REPORT

FEASIBILITY STUDY
FORMER POPE & TALBOT INC. SAWMILL SITE, PORT GAMBLE, WASHINGTON

Prepared for

Pope Resources LP and Olympic Property Group L.L.C.
Poulsbo, Washington 98370

Washington Department of Ecology
Olympia, Washington 98504

Prepared by

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Seattle, Washington 98101

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
μg/L	micrograms per liter
bgs	below ground surface
BMP	best management practice
CAP	Cleanup Action Plan
cm	centimeters
Corps	U.S. Army Corps of Engineers
cPAH	carcinogenic polynuclear aromatic hydrocarbon
CQAP	construction quality assurance project plan
CSL	Cleanup Screening Level
CSM	conceptual site model
CWA	Clean Water Act
cy	cubic yards
DAHP	Washington Department of Archaeology and Historic Preservation
DCA	MTCA Disproportionate Cost Analysis
DMMO	Dredge Material Management Office
DMMP	Dredge Material Management Program
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
ENR	enhanced natural recovery
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GIS	Geographic Information System
HPA	Hydraulic Project Approval
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLLW	mean lower low water
MNR	monitored natural recovery
MTCA	Model Toxics Control Act
NHPA	National Historic Preservation Act
NWP	Nationwide Permit

OPG	Olympic Property Group, L.L.C.
P&T	Pope & Talbot, Inc.
pg/g	picograms per gram
ppt	parts per thousand
PQL	practical quantitation limit
PR	Pope Resources, LP
PSDDA	Puget Sound Dredge Disposal Analysis
PSEP	Puget Sound Estuary Program
RCW	Revised Code of Washington
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SEPA	State Environmental Policy Act
SMA	sediment management area
SMS	Sediment Management Standards
SPI	sediment profile imaging
SQS	Sediment Quality Standard
TEE	terrestrial ecological evaluation
TEQ	toxicity equivalent quotient
TOC	total organic carbon
TVS	total volatile solids
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WSDOT	Washington State Department of Transportation

1 INTRODUCTION

Pope Resources LP (PR) and Olympic Property Group L.L.C. (OPG) conducted a Remedial Investigation/Feasibility Study (RI/FS) at the former Pope & Talbot Inc. (P&T) Sawmill Site (hereinafter the "Port Gamble Mill Site" or "Site") in Port Gamble, Washington, under the terms of the Washington State Department of Ecology (Ecology) Agreed Order No. DE 5631, implemented pursuant to the Model Toxics Control Act (MTCA), Revised Code of Washington (RCW) 70.105D.050 (1). Sampling under the Ecology-approved RI/FS Work Plan and Sampling and Analysis Plan (SAP) (Anchor and EPI 2008) was initiated in July 2008. The RI report was finalized in October 2010 (Anchor QEA and EPI 2010), and included a summary of interim remedial actions previously completed at the Site, and evaluations of site characterization data describing the nature and extent of soil, groundwater, and sediment contamination at the Site.

The purpose of this FS is to develop and evaluate cleanup action alternatives to enable a final cleanup action to be selected by Ecology for both the uplands and marine areas of the Site, recognizing the prior interim actions that have been completed addressing soil, groundwater, and sediment contamination. In accordance with the MTCA Cleanup Regulation (Washington Administrative Code [WAC] 173-340), for those areas of the Site where concentrations of hazardous and/or deleterious substances no longer exceed cleanup levels at the point of compliance, no further cleanup actions are necessary.

1.1 Site Background

As defined by Ecology in the Agreed Order, the Site is generally located at the eastern terminus of Northeast View Drive in Port Gamble, Washington, and includes uplands, adjacent tidelands, and a portion of Port Gamble Bay. The Site is located in north Kitsap County, Washington, and includes the former sawmill property, which is bounded by Hood Canal to the north, Port Gamble Bay to the east, and the Kitsap Peninsula to the west and south (Figure 1-1).

The Site was continuously operated as a sawmill facility for a period of approximately 142 years (1853 to 1995). Over that period, the Site underwent a variety of changes, including expansion of the Site by filling, as well as changes in the location and function of buildings and structures. A detailed history of the Site operations is presented in Parametrix (1999) and is briefly summarized below.

In 1853, the corporate predecessor to P&T established one of the first sawmills on Puget Sound at the Site. At that time, the Site was a relatively small sand spit projecting east from the base of a bluff that forms the western boundary to the mouth of Port Gamble Bay. The Site occupied the location of a former Port Gamble S'Klallam Tribe village and possibly other areas of cultural significance.

The Port Gamble Bay region is known to be archaeologically sensitive. Archaeological site records on file at the Washington Department of Archaeology and Historic Preservation (DAHP) indicate that two aboriginal shell midden sites have been recorded on the eastern shore of the bay across from the Site. A third lithic and tool scatter site on the eastern side of the bay has historically been used as a cemetery by the Port Gamble S'Klallam Tribe. At the time of contact with American settlers, the Port Gamble area was home to a S'Klallam Tribe village, which relocated to the Point Julia ("Little Boston") village site directly across the bay when operations began at the sawmill in 1853.

The mill operated as a forest products manufacturing facility from 1853 to 1995. The Site underwent several changes over that period including filling activities, which expanded the upland area of the Site, moving building locations, and causing changes in functions of buildings and structures. Between 1853 and 1995, operations at the Site included a succession of sawmill buildings, two chip loading facilities, a log transfer facility, and log rafting and storage areas.

During the mill's operating period, logs were rafted and stored offshore of the sawmill property (Figure 1-2). In the late 1920s, a chip barge loading facility was installed on the north end of the Site (denoted the northern embayment). During the mid-1970s, an additional chip barge loading facility (referred to as the alder mill) was constructed in the southeast portion of the sawmill property.

In 1985, P&T transferred ownership of the uplands and adjacent tidelands portion of the Site to PR. P&T continued wood products manufacturing at the Site until 1995 under a lease with PR. Mill operations ceased in 1995 and the sawmill facility was dismantled and removed in 1997. Since 1997, the uplands portion of the Site has been leased at various times to a variety of parties for use as a log sort and wood chipping yard, material handling activities, a marine laboratory, and parking for Washington State Department of Transportation (WSDOT) operations.

In January 1997, Ecology conducted an initial investigation of the Site, which consisted of sampling sediment in four catch basins. The results of that investigation indicated that concentrations of petroleum hydrocarbons and metals were present at levels above MTCA (WAC 173-340) and Sediment Management Standards (SMS; WAC 173-204) chemical criteria for these compounds. Subsequently, Clean Services Company, Inc. removed accumulated materials from 12 catch basins, four valve vaults, and four sumps in April 1997.

In July 1998, Ecology notified P&T of the potential listing of the former sawmill site on Ecology's Confirmed and Suspected Contaminated Site List. Subsequently, detailed environmental investigations were conducted by P&T, PR, and OPG to characterize soil, groundwater, surface water, and sediment quality conditions at the Site (Parametrix 2000). The Site characterization data confirmed the presence of hazardous substances in soil and groundwater at the upland portion of the Site. The investigations also confirmed the presence of wood waste in nearshore sediments. Based on these data, Ecology added the Site to the hazardous sites list in 2001.

Between 2002 and 2005, approximately 26,310 tons of contaminated soils were excavated from the Site uplands, and in 2003 approximately 13,500 cubic yards (cy) of sediment containing accumulations of wood waste and hazardous substances was dredged from a 2-acre area of the aquatic portion of the Site. All of the excavated upland soils, along with wood waste materials dredged in 2003, were disposed at approved upland facilities.

In 2004, follow-on surface sediment sampling and sediment profile imaging (SPI) were conducted by P&T to characterize post-dredge sediment quality conditions at the Site and to provide a baseline dataset for evaluation of anticipated future natural recovery (Parametrix 2004). In 2006, P&T and Ecology performed additional sediment characterization, including benthic infaunal abundance, sediment bioassays, and SPI across a gradient of wood waste levels.

In early 2007, Ecology dredged an additional 17,500 in situ cy of wood waste in a 1-acre area adjacent to the 2003 dredging action and placed a 6-inch layer of clean sand over a portion of the newly dredged area to address dredging residuals. In cooperation with this Ecology-led project, P&T took over the day-to-day management of the dredged material once it was transferred from Port Gamble Bay and subsequently removed salt from the material using an on-site upland holding cell and freshwater washing system. From May to October 2007, porewater salinity levels within the dredged materials were successfully reduced from 26 parts per thousand (ppt) to less than 1 ppt to facilitate upland beneficial reuse.

In November 2007, P&T filed for bankruptcy (Delaware Case No. 07-11738). In accordance with Kitsap County Grading Permit 08-52323, PR subsequently relocated all of the suitable dredged sediments for off-site beneficial reuse at the location depicted in Figure 1-1. Unsuitable solid waste materials were segregated and disposed at an approved off-site landfill facility. All soil segregation, disposal, treatment, and relocation tasks were successfully completed in spring 2009.

1.2 Report Organization

This report is organized as follows:

- Section 1 summarizes the Site background
- Section 2 summarizes the results of the RI studies completed at the Site, including a summary of the Site environmental conditions (nature and extent of contamination) and the conceptual site model (CSM)
- Section 3 describes the basis for the cleanup action, including a summary of cleanup standards and the locations and media requiring cleanup action evaluation
- Section 4 describes the framework for the development and evaluation of cleanup action alternatives, including the objectives of the cleanup action, the applicable regulatory requirements, and screening of remediation technologies
- Section 5 describes the criteria used to evaluate the cleanup action alternatives
- Section 6 presents the development and evaluation of cleanup action alternatives for

the Site

- Section 7 presents a summary of recommended cleanup actions for the Site
- Section 8 presents the references used in preparing this report.

2 CONCEPTUAL SITE MODEL

This section summarizes the conceptual model for the Site based on the results of the RI, which integrated pre-RI data with focused upland and sediment sampling performed in 2008 and 2009. The RI report (Anchor QEA and EPI 2010) included a detailed discussion of interim actions completed at Site, along with analysis of the RI Site characterization data. The CSM summarized in Sections 2.2, 2.3, and 2.5 includes a discussion of the contaminant exposure pathways and potential environmental risks posed by deleterious or hazardous substances that remain at the Site.

2.1 Summary of RI Upland Sampling

The RI report (Anchor QEA and EPI 2010) presented the results of supplemental soil and groundwater sampling and analysis that completed the upland site characterization, as follows:

- Soil with elevated mercury concentrations detected in soil during the 1999 to 2001 investigations was removed during the 2002 interim action. Over the next several years, total mercury was detected sporadically in groundwater samples collected from downgradient monitoring well-7 (MW-7) at concentrations greater than the cleanup level. Additional quarterly performance monitoring was performed in 2009 and documented four consecutive quarters of non-detects for total mercury at the reporting limit of 0.2 micrograms per liter (μg/L).
- Similarly, cadmium was not detected during supplemental 2010 monitoring events (at a reporting limit of 0.4 μg/L). These data confirm that Ecology's objective of four consecutive quarters of non-detects has also been achieved for cadmium.
- Investigations in 2005/2006 delineated the extent of arsenic at concentrations greater than applicable cleanup levels in groundwater over most of the Site. Two additional wells were installed in 2009 to complete the groundwater characterization for arsenic. These two new wells were included in quarterly sampling, along with existing monitoring wells that previously contained elevated arsenic concentrations. Based on the 2009 sampling, total arsenic concentrations in Site groundwater currently range from 1 to 23 μg/L; dissolved arsenic concentrations range from 0.1 to 14 μg/L. While maximum groundwater arsenic concentrations are currently greater than the natural background concentration in Washington State of approximately 5 μg/L, none of the

recent groundwater samples collected from the Site had concentrations exceeding the marine surface water chronic criterion of 36 μg/L.

- Additional soil sampling data were collected in 2009 to complete the characterization of arsenic concentrations in soil remaining at the Site. All of these soil samples contained arsenic at concentrations less than the MTCA Method A soil cleanup level of 20 milligrams per kilogram (mg/kg) based on regional background concentrations, verifying that arsenic sources to groundwater have been successfully removed. The RI concluded that remaining arsenic concentrations detected in groundwater are a result of locally increased arsenic solubility caused by geochemically reducing conditions at the Site, due to varying quantities of wood and other organic matter present in the soil.
- A focused soil investigation was performed in 2009 to evaluate the potential presence of dioxins and furans in shallow soil in the area west and northwest of the former hog fuel burner. The cumulative dioxin/furan toxicity equivalent quotient (TEQ) concentration ranged from 0.5 picograms per gram (pg/g) to 3.8 pg/g, significantly less than the MTCA Method B human health-based soil cleanup level of 11 pg/g.
- Additional surface soil samples were also collected in 2009 to verify the absence of organochlorine pesticides in shallow surface soil at the Site. No organochlorine pesticide compounds were detected in any of the samples analyzed.

2.2 Soil Conceptual Site Model

The upland soil data summarized in the RI report (Anchor QEA and EPI 2010) support the following CSM summary:

- The Site is located at the foot of a steep bluff on a peninsula bounded by Hood Canal to the west and Port Gamble Bay to the east.
- The Site was expanded over time by the addition of fill material to the original tideflat along the shore of Port Gamble Bay. Fill material is generally 2 to 12 feet thick and is made up of mixtures of well graded to poorly graded sand and gravel with minor amounts of silt, clay, shell fragments, and debris including bricks and wood.
- Between 2002 and 2005, approximately 26,310 tons of contaminated soils were excavated from the Site uplands. These previous interim actions successfully reduced hazardous substance concentrations in soils to levels that are protective of human

health throughout the Site.

