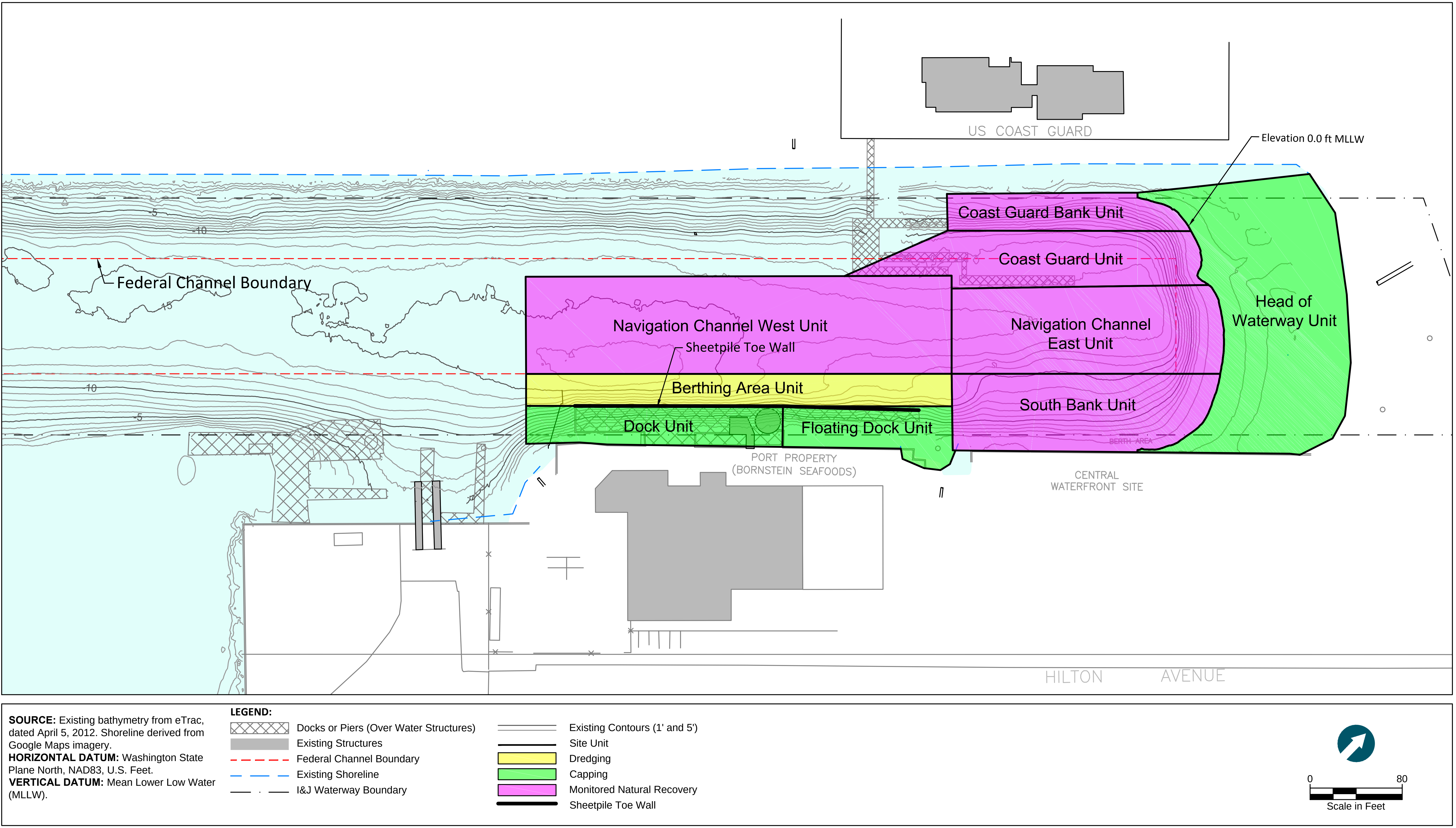
Figure 10-1
Cap with Sheetpile Toe Wall
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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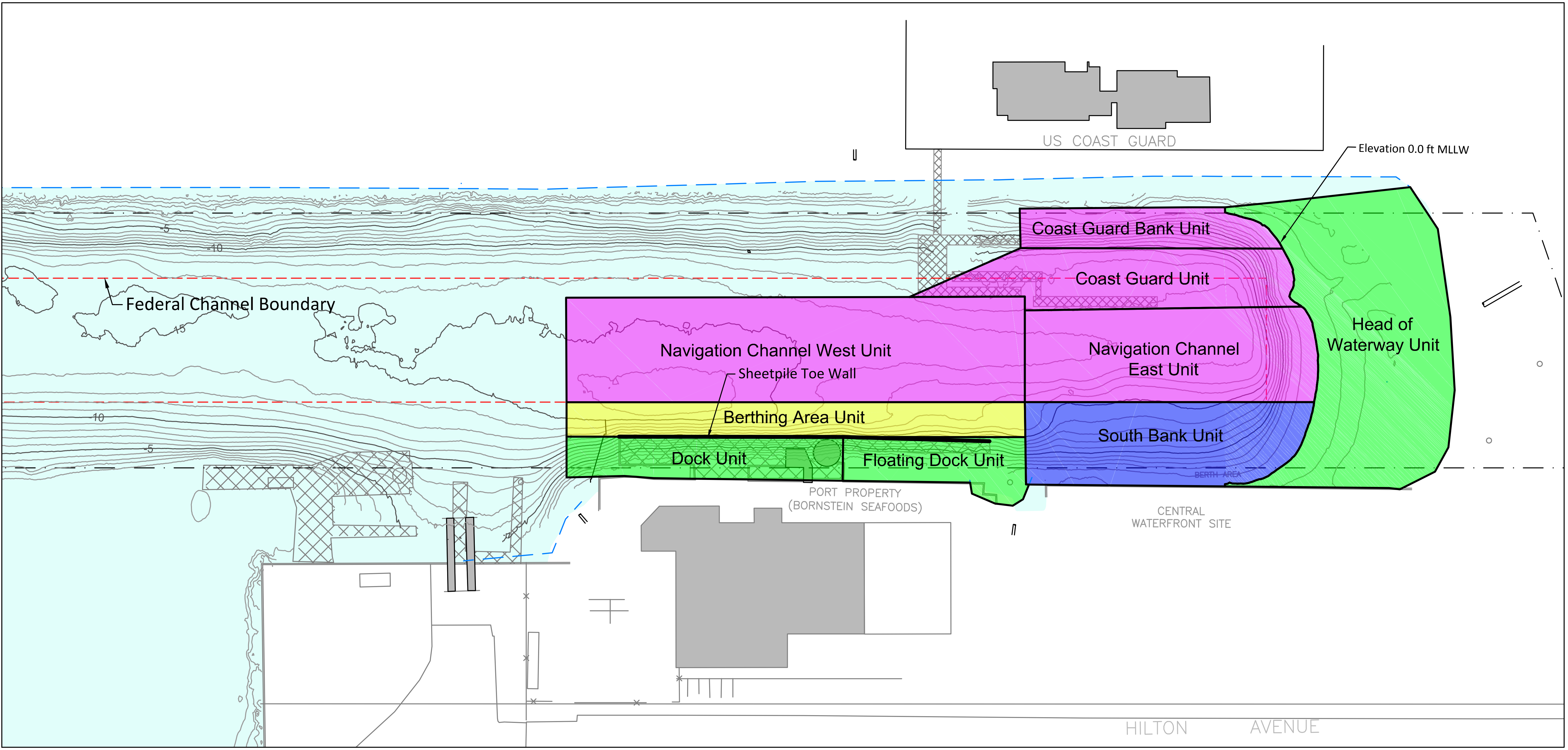
Figure 11-1
Alternative 1
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