- The upland areas of the Site are currently characterized by a contiguous open space bordered by water to the north and east and terrestrial vegetation and residential properties to the west and south. There is currently little to no vegetative cover on the Site because of human activity; plants and shrubs characteristic of disturbed habitats grow on the western and southern borders of the property. The planned future uses of the Site include a combination of mixed uses (e.g., residential, industrial, and commercial uses). To support future redevelopment actions, the Site may receive additional sand fill.
- Soil lead concentrations marginally exceeding conservative ecological screening criteria (but less than residential standards based on human health) remain in isolated areas of the Site near the former fueling area. Post-removal lead detections (boring samples PS-72B and PS-122B) were located in fill soils present between 2 and 5 feet below ground surface (bgs). However, surface soil lead concentrations are less than these screening criteria, and the detected subsurface lead concentrations are within the requirements for post-removal statistical compliance as allowed by Section 173-340-740(7) of the MTCA regulation.
- A simplified site-specific terrestrial ecological evaluation (TEE) was performed to characterize the potential for wildlife to become exposed to these subsurface soils, consistent with MTCA requirements. As discussed in the RI report, based on site-specific TEE exposure pathway information, soils at the Site are unlikely to pose significant adverse effects to terrestrial ecological receptors.
- This FS addresses the need for institutional controls in these soil areas to ensure the continued protection of the environment, consistent with MTCA requirements.

2.3 Groundwater Conceptual Site Model

The upland groundwater data summarized in the RI report (Anchor QEA and EPI 2010) support the following CSM summary:

- Native shallow soils underlying the surface fill are gray, well graded to poorly graded sand deposits with gravel and shell fragments. A regionally extensive glacial lake deposit, the Kitsap Formation, consisting of clay and silt underlies the Site and separates near-surface aquifers from the regional Salmon Springs Aquifer.

- The fill material supported the formation of an unconfined shallow aquifer that is recharged by local precipitation along with overland and shallow flow from the bluffs to the west. Groundwater in the shallow aquifer is generally encountered at approximately 5 to 10 feet bgs.
- Slug test data indicate moderate but variable permeability of the shallow aquifer, characterized by hydraulic conductivity values ranging from 6.3×10^{-5} cm/sec to 1.5×10^{-3} cm/sec. Groundwater flow directions in the shallow aquifer are generally toward the northeast in the northern half of the Site and toward the east in the southern half of the Site. Groundwater flow from the surrounding bluffs, along with tidal effects (see below) are the most significant influences on groundwater flow directions at the Site.
- The shallow aquifer is moderately tidally influenced and is subject to transient nearshore groundwater flow reversals during high tide events. The short-term groundwater flow reversals do not prevent the eventual discharge of groundwater to Port Gamble Bay. Tidal reversals are most pronounced in the near-surface permeable soils of the fill and shallow aquifer, and dissipate rapidly with distance from the shoreline, which is common for unconfined aquifers. Nearshore flow reversals influence the sediment porewater transport of degradation products, particularly in shallow wood waste deposits present in the northern embayment (see Section 2.5).
- Previous interim actions at the Site successfully reduced groundwater concentrations of total petroleum hydrocarbons, mercury, and other hazardous substances to levels that are now protective of human health and the environment. As discussed in Section 2.1, while current total arsenic concentrations in Site groundwater are up to 3 times greater than the natural background concentration, arsenic concentrations are less than the marine surface water chronic criterion. Groundwater arsenic concentrations remaining at the Site are a result of locally increased arsenic solubility caused by geochemically reducing conditions associated with varying quantities of wood and other organic matter present in the soil.
- This FS addresses the need for institutional controls in areas with arsenic concentrations in groundwater that exceed natural background to ensure continued protection of the human health, consistent with MTCA requirements.

2.4 Summary of RI Sediment Sampling

As described in the RI/FS Work Plan (Anchor and EPI 2008), a phased sampling program was employed to complete characterization of the nature and extent of wood waste at the Site. Following Ecology's approval, initial surface sediment sampling of wood waste indicator parameters occurred in late August 2008. After collaborative review of these data with Ecology, detailed follow-on sediment core and bioassay sampling occurred in mid-September 2008. Ecology also separately performed bay-wide sediment sampling in December 2008, which included the collection of several surface sediment samples in the northern and southern portion of the Site (Hart Crowser 2010).

During the 2008 RI sampling, a total of nine supplemental sediment cores were advanced in the vicinity of the former north and south chip loading areas to complete characterization of the horizontal and vertical distribution of wood waste in these areas. These data were combined with the 16 pre-RI sediment cores to provide a refined characterization of the vertical distribution of sediment layers and organic woody material at the Site, along with the elevation of the native (pre-1850) sediment contact.

The 2008 core sampling also included an initial dredge material management program (DMMP) evaluation to assess possible open-water disposal options for sediments that may be dredged from the Site during remedial actions. Composite samples of subsurface sediment were collected at two representative locations within the northern and southern chip loading areas. Each of these samples was analyzed for the full suite of DMMP chemical parameters (including dioxins and furans), along with confirmatory sediment bioassays following DMMP protocols. Concentrations of all chemicals detected in subsurface sediment samples were below both SMS Sediment Quality Standards (SQS) chemical criteria and DMMP screening levels. Similarly, hazardous substance concentrations in surface and subsurface sediment intervals remaining at the Site were also below screening criteria (the limited volume of sediments exceeding SQS chemical criteria were previously removed from the Site during the 2003 interim action). Confirmatory sediment bioassays performed on the subsurface DMMP sample collected from the northern embayment also passed screening criteria for non-dispersive open-water disposal. Thus, sediments that may be dredged from certain target areas of the northern embayment of the Site are potentially suitable for open-water disposal at the Port Gardner non-dispersive disposal site. However, open-water disposal suitability determinations of sediments that may be dredged from these and other Site areas are subject to approval by the DMMP. Further evaluations of sediment cleanup alternatives are presented in Section 6 of this FS report.

Initial surface (0 to 10 centimeter [cm]) sediment sampling at 13 stations occurred in late August 2008, and each sample was analyzed for wood waste indicator parameters including total volatile solids (TVS), total organic carbon (TOC), and porewater ammonia and sulfide. After collaborative review of these data with Ecology, follow-on sediment bioassay sampling occurred in mid-September 2008, targeting 12 Site locations, along with suitable reference samples collected from Carr Inlet and Sequim Bay. (As noted above, Ecology separately performed bay-wide sediment sampling in December 2008, which included several surface sediment samples collected in the northern and southern portion of the Mill Site; Hart Crowser 2010.) A total of five different bioassay tests were performed on surface sediments collected from the Site in 2008, as follows:

- 10-day amphipod acute toxicity test
- 2 to 4-day Puget Sound Estuary Program (PSEP) larval mortality and abnormality test
- 2 to 4-day screen tube larval mortality and abnormality test (comparison of this test with the PSEP method above allows discrimination between the effects of chemical contaminants and physical factors on the larval test)
- 20-day juvenile polychaete growth bioassay
- Microtox® porewater chronic toxicity test

The 2008 bioassay test results revealed that surface sediments collected from the Site area were potentially toxic, but to varying degrees, in laboratory exposures to SMS test organisms. SMS interpretations of these data are discussed in more detail below.

2.5 Sediment Conceptual Site Model

As discussed above, a CSM is a representation of the environmental system and the physical, chemical, and biological processes that determine the transport of contaminants or other substances of concern from sources to receptors. For sediment sites, perhaps even more so than for other types of sites, the CSM can be an important element for evaluating risk reduction approaches. The sediment CSM is typically derived from existing Site data and knowledge gained from other sites, providing both a simple understanding of the Site based on available data and a valuable tool to evaluate the potential effectiveness of remedial alternatives. The sediment data summarized in the RI report (Anchor QEA and EPI 2010) support the following CSM summary:

- Historical releases of sawdust, wood chips, and bark were the primary sources of wood waste in sediment; these sources were controlled between 1995 and 2004.
- Deposition of wood waste immediately adjacent to the Site has historically occurred in two areas: 1) the northern embayment; and 2) the southern mill area. Log-rafting in support of mill operations also contributed to deposition of wood waste south of the mill area.
- The 2003 and 2007 interim action dredging projects successfully removed a total of approximately 31,000 cy of sediments from the southern mill area that contained much of the accumulation of wood waste. Relatively limited sediments exceeding SQS hazardous substance criteria were also previously removed from the Site during the 2003 interim action.
- Wood waste accumulations in the two depositional areas of the Site are highly variable, currently ranging from approximately 2 feet to more than 11 feet thick. Wood waste accumulations in the northern embayment are now buried below approximately 1 foot of cleaner sands.
- Net sedimentation rates at the Site have been measured (through radioisotope dating) to range between approximately 0.4 and 1.0 cm/yr. The upper range value (1.0 cm/yr) may be high as it was measured within the area influenced by wood waste deposition and potentially affected by the nearby filling activities to create the adjacent uplands. Farther south in the middle portion of Port Gamble Bay, sedimentation rates appear to be slightly lower, averaging approximately 0.5 cm/yr (Hart Crowser 2010).
- Bottom water dissolved oxygen (DO) concentrations measured to date in Port Gamble Bay (sampled approximately 0.5 to 0.8 feet above the sediment/water interface) have been within the acceptable range defined in the State Surface Water Quality Standards for marine waters (Chapter 173-201A WAC). The presence of relatively strong offshore currents and the formation of eddies in both the northern and southern embayments promote circulation and flushing processes in the depositional areas immediately adjacent to the Site and likely contribute to maintenance of oxygen

in the overlying waters of the Site. However, the water column sampling in 2006 indicated that the lowest DO concentrations occur immediately above the bottom substrate in the Site.

- Bioassay test interpretation consists of endpoint comparisons of test sediments to the measurements observed in the controls and in reference sediments on an absolute percentage basis, as well as statistical comparison between the test and reference endpoints, where appropriate. The 2006 to 2008 bioassay test results revealed that surface sediments collected from the northern and southern embayments of the Site were potentially toxic, but to varying degrees, in laboratory exposures to SMS test organisms. Exceedances of Cleanup Screening Level (CSL) biological criteria occurred in different bioassay tests performed on Site samples. The locations of bioassay exceedances were generally correlated with elevated concentrations of wood waste indicator parameters, as summarized below.
- Porewater sulfide concentrations in surface sediments collected at the Site over the 2006 to 2008 period ranged from less than 0.1 to 94 milligram per liter (mg/L), with the highest concentrations consistently observed in northern embayment sediments overlying relatively thick buried wood chip deposits. Porewater sulfide data available for the Site were collected using different methods. While the sulfide data are useful in understanding toxicity, relative levels should be interpreted along with other sources of information to evaluate impacted areas. Surface sediment porewater sulfide concentrations within relatively shallow (less than 12 feet below mean lower low water [MLLW] elevation) nearshore areas of the northern embayment exceed the preliminary amphipod toxicity screening criteria of 30 mg/L reported by Caldwell (2005) based on an analysis of woody debris sediment toxicity data available from other sites in the Pacific Northwest. Thus, porewater sulfide concentrations could potentially be a contributing factor to amphipod bioassay test performance at the Site.
- In contrast, while elevated sulfide concentrations are present at depth in parts of the southern embayment, the top foot or more of sediments in the southern embayment wood waste areas contain relatively low porewater sulfide concentrations, below potential toxicity levels.
- As discussed in Section 2.3, the shallow aquifer near the northern embayment shoreline is moderately tidally influenced and is subject to transient nearshore groundwater flow reversals. These tidal reversals, in turn, promote greater sulfide

production within the woody debris deposits by supplying sulfate-rich seawater to the buried wood chips. Tidal reversals at the Site are most pronounced in the near-surface permeable soils of the fill and shallow aquifer. By comparison, the deeper woody debris deposits in the southern bay are likely to be less tidally influenced and sulfide levels were reported to be lower in surface sediments, yet subsurface wood waste in this area was still found to support significant colonies of the sulfur-fixing bacteria *Beggiatoa*.

- While amphipod toxicity measured in the most recent (2006 to 2008) bioassay tests was localized to parts of the northern embayment, the PSEP larval bioassay tests revealed widespread SQS-level biological responses across the Site. Ecology's bay-wide sampling data also reported similar SQS and CSL bioassay responses in PSEP larval tests at many locations throughout Port Gamble Bay (Hart Crowser 2010). Correlation analyses of the bay-wide PSEP larval data (including 2002 sampling data) indicated a variable but nevertheless significant relationship ($P<0.01$) between normal larval survivorship and the sediment TVS concentration. A simple regression was used to estimate a site-specific screening level, where SQS biological effects (defined as less than 15 percent below the normal larval survivorship of the reference sample) occurred when sediment TVS concentrations exceeded approximately 12 percent (dry weight basis). Case-by-case sediment TVS cleanup levels ranging from 10 to 15 percent have been developed at other wood waste cleanup sites in Puget Sound based on bioassay correlation analyses (e.g., Hylebos Waterway and Former Scott Mill). The correspondence of these benchmark values lends additional support to the 12 percent TVS site-specific sediment screening level.
- The screen tube larval mortality and abnormality test data, while more limited in scope than the PSEP larval data, suggest that no adverse biological effects occur using this bioassay method. Comparison of this test with the PSEP method above is thought to distinguish between the effects of chemical contaminants and physical factors. The combined larval bioassay data suggest that biological effects observed in the PSEP larval tests may be attributable to physical factors rather than chemical effects of the sediment/wood waste on overlying water in the test chambers for this test species.
- Two different chronic toxicity bioassay tests have been performed on Site sediments: the juvenile polychaete growth bioassay and the Microtox® porewater chronic

toxicity test. While no biological effects have been observed at the Site using the Microtox® test, a localized reduction in polychaete growth rate exceeding SQS criteria has only been observed at a single location in a nearshore region of the southern chip loading area (sample AS-05).