▨	Docks or Piers (Over Water Structures)
▬	Existing Structures
– – –	Federal Channel Boundary
– – –	Existing Shoreline
— · —	I&J Waterway Boundary
═	Existing Contours (1' and 5')
—	Site Unit
🟨	Dredging
🟩	Capping
🟦	Enhanced Natural Recovery
🟪	Monitored Natural Recovery
━	Sheetpile Toe Wall

0 80
Scale in Feet

Figure 11-2
Alternative 2
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham

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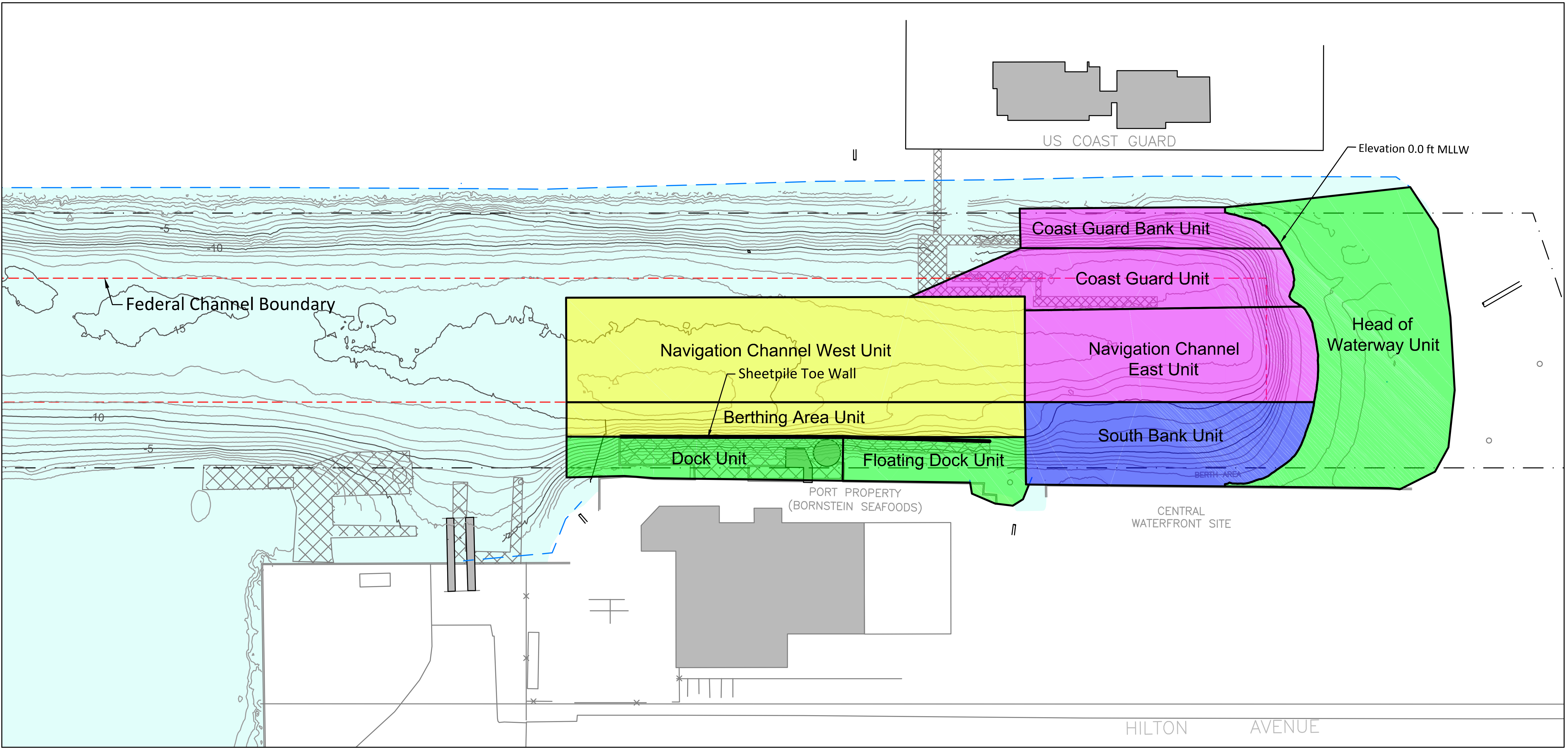

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Jun 04, 2014 9:35am epipkin

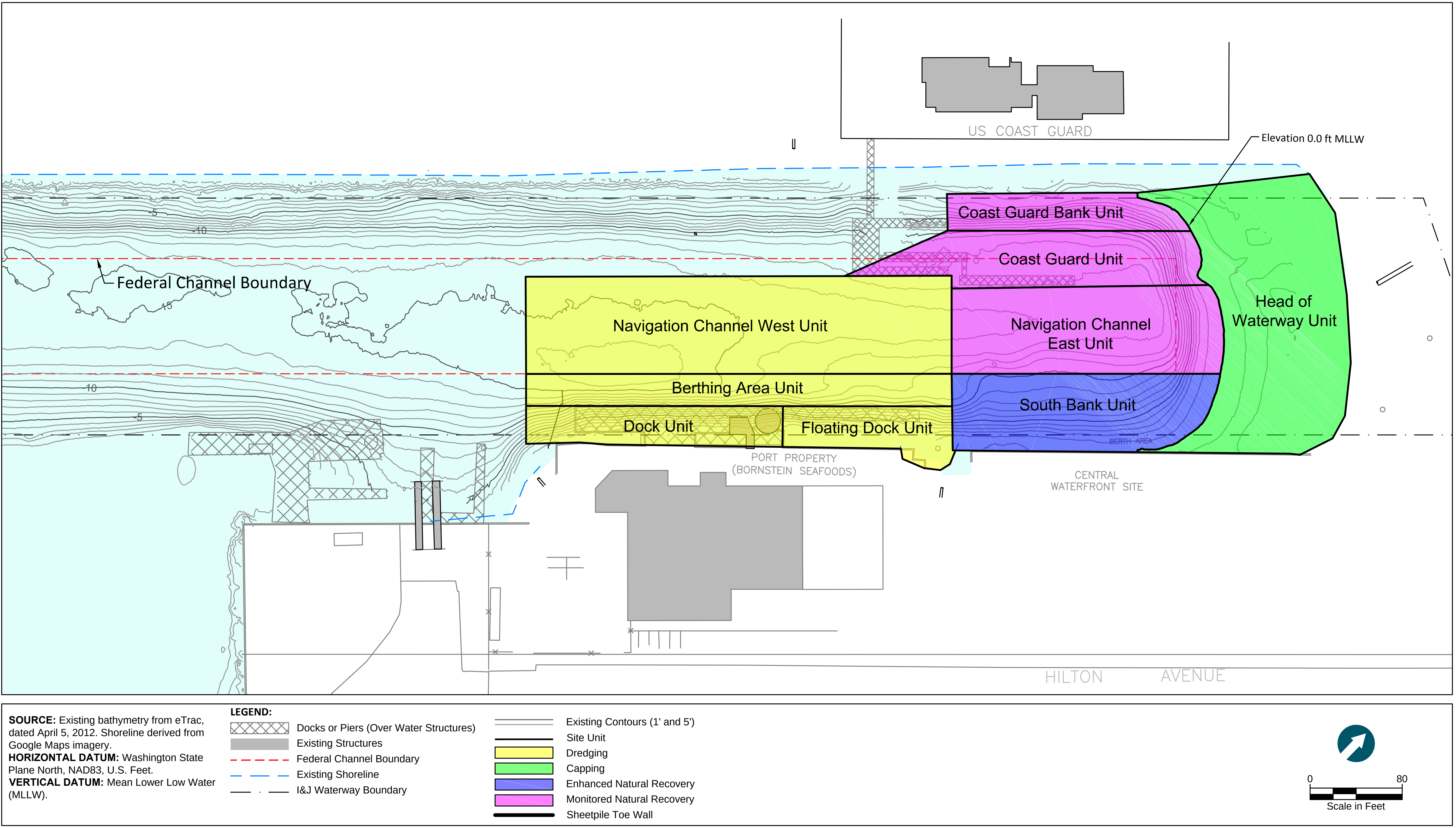
SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ⬜ Existing Structures
- – – – Federal Channel Boundary
- – – – Existing Shoreline
- — · — I&J Waterway Boundary
- ═ Existing Contours (1' and 5')
- — Site Unit
- 🟨 Dredging
- 🟩 Capping
- 🟦 Enhanced Natural Recovery
- 🟪 Monitored Natural Recovery
- ━ Sheetpile Toe Wall