- Sediment quality as measured by the amphipod and PSEP larval bioassays improved significantly from 2002 to 2008, particularly within the southern embayment. For example, average amphipod survival at the Site increased from 35 ± 7 percent in 2002 to 86 ± 3 percent in 2006/08 (mean ± standard error), approaching the average reference area survival of 92 ± 2 percent. Similarly, average PSEP normal larval survivorship increased from 45 ± 2 percent in 2002 to 68 ± 2 percent in 2006/08, also approaching the average reference area survivorship of 74 ± 4 percent. Concurrently, roughly twofold reductions in surface sediment TVS concentrations in the southern embayment occurred over the same time period, consistent with measured net sedimentation rates (0.4 to 1.0 cm/yr) and associated natural recovery processes (e.g., bioturbation and biodegradation within the top 10 cm biologically active zone of the sediments).
- This FS addresses the need for additional sediment remedial actions, including active remedies and continued monitored natural recovery (MNR), to restore and protect ecological receptors at the Site, consistent with MTCA requirements.

3 BASIS FOR CLEANUP ACTION

This section presents the basis for the Site cleanup action. There are two distinct elements that form the basis for the cleanup action: 1) the site-specific cleanup standards; and 2) the locations and media requiring cleanup action evaluation.

3.1 Cleanup Standards

Cleanup standards consist of: 1) cleanup levels that are protective of human health and the environment; and 2) the point of compliance at which the cleanup levels must be met. Preliminary site-specific cleanup standards were developed in the RI for soil, groundwater, and sediment. Detailed information regarding the derivation of these cleanup levels can be found in the RI report. The standards for soil and groundwater are adopted in this FS for the purpose of developing cleanup action objectives for the Site, which are presented in Section 4.1.

Sediment cleanup standards based on SMS bioassays performed within wood waste areas were developed for this FS based on a detailed weight-of-evidence approach that considered the range of scientifically based interpretations of the bioassay data provided under the SMS regulatory framework. The proposed media-specific cleanup levels and points of compliance are summarized in the sections below.

3.1.1 Cleanup Levels

Site-specific cleanup levels for soil that are protective of human health and terrestrial ecological receptors, and cleanup levels for groundwater that are protective of marine surface water, were developed in accordance with MTCA requirements. To be consistent with MTCA requirements, the RI developed preliminary soil cleanup levels based on unrestricted land use, including the more stringent MTCA Method B cleanup levels that assume ground floor residential land use [WAC 173 340 740(3)]. Under MTCA Method B, soil cleanup levels must, at a minimum, be as stringent as:

- Concentrations established under applicable state and federal laws
- Concentrations protective of terrestrial ecological receptors
- Concentrations protective of direct human contact with soil

- Concentrations protective of groundwater.

Each of these criteria was considered during the development of soil cleanup levels, as detailed in the RI report. The proposed cleanup levels used in this FS for constituents detected in Site soil are presented in Table 3-1.

Groundwater at the Site is not considered potable as defined under WAC 173-340-720(2) for the following reasons:

- Groundwater does not serve as a current source of drinking water (WAC 173-340-720(2)(a))
- Hazardous substances that may be present in groundwater are unlikely to be transported to a current or potential future source of drinking water (WAC 173-340-720(2)(c))
- The Site's proximity to surface water that is not suitable as a domestic water supply (i.e., Port Gamble Bay) renders groundwater as non-potable because
  - There are known or projected points of entry of groundwater to surface water (WAC 173-340-720(2)(d)(ii)
  - Surface water is not classified as a suitable domestic water supply source (WAC 173-340-720(2)(d)(iii))
  - Groundwater is sufficiently hydraulically connected to the surface water that groundwater is not practicable to use as a drinking water source (WAC 173-340-720(2)(d)(iv))

Because Site groundwater is not a current or reasonably likely future source of drinking water, cleanup levels for Site soil need not be protective of groundwater as a potential source of drinking water. Additionally, an empirical demonstration was used in the RI report to demonstrate that existing chemical concentrations in Site soil are protective of groundwater as marine surface water.

MTCA Method B cleanup levels protective of marine surface water were developed in accordance with WAC 173-340-730(3) for those constituents detected in groundwater. If necessary, preliminary groundwater cleanup levels were adjusted to be no less than the practical quantitation limit (PQL) or natural background concentration, in accordance with WAC 173-340-730(5)(c). The proposed cleanup levels used in this FS for constituents detected in Site groundwater are presented in Table 3-2.

Cleanup levels for sediments that are protective of benthic infauna were developed in accordance with MTCA and SMS requirements and direction provided by Ecology. Two SMS criteria are promulgated by Ecology (WAC 173-204-320). These include the SQS—the concentration below which effects to benthos are unlikely—and the CSL—the concentration above which more than minor adverse biological effects may be expected. The SQS and CSL values have been developed for a suite of hazardous substances. The SQS are the most stringent SMS criteria and are used in this FS as sediment cleanup levels for the SMS constituents detected in sediment at the Site.

There is no promulgated numeric SMS criterion or accepted sediment screening level for dioxins and furans, and cleanup levels for this group of compounds are currently under further evaluation by Ecology and other regulatory agencies. However, because dioxin/furan TEQ concentrations in surface and subsurface sediments at the Site were below a Puget Sound sediment background concentration of approximately 4 pg/g, no cleanup level is needed for dioxins/furans.

There is also no promulgated SMS numeric criterion for wood waste in sediment; however, there is a narrative standard that "other… deleterious substances in, or on, sediments, shall be at or below levels which cause minor adverse affects in marine biological resources, or which correspond to a significant health risk to humans, as determined by [Ecology]" WAC 173-204-520(5). In 2006 and 2008, a series of supplemental sediment investigations were performed at the Site, as described in the RI report. The primary objective of these supplemental investigations was to conduct a suite of confirmatory biological tests on synoptic surface sediment samples collected from locations representing the range of wood waste at the Site with the potential for deleterious effects. While the bioassay data themselves were used as the primary basis to delineate potential sediment management areas (SMAs) at the Site, correlation analyses using the bay-wide data (including 2002 sampling data) indicated a variable but nevertheless statistically significant relationship ($P<0.01$) between amphipod survival and porewater sulfide levels, as well as TVS concentrations.

Similar correlations were also observed for PSEP larval survivorship. A simple regression was used to estimate porewater sulfide and TVS screening levels that correspond to SQS and CSL criteria. The screening levels estimated for SQS-level biological effects were 10 mg/L for porewater sulfide and approximately 12 percent (dry weight basis) for sediment TVS. CSL biological effects were estimated when porewater sulfide concentrations exceeded 19 mg/L and/or sediment TVS concentrations exceeded approximately 21 percent. These preliminary wood waste screening levels were used in the overall weight-of-evidence delineation of SMAs at the Site, as discussed in Section 6.2.1.

3.1.2 Points of Compliance

Under MTCA, the point of compliance is the point or location on a site where the cleanup levels must be attained. The points of compliance for affected media will be approved by Ecology and presented in a forthcoming Cleanup Action Plan (CAP) for the Site. However, it is necessary to identify proposed points of compliance in order to develop and evaluate cleanup action alternatives in the FS. This section describes the proposed points of compliance for soil, groundwater, and sediment.

The standard point of compliance for the soil cleanup levels shown in Table 3-1 will be throughout the soil column, in accordance with WAC 173-340-740(6)(d) and WAC 173-340-7490(4)(b). For potential terrestrial ecological exposures, MTCA regulations allow a conditional point of compliance to be established from the ground surface to 6 feet bgs (the biologically active zone according to MTCA default assumptions), provided institutional controls are used to prevent excavation of deeper soil [WAC 173-340-7490(4)(a)]. Accordingly, in areas of the Site where potential ecological exposures are a concern, and where appropriate institutional controls can be implemented, a conditional point of compliance for soil concentrations protective of terrestrial ecological receptors may be proposed throughout the soil column from the ground surface to 6 feet bgs.

Because the groundwater cleanup levels (Table 3-2) are based on protection of marine surface water, and not protection of groundwater as drinking water, the proposed conditional point of compliance for groundwater cleanup levels is the point of groundwater discharge to Port Gamble Bay. Previous interim actions at the Site successfully reduced groundwater concentrations of total petroleum hydrocarbons, mercury, and other hazardous substances to levels that are now protective of human health and the environment. As discussed in Section 2.1, while current total arsenic concentrations in Site groundwater are up to 3 times greater than the natural background concentration, arsenic concentrations are less than the marine surface water chronic criterion. Elevated arsenic concentrations remaining in groundwater at the Site are a result of locally increased solubility of arsenic caused by geochemically reducing conditions associated with varying quantities of wood and other organic matter present in the soil. Thus, it is not practicable to meet the natural background-based groundwater cleanup levels within a reasonable restoration timeframe (see WAC 173-340-740(8)(c) and WAC 173-340-360(2)). Existing shoreline wells including MW-8, MW-15, and MW-16 can be used to evaluate compliance.

For marine sediments potentially affected by deleterious wood waste, the point of compliance for protection of the environment is surface sediments within the biologically active surface water habitat zone, represented by samples collected across the top 10 cm below the mudline. This can include deeper sediments that could become exposed given conditions or Site uses that may be expected to occur following cleanup (e.g., storm events or propeller wash that contribute to erosional forces).

3.2 Locations and Media Requiring Cleanup Action Evaluation

This section identifies the locations and environmental media (soil, groundwater, and sediment) at the Site that require cleanup action evaluation.

3.2.1 Uplands Area

Based on the information presented in the RI report, all soils remaining at the Site following completion of interim actions from 2002 to 2005 are below soil cleanup levels that are protective of human health. While localized subsurface soils at the Site contain lead concentrations marginally above TEE-based cleanup levels, these same soils comply with MTCA post-removal compliance monitoring statistical requirements, and are unlikely to pose significant adverse effects to terrestrial ecological receptors. Thus, only institutional controls in these soil areas are needed to ensure the continued protection of the environment, consistent with MTCA requirements.

Similarly, previous interim actions at the Site successfully reduced groundwater concentrations to below cleanup levels based on the marine surface water chronic criterion. Groundwater arsenic concentrations remaining at the Site are a result of geochemically reducing conditions due to varying quantities of wood and other organic matter present in the soil. Thus, only institutional controls in areas with groundwater arsenic concentrations that exceed natural background concentrations are needed to ensure the continued protection of human health, potentially including formal restrictions precluding future drinking water wells on the Site.

3.2.2 Marine Area

Based on the information presented in the RI report, surface sediments in parts of the northern and southern embayment areas of the Site require evaluation of cleanup action alternatives due to the presence of wood waste deposits. Near-surface woody debris deposits at the Site require evaluation of cleanup action alternatives due to the presence of constituents exceeding cleanup levels protective of aquatic ecological receptors, resulting in degraded habitat conditions. These constituents include porewater sulfide, TVS, and bioassay results that exceed SQS biological criteria. As practicable, cleanup actions will consider designs that improve existing habitat conditions.

4 FRAMEWORK FOR CLEANUP ACTION ALTERNATIVE DEVELOPMENT AND EVALUATION

This section presents cleanup action objectives, applicable regulatory requirements for the cleanup action, and a screening evaluation of general response actions and remediation technologies that are potentially applicable to the Site.

4.1 Cleanup Action Objectives

Cleanup action objectives consist of chemical- and medium-specific goals for protecting the environment. The cleanup action objectives specify the media and contaminants of interest, potential exposure routes and receptors, and proposed cleanup goals.

4.1.1 Uplands Area

As discussed in Section 3.2.1, based on the information presented in the RI report, soil and groundwater remaining at the Site following completion of interim actions from 2002 to 2005 are now generally below soil and groundwater cleanup levels. Groundwater with arsenic concentrations greater than natural background-based cleanup levels that remain at the Site are a result of locally elevated arsenic solubility caused by geochemically reducing conditions associated with varying quantities of wood and other organic matter present in the soil; it is not practicable to meet the natural background-based groundwater cleanup levels within a reasonable restoration timeframe. Thus, no further removal or containment remedial actions in upland areas of the Site are necessary to address MTCA requirements. Nevertheless, in order to ensure continued protection of human health and the environment, additional institutional controls are considered in this FS, including measures to limit future contact by terrestrial wildlife and/or terrestrial plants and soil biota and/or food-web exposure to low-level hazardous substances in soil. Measures to continue to ensure that Site groundwater is not used as a future source of drinking water are also considered in this FS.

4.1.2 Marine Area

The objective of the marine area cleanup action is to eliminate, reduce, or otherwise control to the extent feasible and practicable, unacceptable risks to the environment posed by deleterious wood waste in marine sediment in accordance with SMS. Specifically, the objective of the marine area cleanup is to mitigate risks associated with exposure of benthic organisms to deleterious wood waste in the biologically active zone of sediment (the upper 10 cm below the mudline).

4.2 Applicable Regulatory Requirements

In addition to the cleanup standards developed through the MTCA process, other regulatory requirements must be considered in the selection and implementation of a cleanup action. MTCA requires that cleanup standards to be "at least as stringent as all applicable state and federal laws" [WAC 173-340-700(6)(a)]. Besides establishing minimum requirements for cleanup standards, applicable state and federal laws may also impose certain technical and procedural requirements for performing cleanup actions. These requirements are described in WAC 173-340-710. Applicable state and federal laws are discussed below.

While implementation plans are still under development, the cleanup action at the Site will likely be performed pursuant to MTCA under the terms of a Consent Decree between Ecology and one or more implementing parties. Accordingly, the anticipated cleanup action will likely meet the permit exemption provisions of MTCA, obviating the need to follow procedural requirements of the various local and state regulations that would otherwise apply to the action. Similarly, the anticipated cleanup action also qualifies for a U.S. Army Corps of Engineers (Corps) Nationwide Permit 38 (NWP 38). Nevertheless, federal consultation under the Endangered Species Act, Section 401 Water Quality Certification, and other substantive requirements must still be met by the cleanup action. Ecology will be responsible for issuing the final approval for the cleanup action, following consultation with other state and local regulators. The Corps will separately be responsible for issuing approval of the project under NWP 38, following Endangered Species Act consultation with the federal Natural Resource Trustees, and also incorporating Ecology's 401 Water Quality Certification.

4.2.1 MTCA and SMS Requirements

The primary law that governs the cleanup of contaminated sites in the state of Washington is MTCA. The MTCA Cleanup Regulation (WAC 173-340) specifies criteria for the evaluation and conduct of a cleanup action, including criteria for developing cleanup standards for soil and groundwater. When contaminated sediments are involved, the cleanup levels and other procedures are also regulated by the 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. The SMS cleanup standards govern the cleanup of contaminated sediment sites. Both MTCA and SMS regulations require that cleanup actions must protect human health and the environment, meet environmental standards in other applicable laws, and provide for monitoring to confirm compliance with cleanup levels.

MTCA places certain requirements on cleanup actions involving containment of hazardous substances that must be met for the cleanup action to be considered in compliance with soil cleanup standards. These requirements include implementing a compliance monitoring program that is designed to ensure the long-term integrity of the containment system and applying institutional controls where appropriate to the affected area (WAC 173-340-440). The key MTCA 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 MTCA 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 and the companion RI report (Anchor QEA and EPI 2010) were prepared consistent with the requirements of MTCA and the SMS.

4.2.2 Solid and Hazardous Waste Management

The Washington Hazardous Waste Management Act (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 the Site. Related regulations include state and federal requirements for solid waste handling and disposal facilities (40 CFR 241, 257; Chapter 173-350 and -351 WAC) and land disposal restrictions (40 CFR 268; WAC 173-303-340).

4.2.3 Puget Sound Dredged Material Management Program

In Puget Sound, the open-water disposal of sediments is managed under the DMMP. This program is administered jointly by the Corps, the U.S. Environmental Protection Agency (EPA), the Washington Department of Natural Resources (WDNR), and Ecology. The DMMP developed the Puget Sound Dredge Disposal Analysis (PSDDA) protocols, 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 Dredge Material Management Office (DMMO). The DMMP has also designated disposal sites throughout Puget Sound. Initial DMMP characterization of sediments has been performed on representative subsurface samples collected from the wood chip deposit in the northern embayment of the Site (including bioassay and dioxin testing), and these data indicated that wood waste material from this part of the Site is likely suitable for unconfined open-water disposal at a non-dispersive location (e.g., at the nearby Port Gardner disposal site). Similar wood waste materials have also been determined to be suitable for open-water disposal at PSDDA facilities (e.g., DMMP 2009). However, if this option is selected, additional dredged material characterization would be required to complete the suitability determination. Use of PSDDA facilities would need to comply with other DMMP requirements including material approval, disposal requirements, and payment of disposal site fees.

4.2.4 State Environmental Policy Act

The State Environmental Policy Act (SEPA) (RCW 43.21C; WAC 197-11) and the 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 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, SEPA and MTCA requirements will be coordinated, if possible.

4.2.5 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 likely be performed under a Consent Decree, compliance with substantive requirements would be necessary, but a shoreline permit would not likely be required.

4.2.6 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 creates 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 likely be required, though the substantive requirements of an HPA must still be met by the cleanup action.

The FS has been prepared using costs and 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 through agency consultation.

4.2.7 Water Management

4.2.7.1 Clean Water Act

The Clean Water Act (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 the Corps 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.

The SMS acknowledges the Washington Water Pollution Control Act as the primary authorizing legislation for establishing sediment source control standards.

4.2.7.2 Construction Stormwater General Permit

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 the NPDES permit would be obtained during the design phase and a Construction Quality Assurance Project Plan (CQAP) would also be prepared as part of the remedial design process, supplemented as appropriate by the remedial contractor.

4.2.8 Other Potentially Applicable Regulatory Requirements

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

- **Archeological and Historical Preservation** – The Archeological and Historical Preservation Act (16 USCA 496a-1) would be applicable if any subject materials are discovered during Site grading and excavation activities.
- **Health and Safety** – Site cleanup-related construction activities would need to 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 include requirements that workers are to be protected from exposure to contaminants and that excavations are to be properly shored.

These requirements are not specifically addressed in the detailed analysis of cleanup action alternatives because they could be met by each of the alternatives.

4.3 Screening of General Response Actions and Remediation

This section presents a screening evaluation of potentially applicable general response actions and remediation technologies for the cleanup action. The screening evaluation is carried out for each of the environmental media (soil, groundwater, and sediment) requiring cleanup action evaluation. Based on the screening evaluation, selected response actions and technologies are carried forward for use in the development of cleanup action alternatives.

4.3.1 Soil and Groundwater Response Actions

4.3.1.1 No Action

Based on the results of the RI, the No Action alternative could potentially achieve the project objective of protecting human health and the environment and thus has been retained in this FS.

4.3.1.2 Institutional Controls

Additional institutional controls may be implemented as appropriate, depending on the preferred cleanup action alternative. Such additional controls could include environmental covenants for upland soils and groundwater.

Institutional controls include restrictive covenants (e.g., deed restrictions) to ensure the continued protectiveness of the extensive interim remedial actions completed at the Site from 2002 to 2005. In certain situations, restrictive covenants can be effective and implementable where the covenant requires maintenance of the protective barriers that keep ecological receptors from contacting potentially contaminated subsurface soil. Institutional controls would require long-term monitoring to ensure that the Site conditions remain as required to achieve cleanup action objectives.

4.3.2 Sediments Response Actions

4.3.2.1 No Action

The No Action alternative does not achieve the project objective of protecting the environment and thus has been screened from further evaluation for sediments.

4.3.2.2 Institutional Controls

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

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

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

4.3.2.3 Source Control and Natural Recovery

Wood waste source controls within the Port Gamble Bay area were implemented during and following mill operations. Natural processes that are fundamental to the recovery of wood waste-impacted sediments following source control include sedimentation and biodegradation. The MNR remedy relies on these processes to reduce risks to acceptable levels following source control, while monitoring recovery over time to verify remedy success (Magar et al. 2009). The CSM depicts how specific natural recovery processes operate at the Site to reduce risk, and forms the basis for evaluating natural recovery processes during remedy selection. The sediment CSM for the Site is presented in Section 2.5.

MNR lines of evidence can be developed from rigorous analyses of Site data (e.g., laboratory and field studies, modeling, and other activities) that define the role of natural processes in reducing risk. Key factors for determining whether MNR is an appropriate remedy include the ability to achieve and sustain an acceptable level of risk reduction through natural processes within an acceptable period of time. Predicting future natural recovery rates requires site-specific inputs to numerical models, such as the net sedimentation rate (which averages approximately 0.4 to 1.0 cm/yr at the Site), to quantify processes described in the CSM and associated lines of evidence. Numerical models can be used to develop estimates of time to recovery using baseline data to determine likely effectiveness of MNR implementation.

As summarized in Section 2.5, sediment quality as measured by the amphipod and PSEP larval bioassays improved significantly from 2002 to 2008, particularly within the southern embayment. Average amphipod survival at the Site increased from 35 ± 7 percent in 2002 to 86 ± 3 percent in 2006/08 (mean ± standard error), approaching the average reference area survival of 92 ± 2 percent. Similarly, average PSEP normal larval survivorship increased from 45 ± 2 percent in 2002 to 68 ± 2 percent in 2006/08, also approaching the average reference area survivorship of 74 ± 4 percent. In addition, roughly twofold reductions in surface sediment TVS concentrations in the southern embayment occurred over the same time period.

Natural recovery processes operate regardless of the selected remedy. Effective sediment remedies may incorporate MNR in combination with approaches such as capping or dredging. Factors particularly favorable to MNR include evidence that natural recovery will effectively reduce risks within an acceptable time period, the ability to manage risks during the recovery period, and (where physical isolation is important) a low potential for exposure of buried contaminants. In SMAs where this technology is potentially promising, MNR was retained as a response action for more detailed evaluation in this FS.

4.3.2.4 Enhanced Natural Recovery

Enhanced natural recovery (ENR) is a commonly used technology to manage sediments that require action. ENR entails placement of a thin cover of clean sediment to accelerate the natural rate of recovery of the sediments. As discussed above, deposition of clean sediment plays a role in the natural recovery of wood waste-impacted sediments. Recovery can often be enhanced by actively providing a layer of clean sediment to the target area. This is often referred to as "enhanced" natural recovery or thin-layer cover and typically consists of placing a nominal 6-inch-thick layer of clean sediment over existing contaminated sediments.

4.3.2.5 Engineered Containment

Engineered containment for sediments involves placing a suitable cap to isolate contaminated material. In the aquatic environment, the containment must be designed to withstand erosive forces generated by wave action and propeller wash, and must be thick enough to provide the required isolation of the material contained by the cap. Monitoring results at other sites in the Puget Sound region have shown that containment can provide effective sediment remediation, without the risks involved in removing contaminants by dredging (Sumeri 1996).

Placing a thicker layer of cap material (typically 1 to 3 feet thick) can provide isolation of potentially contaminated sediments. However, thick sediment caps in shallow nearshore areas could eliminate significant areas of aquatic habitat, requiring compensatory mitigation or combination with dredging (dredge and cap remedies). Armored caps (e.g., with a gravel surface) may potentially be appropriate for consideration in sediment areas with high potential for disturbance (e.g., from propeller wash).

If selected as part of the Site remedy, a sediment cap would be designed to effectively contain and isolate contaminated sediments from the biologically active surface zone in accordance with EPA and Corps cap design criteria (see below). The cap would be designed to be thick enough and of sufficient grain size to maintain its integrity under reasonable worst case conditions.

Engineered caps at the Site would be designed to ensure that wood waste is effectively confined below the cap and that post-cap surface sediment (0 to 10 cm) porewater sulfide concentrations are either maintained below the no effects threshold of 3.4 mg/L established by the DMMP for *Neanthes* testing (Kendall and Barton 2004), or are otherwise within the Puget Sound background surface sediment range based on sampling at appropriate reference locations (e.g., DMMP reference sites; Caldwell 2005).

Cap designs to ensure that porewater sulfide exposure is maintained below these performance standards would be developed considering elevated subsurface sediment porewater concentrations measured during the RI/FS, and also considering groundwater upwelling and tidally induced transient porewater flow reversal processes at the Site. The upwelling velocity is a critical parameter in cap design, as it often controls contaminant flux into surface sediments. Tidal reversals can promote sulfide production in wood waste deposits by supplying sulfate-rich seawater to wood chips confined below the cap, and are most pronounced in the near-surface permeable soils of the shallow aquifer at the Site. The boundary between dredging and capping remedies at the Site is estimated to be approximately -25 feet MLLW based on available sampling data (e.g., surface sediment porewater sulfide measurements and bioassay data).

A sediment cap would likely be constructed of clean sand and could be placed by a number of mechanical and hydraulic methods. Capping has been used commonly in sediment remediation projects conducted in the northwest. Sediment capping is a proven technology to prevent exposure to contaminated sediments and could be easily implemented at the Site. Sediment caps can be relatively inexpensive remediation technologies. Therefore, engineered containment has been retained as a remedial alternative.