0 80
Scale in Feet

Figure 11-3
Alternative 3
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

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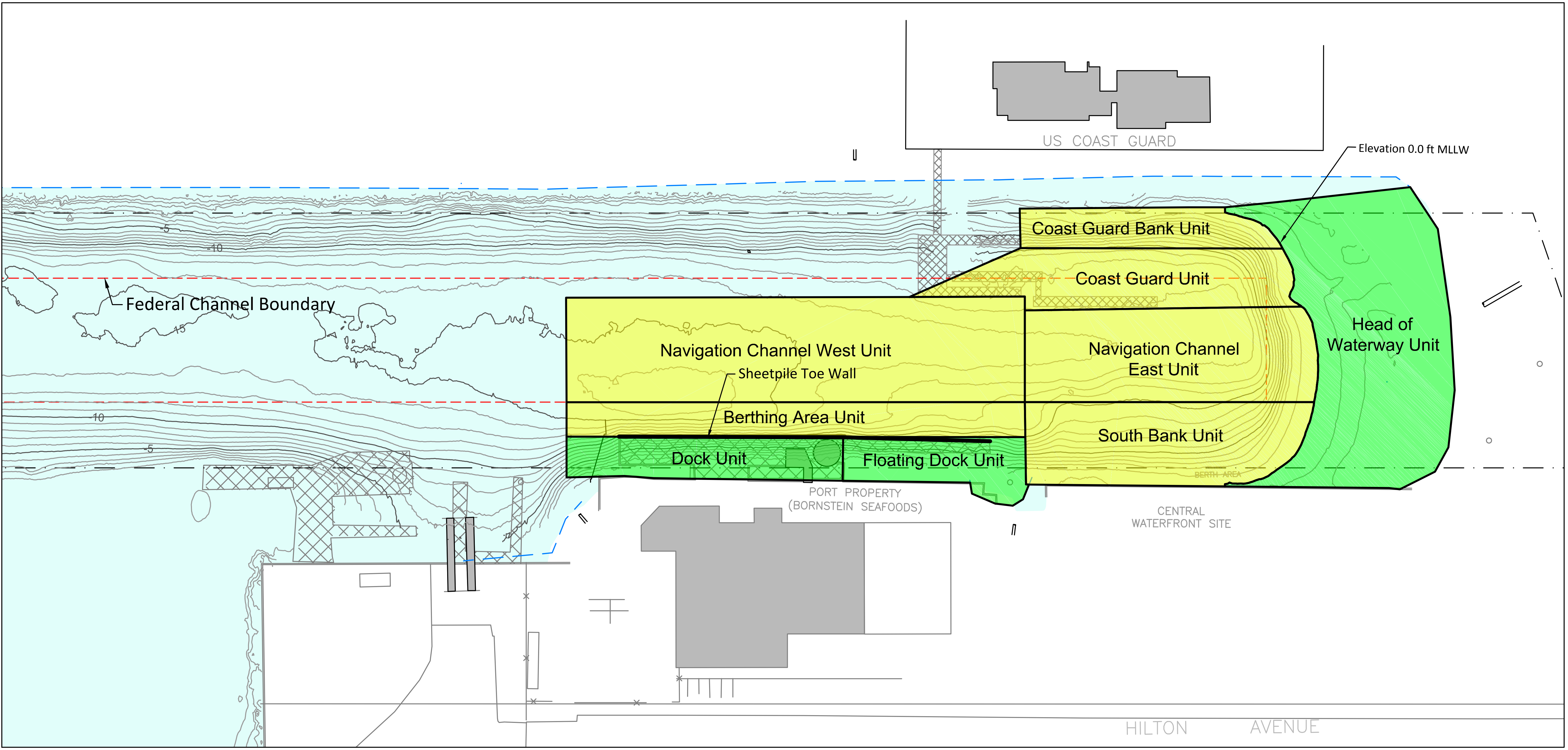
Figure 11-4
Alternative 4
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham



SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ▬ Existing Structures
- – – – Federal Channel Boundary
- – – – Existing Shoreline
- — · — I&J Waterway Boundary
- ═ Existing Contours (1' and 5')
- — Site Unit
- 🟨 Dredging
- 🟩 Capping
- ━ Sheetpile Toe Wall