Table 4-1 provides a general summary of protective cap designs in Puget Sound that have been developed and approved under both EPA and Ecology cleanup programs. Cap designs must meet stringent criteria set forth in the EPA and the Corps design guidance, including:

- *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 2005)
- *Technical Guidance for Subaqueous Dredged Material Capping* (Palermo et al. 1998b)
- *Assessment and Remediation of Contaminated Sediments (ARCS) Program Guidance for In Situ Subaqueous Capping of Contaminated Sediments* (Palermo et al. 1998a)

These guidance documents provide detailed procedures for cap design, cap placement operations, and monitoring of engineered caps, and have been relied upon extensively for successful cap designs at other SMS cleanup sites. Caps designed according to the EPA and Corps guidance have been demonstrated to be protective of human health and the environment (EPA 2005). The thickness and other design specifications for in situ engineered caps in Port Gamble would be determined during remedial design based on detailed analyses of the following components:

- Bioturbation/habitat quality
- Erosion (e.g., propeller wash, tidal currents, waves, wakes, and slope stability)
- Chemical isolation (accounting for tidal advection of porewater/groundwater)
- Consolidation
- Operational considerations (e.g., gas generation and placement inaccuracies)

During remedial design, appropriate cap designs in different areas of the Site would be determined individually for each component based on location-specific design parameters. Consistent with the EPA and Corps cap design guidance, the total cap thickness that satisfies all design components would be determined based on the sum of the individual component thicknesses listed above. However, for the purposes of this FS, conceptual-level cap designs were developed based on a review of engineered caps designed, approved, and successfully constructed and monitored in other areas of Puget Sound, also taking into consideration site-specific conditions within Port Gamble. Based on this initial review, this FS developed two different preliminary cap designs based on the water depth above the cap, considering likely future propeller wash forces and groundwater flow/porewater sulfide transport:

Cap Type	Criteria	Thickness	Components
I	Elevation of final cap surface shallower than -15 feet MLLW	36 inches	12 inches habitat mix surface over 12 inches quarry spall armor over 12 inches sand base
II	Elevation of final cap surface deeper than -15 feet MLLW	18 inches	Sand

Potential sources of sand include the local quarry owned by PR, which was used as the primary source for the post-dredge sand cover successfully placed during the 2007 interim action. Where the local quarry does not contain sufficient quantity of sand, and for larger sized aggregates, a commercial quarry would be the likely source of cap material. Beneficial reuse of Snohomish River maintenance dredged material and other suitable sediments may also be considered during remedial design. For costing purposes, the designs above are considered to be the final placed thicknesses (i.e., including overplacement allowances).

4.3.2.6 Removal

Removal of sediments from the aquatic environment is a common approach to addressing materials that require remedial action, and was used during both the 2003 and 2007 interim actions. If selected as a part of the final remedy, removal would likely be performed from a barge-mounted clamshell dredge, similar to these prior actions. Removal was retained as a response action for more detailed evaluation in this FS.

A number of site-specific operational conditions influence the effect of environmental dredging of contaminated sediment on aquatic systems. Site experience shows that resuspension of contaminated sediment and release of contaminants occur during dredging and that contaminated sediment residuals will remain following operations, which can affect the magnitude, distribution, and bioavailability of the contaminants and the exposure and risk to receptors of concern. Dredging residuals have been shown to be particularly problematic at sites with considerable debris (Patmont and Palermo 2007). 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).

The extent of marine area removal at the Site is potentially limited by adjacent upland stability considerations. Within the southern mill area, the depth of marine removal could cause significant undermining of upland structures. Such undermining can be minimized through the use of shoring; however, complete removal of buried deep deposits may still not be possible even with shoring unless substantial upland excavation is performed along with the demolition and replacement of near-shore upland structures. Because of slope stability concerns, where deeply buried deposits remain in shoreline embankment areas, a combination of dredging on the angle of repose and a cap engineered to retain slope stability may be required.

4.3.2.6.1 Disposal and/or Reuse Options

There are several options for disposal of marine sediments. For those sediments that are determined (by the DMMP) to be suitable for open-water disposal, such sediments 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, wood waste within northern embayment sediments would likely be determined to be suitable for open-water disposal at the non-dispersive DMMP site in Port Gardner near Everett, Washington. However, additional testing and suitability determinations by the DMMP would be required during design to verify the suitability of these materials for open-water disposal.

For debris and sediments that are not suitable for open-water disposal, upland disposal at a permitted municipal or private landfill (e.g., construction debris landfill or Subtitle D landfill) may be necessary. Sediments excavated using water-based equipment could be loaded on a barge, and could potentially be shipped directly to a Canadian landfill, or to a barge-truck-rail transloading facility for shipment to a United States landfill with rail access.

While a practicable beneficial reuse opportunity for wood waste material was not identified during this FS, there may be potential future opportunities to reuse some of the wood material beneficially, such as topsoil for upland reuse. In this case, debris would need to be screened out, larger pieces chipped, and salt rinsed (i.e. "sparged") from the material prior to reuse. Successful sparging of salinity from wood debris was demonstrated as part of the 2007 interim action at the Site, where wood debris sediments were dredged from Port Gamble Bay and placed within a nearshore upland stockpile containment structure (i.e., 4-foot-thick sparging basin). Freshwater was applied through a simple sprinkler system, which successfully reduced porewater salinity within the sparging basin to below secondary drinking water standards (less than 0.5 ppt) within a period of approximately four months (Anchor QEA and EPI 2010). Leachate from the sparging basin did not exceed discharge criteria, and was passively returned to Port Gamble Bay. Much of the sparged Port Gamble material was successfully reused as an upland soil amendment for a proposed future local soccer field (Figure 1-1).

At the Site, the practicability of beneficial reuse of wood waste sediments is limited by the available land to facilitate sparging, and also by logistics and costs associated with transport of sparged materials to prospective beneficial reuse locations. While specific practicable beneficial reuse opportunities were not identified during this FS, if this option were to be selected as part of the final Site remedy, such opportunities would be further explored and evaluated during remedial design.

4.3.2.7 Ex Situ Treatment

As discussed above, ex situ treatment of wood waste using relatively low cost sparging technologies has been demonstrated as a method to remove salt from the material to facilitate beneficial reuse of these materials. However, in order to be cost-effective, ex situ treatment by sparging requires a significant upland space available adjacent to the project site for up to one year while sparging is performed. While other remedial technologies such as thermal desorption, incineration, stabilization, and soil washing could potentially be applied to the Site, such technologies are substantially more expensive than off-site landfill disposal, and many of these technologies have limited effectiveness for sediments with a high organic content (e.g., wood waste). Thus, no ex situ treatment technologies, other than sparging to facilitate beneficial reuse of wood waste materials, were retained for further evaluation.

4.3.2.8 In Situ Treatment

ElectroChemical Remediation Technology is an innovative technology for destroying organic contaminants in situ by applying an alternating current across electrodes placed in the subsurface. In theory, the applied voltage creates redox reactions that destroy contaminants and organic materials such as wood debris through oxidation-reduction mechanisms. The primary advantage of this technology is that it has the potential to treat sediment in situ. The disadvantages are that it has produced mixed results at the field level, and studies indicate that treatment is less effective in sediments with high wood organic content such as those common at the Site. Because field trials have not documented successful application of this technology to high organic content sediments, in situ treatment of marine sediments was screened from further evaluation in this FS.

5 MTCA EVALUATION CRITERIA

This section presents a description of the threshold requirements for cleanup actions under MTCA and the additional criteria used to evaluate the cleanup action alternatives.

5.1 MTCA Threshold Requirements

Cleanup actions performed under MTCA must comply with several basic requirements. Cleanup actions alternatives that do not comply with these criteria are not considered suitable cleanup actions under MTCA. The four threshold requirements for cleanup actions are:

- Protection of human health and the environment
- Compliance with cleanup standards
- Compliance with applicable state and federal laws
- Provision for compliance monitoring.

5.1.1 Protection of Human Health and the Environment

Cleanup actions performed under MTCA must ensure that both human health and the environment are protected as a result of the action.

5.1.2 Compliance with Cleanup Standards

Compliance with cleanup standards requires, in part, that cleanup levels are met at the applicable points of compliance. Where a cleanup action involves containment of soils and sediments with hazardous substance concentrations exceeding cleanup levels at the point of compliance, the cleanup action may be determined to comply with cleanup standards, provided the requirements specified in WAC 173-340-740(6)(f) are met, specifically:

- The remedy is permanent to the maximum extent practicable
- The remedy is protective of human health
- The remedy is protective of terrestrial ecological receptors
- Institutional controls are implemented
- Compliance monitoring is provided (this is also a threshold requirement) with periodic reviews
- The type and amount of hazardous substances remaining on site, and measures to

prevent migration of and contact with these substances are specified in the draft CAP.

5.1.3 Compliance with Applicable State and Federal Laws

Cleanup actions conducted under MTCA must comply with applicable state and federal laws. The term "applicable state and federal laws" includes legally applicable requirements and those requirements that Ecology determines to be relevant and appropriate as described in WAC 173-340-710.

5.1.4 Provision of Compliance Monitoring

The cleanup action must allow for compliance monitoring in accordance with WAC 173-340-410. Compliance monitoring consists of protection monitoring, performance monitoring, and confirmational monitoring. Protection monitoring is conducted to confirm that human health and the environment are adequately protected during construction and the operation and maintenance period of a cleanup action. Performance monitoring is conducted to confirm that the cleanup action has attained cleanup standards and, if appropriate, remediation levels or other performance standards. Confirmational monitoring is conducted to confirm the long-term effectiveness of the cleanup action once cleanup standards and, if appropriate, remediation levels or other performance standards have been attained.

5.2 Additional MTCA Requirements

5.2.1 Provide for Permanent Solutions to the Maximum Extent Practicable

MTCA requires that when selecting from cleanup action alternatives that fulfill the threshold requirements, the selected action shall use permanent solutions to the maximum extent practicable [WAC 173-340-360(2)(b)(i)].

MTCA specifies that the permanence of these qualifying alternatives shall be evaluated by balancing the costs and benefits of each of the alternatives using a disproportionate cost analysis (DCA) in accordance with WAC 173-340-360(3)(e). The criteria for conducting this analysis are described in Section 5.4.

5.2.2 Provide a Reasonable Restoration Timeframe

In accordance with WAC 173-340-360(2)(b)(ii), MTCA places a preference on those cleanup action alternatives that, while equivalent in other respects, can be implemented in a shorter period of time. MTCA includes a summary of factors to be considered in evaluating whether a cleanup action provides for a reasonable restoration timeframe [WAC 173-340-360(4)(b)].

5.2.3 Provide for Consideration of Public Concerns

Ecology will consider public comments submitted during the RI/FS process in making its preliminary selection of an appropriate cleanup action alternative. This preliminary selection is subject to further public review and comment when the proposed remedy is published by Ecology in a draft CAP. While public concerns are addressed by Ecology through the review process, they are also expressly considered as an element of the DCA evaluation for each alternative.

5.3 Additional SMS Evaluation Criteria

Remedy selection criteria under SMS regulations are generally the same as those required under MTCA. The SMS evaluation criteria are specified in WAC 173-204-560(4)(f) through (k). While most of the requirements have a direct correlation to MTCA criteria, two additional SMS criteria are not specifically addressed by MTCA:

- The degree to which recycling, reuse, and waste minimization are employed; and
- Analysis of environmental impacts consistent with SEPA requirements.

These criteria will be addressed during development of the CAP.

5.4 MTCA Disproportionate Cost Analysis

The MTCA DCA described in WAC 173-340-360(3)(e) is used to evaluate which of the alternatives that meet the threshold requirements are protective to the maximum extent practicable. This analysis involves comparing the costs and benefits of alternatives and selecting the alternative whose incremental costs are not disproportionate to the incremental benefits. The evaluation criteria for the disproportionate cost analysis are specified in WAC

173-340-360(3)(f), and include protectiveness, permanence, cost, long-term effectiveness, management of short-term risks, implementability, and consideration of public concerns.

In order to favor the benefits of criteria associated with the primary goals of the remedial action, a weighting system was used specific to the context of the FS for this Site. The criteria associated with environmentally based benefits are more highly weighted than other criteria that are associated with non-environmental factors, consistent with Ecology direction. The weighting factors are subjective and serve to represent the importance of each of the benefits criterion at this Site, relative to the MTCA requirement to protect human health and the environment. Each of the MTCA criteria used in the DCA and the weighting factors ascribed to the criteria are described below.

5.4.1 Protectiveness

The overall protectiveness of a cleanup action alternative is evaluated based on several factors. Primary considerations include the extent to which human health and the environment are protected and the degree to which overall risk at a site is reduced. Both on-site and off-site reductions in risk are considered. Protectiveness also gauges the degree to which the cleanup action may perform above the level of the specific standards presented in MTCA. Finally, it is a measure of the improvement of the overall environmental quality at the site. For this FS, a weighting factor of 30 percent was applied toward the overall benefit analysis. This means that, despite being only one of six factors (17 percent) for which a numeric value was assigned, the numeric factor assigned to protectiveness for each alternative was up-weighted to represent 30 percent of the numeric benefit analysis. This high weighting is warranted due to the overall importance of protection of human health and the environment as a primary goal of cleanup at the Site.

5.4.2 Permanence

MTCA specifies that when selecting a cleanup action alternative, preference shall be given to actions that are "permanent solutions to the maximum extent practicable." Evaluation criteria include the degree to which the alternative permanently reduces the toxicity, mobility, or mass of hazardous substances, including the effectiveness 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 processes, and the characteristics and quantity of treatment residuals generated. A weighing factor of 20 percent was assigned to the numeric values associated with this evaluation criterion. This criterion has the second highest weighting factor, due to the importance of the need or lack of need for further action in the future.

5.4.3 Cost

The analysis of cleanup action alternative costs under MTCA includes all costs associated with implementing an alternative, including design, construction, long-term monitoring, and institutional controls. Costs are intended to be comparable among different alternatives to assist in the overall analysis of relative costs and benefits of the alternatives. The costs to implement an alternative include the cost of construction, the net present value of any long-term costs, and agency oversight costs. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls. Cost estimates for removal and disposal technologies include processing, analytical, labor, and waste management costs. The design life of the cleanup action is estimated, and the costs of replacement or repair of major elements are included in the cost estimate. Costs were compared against benefits to assess cost-effectiveness and practicability of the cleanup action alternatives. No weighting factor was applied to this quantitative category.

5.4.4 Long-Term Effectiveness

Long-term effectiveness is a parameter that expresses the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards over the long-term performance of the cleanup action. The MTCA regulations contain a specific preference ranking for different types of technologies that is to be considered as part of the comparative analysis. The ranking places the highest preference on technologies such as reuse/recycling, treatment, immobilization/solidification, and disposal in an engineered, lined, and monitored facility.

Lower preference rankings are applied for technologies such as on-site isolation/containment with attendant engineered controls, and institutional controls and monitoring. The regulations recognize that, in most cases, the cleanup alternatives will combine multiple technologies to accomplish the cleanup action objectives. The MTCA preference ranking must be considered along with other site-specific factors in the evaluation of long-term effectiveness. A weighting factor of 20 percent was assigned to the long-term effectiveness based on the importance of achieving final environmental cleanup without the need for future actions to ensure protection of human health and the environment.

5.4.5 Management of Short-Term Risks

Evaluation of this criterion considers the relative magnitude and complexity of actions required to maintain protection of human health and the environment during implementation of the cleanup action. Cleanup actions carry short-term risks, such as potential mobilization of contaminants during construction, or safety risks typical of large construction projects. In-water dredging activities carry a risk of temporary water quality degradation and potential sediment recontamination. Some short-term risks can be managed to some degree through the use of best practices during project design and construction, while other risks are inherent to project alternatives and can offset the long-term benefits of an alternative. The weighting factor of short-term risk management for this FS evaluation was 10 percent. The lower rating was based on the limited timeframe associated with the risks and the general ability to correct short-term issues during construction without significant effect on human health and the environment.

5.4.6 Implementability

Implementability is an overall metric expressing the relative difficulty and uncertainty of implementing the cleanup action. Evaluation of implementability includes consideration of technical factors such as the availability of mature technologies and experienced contractors to accomplish the cleanup work. It also includes administrative factors associated with permitting and completing the cleanup. The weighting factor for implementability was 10 percent. Implementability is less associated with the primary goal of the cleanup action, protection of human health and the environment, and therefore has a lower weighting factor. In addition, the issues associated with the implementability are reflected in the remedy costs.

5.4.7 Consideration of Public Concerns

The public involvement process under MTCA is used to identify potential public concerns regarding cleanup action alternatives. The extent to which an alternative addresses those concerns is considered as part of the evaluation process. This includes concerns raised by individuals, community groups, local governments, tribes, federal and state agencies, and other organizations with an interest in the site. The weighting factor used for this criterion was 10 percent. Similar to the applied factor for implementability, the low weighting of public concerns prevents duplication of issues that are addressed with other criteria. Historically, public concerns for most sites are typically related to environmental concerns and performance of the cleanup action, which are addressed under other criteria such as protectiveness and permanence.

6 DEVELOPMENT AND EVALUATION OF CLEANUP ACTION ALTERNATIVES

In this section, the technologies and process options for cleanup technologies retained through the screening evaluation described in Section 4 are used to develop alternatives to address the cleanup action objectives for impacted areas and media at the Site. This section also provides a comparative analysis of the cleanup action alternatives. Each alternative addresses impacted media with a combination of technologies appropriate for Site conditions.

The cleanup action alternatives developed in this section are based on conceptual-level designs for the implementation of individual technologies described in Section 4.3. The design parameters used to develop the alternatives are based on engineering judgment and current knowledge of Site conditions. The final design for the preferred alternatives may require additional characterization and analysis to refine the scope and costs associated with the selected cleanup action.

6.1 Uplands Area

As discussed in Section 4.3.1, additional institutional controls could potentially be implemented to further ensure the continued protectiveness of the extensive interim remedial actions completed at the Site from 2002 to 2005. Such additional controls could include restrictive covenants for upland groundwater and/or soils. One of the key objectives of the completed interim actions and of the final remedy is to not significantly encumber land value, future use, future sale, and/or reasonable redevelopment options at the Site.

For the purpose of this FS, all final cleanup alternatives were assumed to include restrictive covenants that would preclude future use of the shallow aquifer at the Site for future drinking water supply. In addition, all alternatives assume that the presence of soil covers to minimize the potential for future terrestrial wildlife impacts at the Site would also be documented in Kitsap County property records, to minimize the potential for future impacts resulting from disturbance of these areas using the existing Kitsap County permitting (e.g., grading permit) process. The specific scope and form of such institutional controls would be determined during development of the CAP.

6.2 Marine Area

This section describes the marine area cleanup action alternatives, including a description of the various SMAs considered, an initial screening of appropriate remedial technologies for each SMA, the evaluation and comparison of the marine area alternatives, and the MTCA DCA for each alternative.

6.2.1 Delineation and Description of Sediment Management Areas

Because there is no promulgated numeric SMS criterion for wood waste (only the narrative standard), sediment cleanup requirements at the Site were determined based on interpretations of a suite of confirmatory biological tests performed on surface sediment samples collected in wood waste areas at the Site with the potential for deleterious effects. Bioassay test interpretations under SMS consist of endpoint comparisons of test sediments to the measurements observed in reference sediments, including statistical comparisons between the test and reference endpoints. As discussed in the RI report (Anchor QEA and EPI 2010), the bioassay tests revealed that surface sediments collected from the northern and southern embayments of the Site were potentially toxic, but to varying degrees, in laboratory exposures to SMS test organisms. Bioassay responses at the Site have varied significantly over time, as amphipod and PSEP larval toxicity as measured by the bioassays declined significantly from 2002 to 2008, particularly within the southern embayment. Bioassay responses have also varied spatially at the Site, with highest toxicity consistently observed in surface sediments collected from areas of the northern embayment that overlie the buried wood chip deposit.

The delineation of sediment areas requiring remedial action under SMS and/or MTCA was initially based on point-by-point interpretations of all bioassay data collected at the Site over the period from 2002 to 2008. The point-by-point interpretations were based on comparisons of test results with matched reference samples meeting acceptance criteria that were collected during the same sampling event, as summarized in the RI report (Anchor QEA and EPI 2010). Summary interpretations of the point-by-point SMS bioassay data for the amphipod (2006 and 2008 data only), PSEP larval (all 2002 to 2008 data), and *Neanthes* (all 2002 to 2008 data) bioassay tests are presented in Figures 6-1 to 6-3, respectively. The cumulative point-by-point SMS bioassay interpretation based on these data is presented in

Figure 6-4. Based on this initial evaluation, only the 2007 interim action area of the Site is currently below SQS biological criteria. Potentially widespread deleterious effects indicated by the initial PSEP larval bioassay point-by-point interpretations (Figure 6-2) have also been observed in other areas of Port Gamble Bay (Hart Crowser 2010). Importantly, similar responses of the PSEP larval bioassay have also been observed in other studies of Puget Sound reference areas, frequently confounding SMS bioassay interpretations.

While the bioassay data themselves were used as the primary basis to delineate potential SMAs at the Site, statistically correlated ($P<0.01$) wood waste indicator parameters including surface sediment porewater sulfide and TVS concentrations (developed using the bay-wide sampling data collected from 2002 to 2008) were also used in the overall weight-of-evidence delineation of SMAs at the Site. These analytes do not have SMS criteria. However, two screening levels—SL1 and SL2, which are roughly equivalent to SQS and CSL levels—were estimated based on a site-specific relationship between their concentrations and bioassay results. The spatial distributions of surface sediment porewater sulfide and TVS concentrations at the Site are presented in Figures 6-5 and 6-6, respectively, based on geostatistical (ordinary kriging) analyses of the combined 2002 to 2008 data. During this sampling period, surface sediment porewater sulfide concentrations exceeding screening levels were generally confined to relatively shallow, nearshore areas of the northern embayment overlying buried wood chip deposits (Figure 6-5). Surface sediment TVS concentrations exceeding the SL1 screening criterion occurred in parts of both the northern and southern embayments closest to historical chip loading facilities, while surface sediment TVS concentrations exceeding the SL2 screening criteria were limited to parts of the southern embayment (Figure 6-6). The spatial distributions of these wood waste indicator parameters, based on extensive sampling data, were used to help delineate SMAs for the purpose of this FS (see below).

As discussed above, delineation of SMAs for this FS used a detailed weight-of-evidence approach that considered the range of scientifically based interpretations of the bioassay data provided under the SMS regulatory framework. The variability in bioassay performance observed in reference samples collected from both Carr Inlet and Sequim Bay was determined to have a pronounced effect on overall bioassay interpretations, particularly for the PSEP larval test. This can be seen by comparing the cumulative frequency distributions of the reference sample bioassay data with samples collected from the Site (Figures 6-7 and 6-8).

While the 2002 data clearly revealed relatively high amphipod and PSEP larval toxicity across much of the Site (sampling conducted shortly after source controls were implemented), subsequent bioassay testing performed in 2006 and 2008 indicated that most of the Site had recovered to toxicity levels similar to that of the reference areas (Figures 6-7 and 6-8). The few remaining bioassay exceedances were largely limited to parts of the northern and southern embayments that also contained the highest surface sediment porewater sulfide and/or TVS concentrations (Figures 6-5 and 6-6). Comparison of the Site bioassay data with average reference performance (and statistical comparisons based on reference "envelope" analyses) provides a more accurate assessment of biological effects, explicitly incorporating reference sample variability into the interpretations. The reference envelope interpretation, which more accurately reflects baseline conditions unrelated to wood waste, was performed according to SMS interpretation criteria.

For the purpose of the FS for the Port Gamble Mill Site, an overall weight-of-evidence approach was used to delineate SMAs at the Site, resulting in a total of ten lines of evidence as follows:

- SMS point-by-point bioassay interpretations (four lines, one for each SMS bioassay; this was also the primary line of evidence used to define the Site boundary):
    1. Amphipod survival (2006 to 2008 data; Figure 6-1)
    2. PSEP normal larval survivorship (all 2002 to 2008 data; Figure 6-2)
    3. *Neanthes* growth (all 2002 to 2008 data; Figure 6-3)
    4. Microtox luminescence (all 2002 to 2008 data; no SQS effects noted at the Site)
- Average reference envelope interpretation (four lines, one for each SMS bioassay):
    5. Amphipod survival (based on kriging of all 2002 to 2008 data; see Figure 6-7)
    6. PSEP normal larval survivorship (all 2002 to 2008 data; see Figure 6-8)
    7. *Neanthes* growth (based on kriging of all 2002 to 2008 data)
    8. Microtox luminescence (all 2002 to 2008 data; no SQS effects noted at the Site)
- Indicator parameter distributions (two lines)

9. Surface sediment porewater sulfide concentration (based on kriging of all 2002 to 2008 data; Figure 6-5)
10. Surface sediment TVS concentration (based on kriging of all 2002 to 2008 data; Figure 6-6)

Each line of evidence received the following weighting:

- Less than SQS = 0
- Between SQS and CSL = 1
- Greater than CSL = 2

Using the data layers summarized above, a geographic information system (GIS) analysis was used to combine each line of evidence to determine the spatial distributions of the cumulative weight-of-evidence of adverse biological effects at the Site. A summary of the overall weight-of-evidence at the Site is presented in Figure 6-9. Table 6-1 presents the scoring for each sample location included in the analysis.

Based on the weight-of-evidence evaluations, four different SMA characteristics were identified:

- SMA-1: High concentration wood chip deposits in shallow water and relatively strong weight-of-evidence of adverse biological effects
- SMA-2: High and/or moderate concentration wood chip deposits in moderate water depths and moderate weight-of-evidence of adverse biological effects
- SMA-3: Moderate concentration bark or other wood waste deposits in deeper water and moderate or mixed weight-of-evidence of adverse biological effects
- SMA-4: Low concentration bark or other wood waste deposits in deeper water and mixed weight-of-evidence of adverse biological effects

Delineation of these SMAs at the Site is depicted in Figure 6-9.

6.2.2 Initial Screening of Technologies for SMAs

While Section 4.3.2 provided a general screening for all remedial technologies that would be considered for sediments, the retained technologies were further screened for application to specific SMAs based on the weight-of-evidence and/or site characteristics of each SMA. This section provides an initial screening of alternatives relative to the SMAs, and summarizes the alternatives that were carried forward for detailed evaluation.

6.2.2.1 SMA-1

Located in the part of the northern embayment, SMA-1 contains a buried deposit of wood chips extending approximately 6 feet below mudline, located in relatively shallow water (less than 15 feet below MLLW). This SMA has the highest surface sediment porewater sulfide concentrations (Figure 6-5), and also the highest overall weight-of-evidence of adverse biological effects (Figure 6-9). A focused range of remedial technologies including dredging and dredging combined with engineered containment (dredge and cap) were identified as potentially appropriate remedial alternatives to address wood waste and associated biological impacts in SMA-1.