0 80
Scale in Feet

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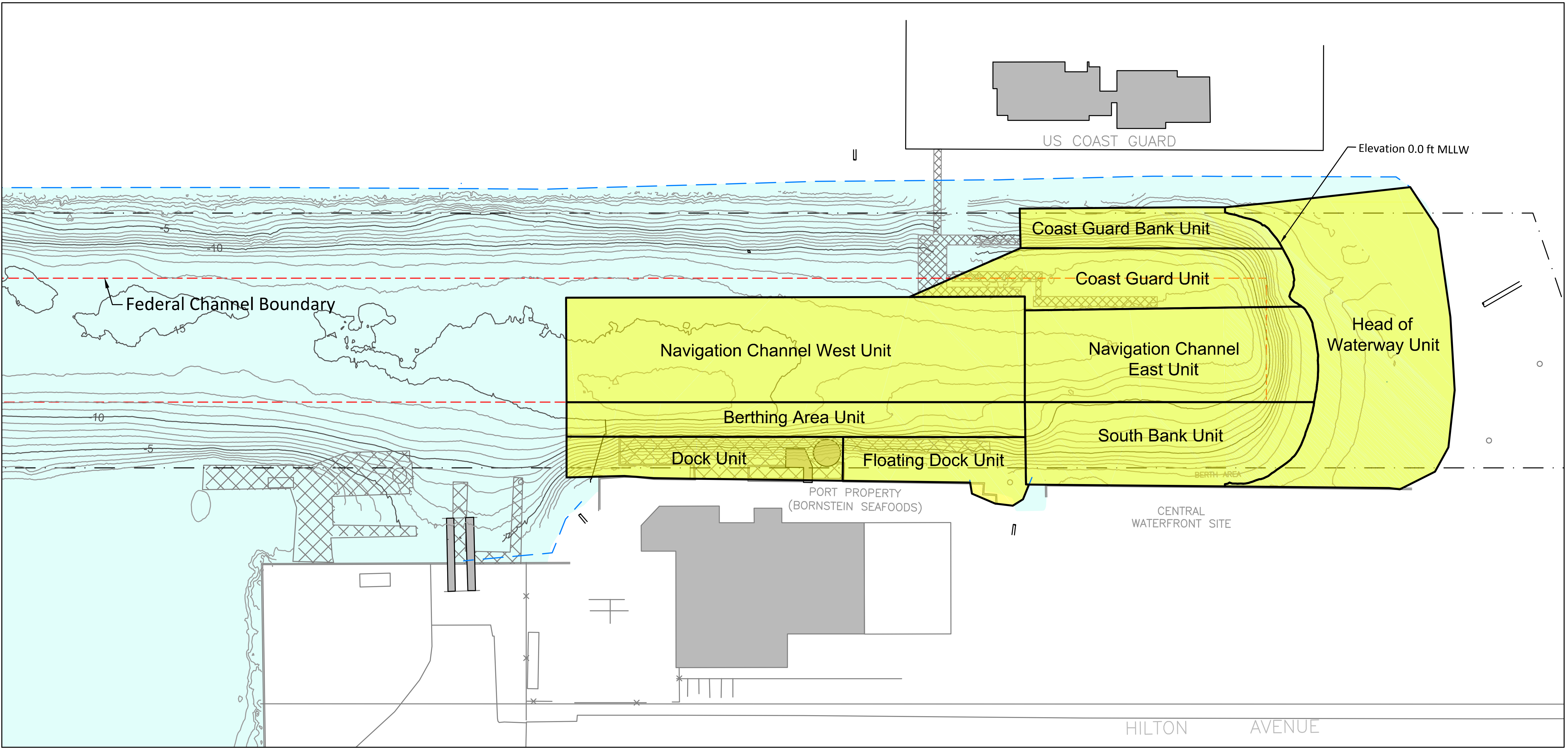
Figure 11-5
Alternative 5
Draft RI/FS Report
I & J Waterway Site
Port of Bellingham



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Jun 04, 2014 9:34am epipkin

SOURCE: Existing bathymetry from eTrac, dated April 5, 2012. Shoreline derived from Google Maps imagery.
HORIZONTAL DATUM: Washington State Plane North, NAD83, U.S. Feet.
VERTICAL DATUM: Mean Lower Low Water (MLLW).