Engineered containment in the absence of dredging in SMA-1 would likely not result in an effective remedial alternative. A cap constructed in this area of the Site would need to be able to attenuate (primarily through oxidation) porewater sulfide generated by the chemical reaction of sulfate in marine water with underlying decomposing wood waste. Based on initial cap performance modeling, such attenuation may be only marginally effective in the shallow subtidal zone of SMA-1 that is subject to tidal reversals and associated sulfide transport. Because of these site characteristics, which are unique to SMA-1 (see Figure 6-5), engineered containment in SMA-1 was not retained for detailed evaluation.

As with engineered containment, ENR and MNR do not address the sulfide impacts from the wood waste area of SMA-1. Thus, both of these technologies were not retained for detailed evaluation applied to SMA-1.

Dredge Alternative Description

Geophysical survey work performed in the northern embayment identified a concentrated deposit of wood chips within the footprint of the chip loading facility (Figure 6-10). This deposit is located directly below surface sediments containing elevated porewater sulfide concentrations and the delineated area of benthic impacts in SMA-1. Targeted removal of this wood chip deposit is the goal of the SMA-1 dredging alternative. The geophysical survey data delineated both the horizontal and vertical limits of the targeted dredge prism; coring data collected in this area verified the accuracy of this delineation within SMA-1. Dredging in SMA-1 entails the following major elements:

- Demolition of the existing piles within the wood chip footprint. Based on aerial and ground photos, approximately 290 piles are assumed necessary to be removed to accommodate dredging.
- Dredging of approximately 9,000 cy (excluding overdredge allowances) of wood chips and associated sediments located in the vicinity of the former chip loading dock. Based on the combined sediment coring and sub-bottom profiling data, which delineated the extent of wood chips in SMA-1, dredging would extend over an area of approximately 0.9 acres.
- Screening and removal of debris for upland disposal.
- Transport and disposal of dredge material at a non-dispersive DMMP open-water disposal site—presumed to be Port Gardner in Everett.
- Placing a minimum 6-inch thick post-dredge residuals cover over the entire SMA-1 area (i.e., extending beyond the dredge prism over a total of approximately 1.4 acres).

The estimated construction duration of this remedial alternative is approximately 3 months. Figure 6-10 presents the conceptual dredge remedy in SMA-1.

Dredge and Cap Alternative Description

The dredge and cap alternative in SMA-1 entails the following major elements:

- Demolition of the existing piles within the wood chip footprint. Based on aerial and ground photos, approximately 290 piles are assumed necessary to be removed to accommodate dredging.
- Dredging approximately 4,500 cy (excluding overdredge allowances) of wood chips to accommodate a minimum 3-foot-thick cap, returning SMA-1 to its current grade. The dredge cut in this alternative would extend over an area of approximately 0.9 acres.
- Screening and removal of debris for upland disposal.
- Transport and disposal of dredge material at a non-dispersive DMMP open-water

disposal site—presumed to be Port Gardner in Everett.

- Placing an engineered cap over the dredge footprint. The cap is assumed to consist of 12 inches of sand overlain by 12 inches of gravel, with a 12-inch thick habitat mix final dressing over the 0.9 acre footprint.
- Placing a residuals management cover (minimum 6-inch thick) over the remaining 0.5 acre SMA-1 footprint.

The estimated construction duration of this remedial alternative is approximately 3 to 4 months. Figure 6-11 presents the conceptual dredge and cap remedy in SMA-1.

6.2.2.2 SMA-2

Located in part of the southern embayment, SMA-2 also contains a buried deposit of wood chips extending approximately 5 feet below mudline, but unlike SMA-1 is located in deeper water (more than 20 feet below MLLW). Deeper portions of this SMA may be less subject to tidal reversals of groundwater/porewater. While lower surface sediment porewater sulfide concentrations were reported in SMA-2 (see Figure 6-5), the presence of substantial subsurface *Beggiatoa* mats in the wood waste in this area indicate similar dynamics to SMA-1, particularly within shallower areas. SMA-2 has relatively high concentrations of wood waste near the sediment surface, as evidenced by relatively high surface sediment TVS concentrations (Figure 6-6), and moderate to high overall weight-of-evidence of adverse biological effects (Figure 6-9).

A focused range of remedial technologies including dredging, dredge and cap, and engineered containment were identified as potentially appropriate remedial alternatives to address wood waste and associated biological impacts in SMA-2. The dredge and cap and engineered containment options are given further consideration in SMA-2, recognizing uncertainty and complexity required for these options to fully isolate the wood waste and its effects. Because of its depth, the conceptual cap design for most of SMA-2 (below -15 feet MLLW) would consist of 18 inches of sand (see Section 4.3.2). A thicker armored cap would be used in shallower areas to resist propeller wash and other disturbances.

Other remedial technologies including ENR and MNR would not likely provide sufficient protection, relative to the focused list of technologies above. Thus, both of these technologies were not retained for detailed evaluation applied to SMA-2.

Dredge Alternative Description

Dredging to the maximum extent practicable in SMA-2 entails the following major elements:

- Demolition of the existing piles within the dredging footprint. Based on aerial and ground photos, approximately 432 piles are assumed necessary to be removed to accommodate dredging.
- Installation of temporary sheetpile shoring as necessary to facilitate dredging.
- Dredging approximately 26,000 cy (excluding overdredge allowances) of wood chips and associated sediment over an area of about 2.6 acres. This dredge cut in SMA-2 would require removal of thicker deposits at the toe of the slope, necessitating the shoring described above.
- Screening and removal of debris for upland disposal.
- Transport and disposal of dredge material at a non-dispersive DMMP open-water disposal site—presumed to be Port Gardner in Everett.
- Placing a minimum 6-inch thick post-dredge residuals cover. For cost purposes, up to 12 inches of sand have been assumed for purchase and placement.

The estimated construction duration of this remedial alternative is approximately 4 to 6 months. Figure 6-12 presents the conceptual dredge remedy in SMA-2.

Dredge and Cap Alternative Description

The dredge and cap alternative in SMA-2 entails the following major elements:

- Demolition of the existing piles within the dredging footprint. Based on aerial and ground photos, approximately 432 piles are assumed necessary to be removed to accommodate dredging.
- Dredging approximately 10,000 cy (excluding overdredge allowances) of wood chips and associated sediment over an area of about 1.3 acres.
- Screening and removal of debris for upland disposal.
- Transport and disposal of dredge material at a non-dispersive DMMP open-water

disposal site—presumed to be Port Gardner in Everett.

- Placing an engineered cap over the dredge footprint. The cap is assumed to consist of 12 inches of sand overlain by 12 inches of gravel, with a 12-inch thick habitat mix final dressing (Type I cap) covering approximately 0.1 acres in the shallow water slope areas. The cap would confine any wood waste deposits on the slope that are exposed during dredging but impracticable to fully remove without destabilizing the slope.
- Placing a Type II engineered cap in the deeper water of the dredge footprint. The cap is assumed to consist of 18 inches of sand and covers approximately 0.75 acres.
- Placing a 6-inch sand cover over the "halo" surrounding the dredge and cap areas, as well as over portions of the dredge footprint where native contact is reached. This area is estimated at approximately 1.75 acres.

The estimated construction duration of this remedial alternative is approximately 5 to 6 months. Figure 6-13 presents the conceptual dredge and cap remedy in SMA-2.

Engineered Containment Alternative Description

Engineered containment in SMA-2 entails constructing a sand cap as follows:

- Demolition of the existing piles within the cap footprint. Based on aerial and ground photos, approximately 432 piles are assumed necessary to be removed to accommodate capping.
- Purchase, transport, and placement of an engineered sand cap. The cap is assumed to be a Type II cap, consisting of 18 inches of sand. The estimated volume of sand required to cap the approximate 2.6-acre footprint is 9,350 tons.

The estimated construction duration of capping in SMA-2 is approximately 2 months. Figure 6-14 presents the conceptual engineered containment remedy in SMA-2.

6.2.2.3 SMA-3

Also located in part of the southern embayment, SMA-3 contains a buried deposit of bark extending approximately 4 feet below mudline and, like SMA-2, is located in deeper water (more than 20 feet below MLLW). This SMA also has low surface sediment porewater sulfide concentrations (Figure 6-5) and moderate concentrations of wood waste at the sediment surface, as evidenced by TVS concentrations (Figure 6-6), along with mixed weight-of-evidence of adverse biological effects (Figure 6-9). Based on biological testing results collected between 2002 and 2008, there is strong indication that this area recovered rapidly following source control implementation in the late 1990s/early 2000s. Surface sediment TVS concentrations have shown a similar recovery in SMA-3, declining from 29 ± 9 percent in 1999 to 12 ± 2 percent in 2008.

A focused range of remedial alternatives including engineered containment, ENR, and continued MNR were identified as potentially appropriate remedial alternatives to address wood waste and associated biological impacts in SMA-3. Because of its depth, the conceptual cap design for SMA-3 would consist of 18 inches of sand (Type II cap).

Dredging was eliminated from further consideration in SMA-3 because this technology would not likely provide sufficient protection, relative to the focused list of retained technologies listed above. Dredging-related resuspension and residuals anticipated during and following removal of the SMA-3 deposit, particularly given that a considerable amount of buried logs and other debris are present in this area that would exacerbate dredging releases (Patmont and Palermo 2007), would result in a post-dredge surface with greater biological impacts than the current sediment surface, necessitating placement of a post-dredge cap or cover. Not only would dredging of SMA-3 lead to greater short-term environmental impacts, but this technology would be considerably more difficult to implement, relative to the other retained technologies. The overall risks associated with implementing a dredging remedy in SMA-3 are considerably greater than the other technologies, and would provide little if any net environmental benefit. Thus, dredge and dredge and cap technologies were not retained for detailed evaluation applied to SMA-3.

Engineered Containment Alternative Description

Engineered containment in SMA-3 entails constructing a sand cap as follows:

- Demolition of the existing piles within the cap footprint. Based on aerial and ground photos, approximately 102 piles are assumed necessary to be removed to accommodate capping.
- Purchase, transport, and placement of an engineered sand cap over the approximate

3-acre footprint of SMA-3. The cap is assumed to be a Type II cap, consisting of 18 inches of sand.

The estimated construction duration of capping in SMA-3 is approximately 2 to 3 months. Figure 6-15 presents the conceptual engineered containment remedy in SMA-3.

ENR Alternative Description

ENR in SMA-3 consists of the following major project elements:

- Demolition of the existing piles within the cap footprint. Based on aerial and ground photos, approximately 102 piles are assumed necessary to be removed to accommodate cover placement.
- Purchase, transport, and placement of sand to create a minimum 6-inch-thick cover over the approximate 3-acre footprint of SMA-3. For cost purposes, up to 12 inches of material are assumed purchased to create the minimum 6-inch-thick layer.
- Post-construction monitoring. Up to five long-term monitoring events would be performed to verify the protectiveness of this option (approximately $30,000 per event).

The estimated initial construction duration for ENR in SMA-3 is approximately 2 months. Post-construction monitoring would be performed over a 5 to 10-year period, and would be defined in more detail in the CAP.

MNR Alternative Description

The MNR remedy in SMA-3 does not entail active construction. Rather, MNR would consist of a series of sediment monitoring events at a scope and frequency defined in the CAP to verify the anticipated continued recovery of the benthic community due to natural processes (sedimentation, bioturbation, and biodegradation). Similar to the ENR alternative, long-term monitoring would be performed over a 5 to 10-year period (with more extensive sampling and analysis at approximately $50,000 per event), and would be defined in more detail in the CAP. The MNR plan would include clear endpoints and timeframes for measuring success and triggers for initiating more active alternatives if recovery is not occurring in a reasonable timeframe.

6.2.2.4 SMA-4

As with SMA-3, ongoing natural recovery is evident when comparing biological test results of samples collected in outlying areas of SMA-4 from 2002 to 2008 (e.g., see Figures 6-5 and 6-6). The SMA-4 areas are characterized by low concentration wood waste deposits in deeper water and low or mixed weight-of-evidence of adverse biological effects (Figure 6-9).

Because the evidence of current biological impacts in SMA-4 is relatively limited, technologies such as dredging or engineered containment, which would remove or place a thick sequence of sand over recovering sediments and functioning habitat, respectively, would lead to unnecessary disruptions of the biological communities present in SMA-4. Thus, dredge, dredge and cap, and engineered containment technologies were not retained for detailed evaluation applied to SMA-3. However, natural recovery could potentially be accelerated through thin cover placement, which is not as disruptive to the biota. For SMA-4, only ENR and MNR were retained for detailed evaluation.

ENR Alternative Description

ENR in SMA-4 consists of the following major project elements:

- Demolition of the existing piles within the cap footprint. Based on aerial and ground photos, approximately 80 piles in SMA-4a and 450 piles in SMA-4b are assumed necessary to be removed to accommodate cover placement.
- Purchase, transport, and placement of sand to create a minimum 6-inch-thick cover over the approximate 2.3-acre footprint of SMA-4a, along with additional sand to cover the approximate 11-acre footprint of SMA-4b. For cost purposes, up to 12 inches of material are assumed purchased to create the minimum 6-inch thick layer.
- Up to five long-term monitoring events would be performed to verify the protectiveness of this option (approximately $30,000 per event).