LEGEND:

- ▨ Docks or Piers (Over Water Structures)
- ▇ Existing Structures
- - - - Federal Channel Boundary
- - - - Existing Shoreline
- — · — I&J Waterway Boundary
- ═ Existing Contours (1' and 5')
- — Site Unit
- 🟨 Dredging

0 80
Scale in Feet

Figure 11-6
Alternative 6
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

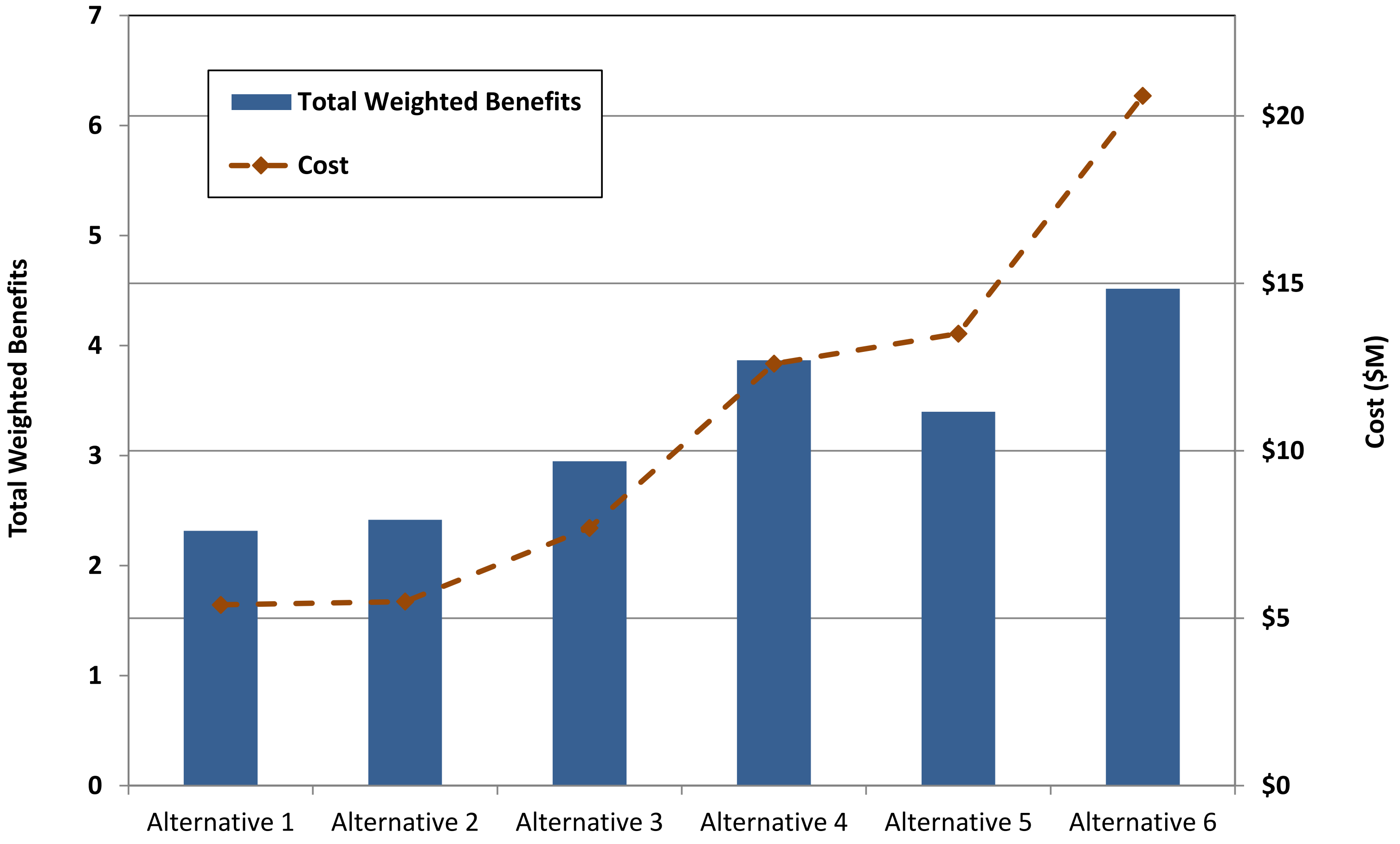

Figure 12-1
Disproportionate Cost Analysis Summary – Bar Chart
Draft RI/FS Report
I&J Waterway Site
Port of Bellingham

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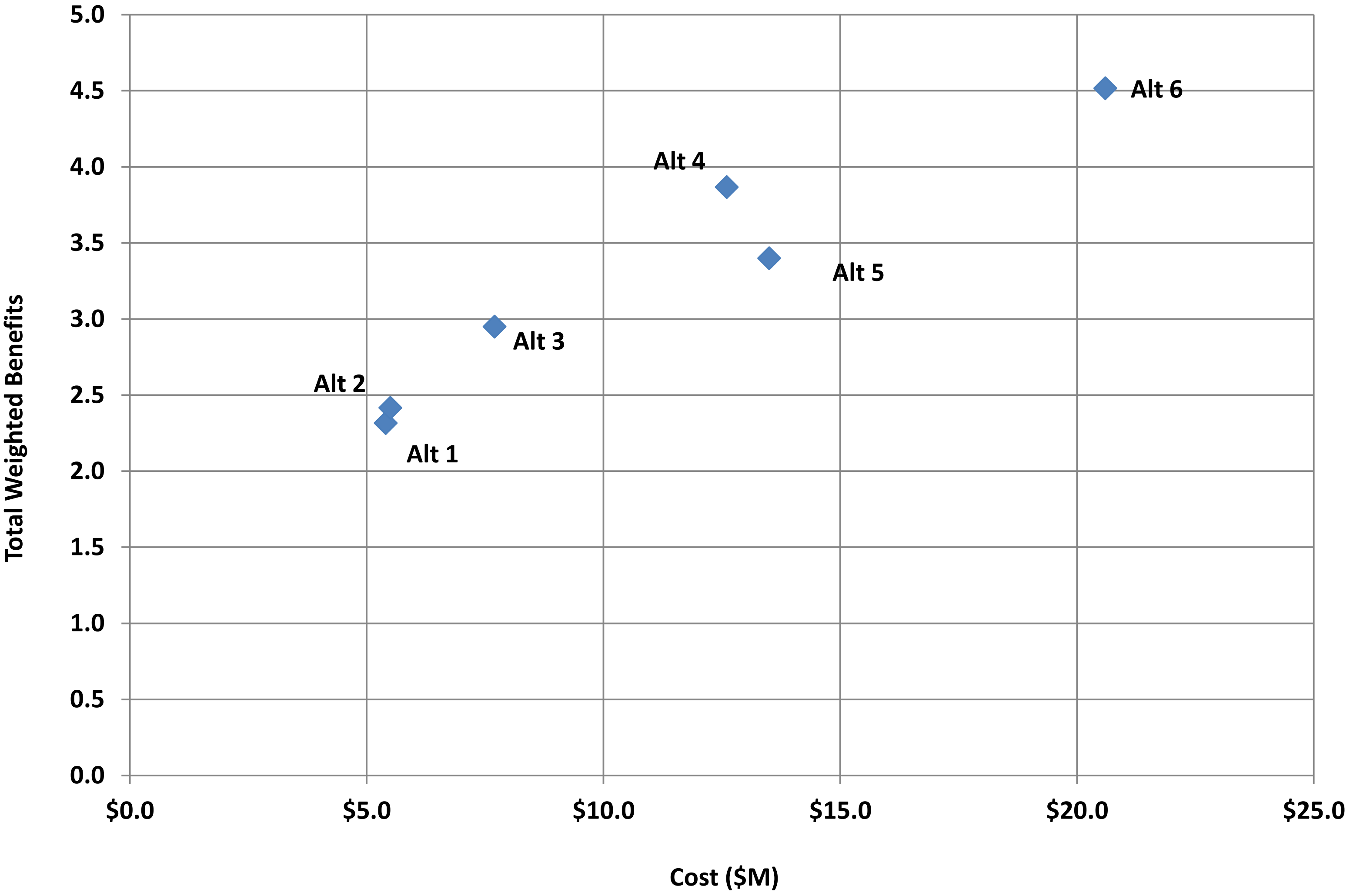

Figure 12-2

Disproportionate Cost Analysis Summary – Scatter Plot

Draft RI/FS Report

I&J Waterway Site

Port of Bellingham

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