The estimated initial construction duration for ENR in SMA-4 is approximately 4 to 6 months. Post-construction monitoring would be performed over a 5 to 10-year period, and would be defined in more detail in the CAP.

MNR Alternative Description

As with SMA-3, the MNR remedy in SMA-4 does not entail active construction. Rather, MNR would consist of a series of sediment monitoring events at a scope and frequency defined in the CAP to verify the anticipated continued recovery of the benthic community due to natural processes (sedimentation, bioturbation, and biodegradation). Similar to the ENR alternative, long-term monitoring would be performed over a 5 to 10-year period (with more extensive sampling and analysis at approximately $50,000 per event), and would be defined in more detail in the CAP.

6.2.3 Detailed Evaluation and Comparison of Marine Alternatives

Table 6-2 provides a summary of the technologies that were retained for detailed evaluation as described in Section 6.2.2. This section provides a narrative description of the evaluation and comparison of these alternatives for each SMA. In each description, an absolute numeric ranking is provided ranging from 1 to 5, where 1 is the lowest (least favorable) ranking and 5 is the highest (most favorable) ranking. These absolute rankings are further modified by weighting factors for the DCA as described in Section 5.4.

6.2.3.1 SMA-1

6.2.3.1.1 Protectiveness

Dredging in SMA-1 would remove most of the wood chip deposit present in this area, leaving approximately 5 percent of the dredged mass of wood waste as a residual layer on the post-dredge sediment surface (Patmont and Palermo 2007). The resulting post-dredge sediment surface would likely require placement of a sand cover to mitigate these releases, providing an overall reduction in risk to this shallow water marine environment.

The prospective disposal facility for sediments dredged from SMA-1 is the Port Gardner non-dispersive open-water disposal site near Everett. Prior to disposal, the DMMP agencies would determine whether disposal of these materials at the Port Gardner open-water disposal site can be performed in a manner that is protective of the environment, as indicated from screening-level SMA-1 testing data collected during the RI. (Note that the DMMP has recently accepted similar wood waste materials from other MTCA/SMS sites for open-water disposal.) The use of the DMMP disposal site requires a multi-agency suitability review and approval to ensure overall protectiveness.

The dredging alternative has been ranked highest, with an absolute score of 5 for protectiveness.

The dredge and cap remedy would partially remove the wood chip deposit in SMA-1, with the remaining deposit contained by an engineered cap. Because this alternative leaves some wood waste on site, a potential continuing source of porewater sulfide to surface sediments, and because the engineered cap would require ongoing monitoring and maintenance, there is some residual risk associated with this alternative compared to the dredging alternative. For this reason, the dredge and cap alternative has been ranked lower than the dredge alternative, with an absolute score of 3 for protectiveness.

6.2.3.1.2 Permanence

Upland sources of wood waste have been controlled, and the Site no longer has an active mill facility or log storage operations. Removal of mixed wood waste and sediment from the marine environment would control sulfide generation in SMA-1, which is a byproduct of the breakdown of wood. While dredging is expected to generate residuals, they can be effectively managed in this case through placement of a clean layer of sediment over the post-dredge surface. Thus, the dredging alternative would result in a permanent remedy for SMA-1. This alternative has been given an absolute score of 5 for permanence.

The dredge and cap alternative would result in the partial removal of the SMA-1 wood chip deposit. The cap would be engineered to provide permanent containment of remaining wood waste, and would be monitored and maintained as needed. However, a potential source of sulfide would remain in the marine environment in SMA-1. Because this potential source would remain, the dredge and cap alternative has been given an absolute score of 3 for permanence.

6.2.3.1.3 Long-Term Effectiveness

MTCA has the highest preference for removal, and a lower preference for containment when evaluating long-term effectiveness. However, both dredging and capping technologies are well proven for sediment remediation projects and can provide a high degree of long-term effectiveness when appropriately implemented and maintained. In recognition of the MTCA preference for removal, the dredge alternative has been given an absolute score of 5, and the dredge and cap alternative has been given an absolute score of 3 (because some containment is still used) for long-term effectiveness.

6.2.3.1.4 Management of Short-Term Risks

The dredge and dredge and cap remedies have similar short-term risk potential. The risks associated with dredging include potential short-term water quality impacts, contaminant re-suspension, and residuals generation. The nature of dredging requires structure demolition in the dredge footprint and requires the use of heavy construction equipment, which presents a safety risk. While short-term risk can be minimized through best management practices (BMPs) and diligent attention to safety, the risk cannot be entirely eliminated. Thus, for SMA-1, both the dredge and dredge and cap remedies have been assigned an absolute score of 3 for management of short-term risks.

6.2.3.1.5 Technical and Administrative Implementability

Both the dredge and the dredge and cap alternatives rank high for technical and administrative implementability in SMA-1. The technologies to perform the work are well proven. However, while disposal of dredge material in the DMMP open-water site is considered feasible under the current regulatory program, the use of DMMP sites is subject to agency review on a case-by-case basis, and suitability requirements for wood waste materials could potentially change in the future. While less reliant on open-water disposal, the dredge and cap alternative will entail more detailed consideration of future land uses in the relatively shallow capped area, and may result in some use restrictions that are not necessary with the dredge alternative. There are also additional administrative issues that may need to be addressed for placing, monitoring, and maintaining a cap. Based on these factors, the dredge alternative has been assigned an absolute score of 4 and the dredge and cap alternative has been assigned an absolute score of 3 for implementability.

6.2.3.1.6 Consideration of Public Concerns

Historically, the public has often expressed an interest in the maximum removal of contaminants through dredging. More recently, there has been an increasing public awareness that dredging may not achieve the complete removal that was historically thought to be possible. Thus, while it is anticipated that the public would favor removal most highly, there is recognition and concern over potential impacts associated with dredging. For SMA-1, the dredging alternative has been assigned an absolute score of 4 for consideration of public concerns.

By definition, the dredge and cap alternative removes less material and entails leaving some woody debris in the aquatic environment. Despite proven protectiveness with this type of approach, the public has often viewed a capping option more negatively than a full dredge option. Accordingly, the dredge and cap alternative has been given an absolute score of 3 for consideration of public concerns.

6.2.3.2 SMA-2

6.2.3.2.1 Protectiveness

As with SMA-1, the dredge alternative in SMA-2 would remove most of the buried wood chip deposit with placement of a post-dredge cover, would provide the maximum protectiveness to the marine environment. Considerations for disposal of dredge material from SMA-2 are also the same as described for SMA-1. Based on these considerations, the dredging alternative has been assigned an absolute score of 5 for protectiveness.

Considerations for the dredge and cap remedy are similar in SMA-2 as for SMA-1. However, because dredging in the shallower water would eliminate future sulfide impacts in SMA-2, and the fact that any residual wood waste can be effectively contained with the cap, the dredge and cap alternative has been assigned a score of 5 for protectiveness in SMA-2.

Engineered caps applied to SMA-2 are expected to have a high degree of protectiveness as well. However, as with SMA-1, because of the need for ongoing monitoring and maintenance associated with caps, and due to the presence of potential sulfide impacts in the shallower water areas, the engineered containment alternative ranks lower than alternatives that include removal. The engineered containment alternative applied to SMA-2 has been assigned an absolute score of 3 for protectiveness.

6.2.3.2.2 Permanence

Given the same considerations as with SMA-1, the dredging alternative would result in a permanent remedy for SMA-2. This alternative has been given an absolute score of 5 for permanence.

The dredge and cap alternative would result in the partial removal of wood waste from sediment while providing permanent containment of remaining woody debris. Because wood waste would remain on site, the dredge and cap alternative was assigned an absolute score of 4 for permanence.

The engineered containment alternative would be designed to completely contain the mixed sediment and wood waste in SMA-2. As with the dredge and cap alternative, wood waste would remain in the marine environment and thus this alternative was assigned an absolute score of 3 for permanence.

6.2.3.2.3 Long-Term Effectiveness

The dredge and dredge and cap alternatives for SMA-2 have the same considerations as for SMA-1 and thus are scored in the same fashion, with an absolute score of 5 for dredging. The dredge and cap alternative has similar long-term effectiveness as the dredge alternative because significant wood waste is removed, and any remaining residuals can be effectively contained. Thus the dredge and cap alternative has been assigned an absolute score of 5 for long-term effectiveness. Because of the potential need for maintenance, the engineered containment-only alternative has been assigned an absolute score of 3 for long-term effectiveness.

6.2.3.2.4 Management of Short-Term Risks

The dredge alternative has similar short-term risk considerations as for SMA-1. In addition, in SMA-2 there is increased risk for deeper dredging at the toe of the slope for the full removal scenario. Deep dredging at the toe of slopes could induce slope instability that could jeopardize upland structures and shoreline features. This risk can be managed in part through installation of temporary shoring, which is an additional construction element compared to the SMA-1 dredging alternative. Because of the increased risk associated with dredging in SMA-2, the dredging alternative has been assigned an absolute score of 2 for management of short-term risks.

The dredge and cap alternative has similar short-term risk considerations as for SMA-1 and accordingly has been assigned an absolute score of 3 for management of short-term risk.

The engineered containment alternative entails placement of new material at the mudline, but does not require excavation. While the equipment requirements are similar for dredging and capping, there is no potential for generation of dredge residuals or re-suspension of contaminants, and any short-term water quality impacts would be as a result of the placement of clean material (as opposed to suspended sediment generation from contaminated sediment dredging). Thus, the short-term risks for engineered containment are lower than for the alternatives involving dredging. An absolute score of 4 has been assigned for engineered containment in SMA-2 for the management of short-term risks.

6.2.3.2.5 Technical and Administrative Implementability

The dredge alternative in SMA-2 could present some implementability challenges similar to those described under SMA-1 for open-water disposal of dredge material. As previously discussed, deep dredging at the toe of the slope in SMA-2 would require determining cut angles to avoid slope instability. There are substantial structures present in SMA-2 that would need to be removed to accommodate a full removal scenario. Because of these challenges, the dredge alternative has been given an absolute score of 3 for implementability in SMA-2.

The dredge and cap alternative has relatively fewer implementability concerns compared to the full removal dredge alternative because the required depth of dredging would be limited. Moreover, the SMA-2 wood waste deposit is significantly deeper than the SMA-1 deposit, resulting in relatively few potential use restrictions if this area was capped. Implementability considerations for the dredge and cap alternative in SMA-2 are similar as those for SMA-1.

Thus, the absolute score assigned to the dredge and cap alternative is 4 for implementability in SMA-2.

Engineered containment relies on proven technologies and has been demonstrated at sites throughout Puget Sound. Technical implementability of capping is generally straightforward although layered caps are more difficult to construct compared to a cap composed of a single material. Because woody debris would remain in place in a capping scenario, additional administrative requirements would be expected (e.g., ongoing operations, maintenance, and monitoring with periodic agency review). Thus, the engineered containment alternative has been given an absolute score of 4 for implementability in SMA-2.

6.2.3.2.6 Consideration of Public Concerns

As with SMA-1, it is likely the public would prefer complete removal in SMA-2. At the same time, the risks associated with dredging would be a concern. Similar to SMA-1, the dredge alternative has been assigned a score of 4 for SMA-2.

Both the dredge and cap and the engineered containment alternatives entail leaving woody debris in the aquatic environment. It is expected, therefore, that public concerns would be similar for both options, and would be similar for the dredge and cap alternative in SMA-1. For SMA-2, the dredge and cap and engineered containment alternatives have been given an absolute score of 3 for consideration of public concerns.

6.2.3.3 SMA-3

6.2.3.3.1 Protectiveness

The engineered containment alternative in SMA-3 would be implemented in a similar fashion as described for SMA-2. Also similar to SMA-2, an engineered cap ranks highly for protectiveness. For these reasons, the engineered containment alternative has been given an absolute score of 5 for protectiveness.

ENR in SMA-3 would entail placing a nominal 6-inch cover of clean sand over the area. This layer would partially mix with the existing sediment and increase the rate of natural recovery. SMA-3 contains moderate concentrations of bark and has moderate to mixed weight of evidence for adverse biological effects. Thus, the protectiveness of ENR in SMA-3 would be high in areas with minimal biological impact and would substantially accelerate the recovery rate where acute toxicity still persists. Compared to engineered containment, ENR ranks lower for protectiveness and was assigned an absolute score of 4.

As discussed in Section 2.5, natural recovery as measured by considerable reductions in both surface sediment toxicity and TVS concentrations occurred in SMA-3 from 2002 to 2008, and these natural recovery processes (sedimentation rates reported from 0.4 to 1.0 cm/yr, bioturbation and biodegradation within the top 10 cm biologically active zone) are expected to continue into the future. MNR in SMA-3 would require periodic sampling and analysis to evaluate further reductions in toxicity due to these natural processes. Given that existing toxicity would continue to occur until reduced over time by natural conditions, MNR was considered less protective than ENR. Thus, MNR has been assigned an absolute score of 3 for protectiveness in SMA-3.

6.2.3.3.2 Permanence

The engineered containment alternative would be designed to contain bark deposits present in SMA-3. While large bark deposits have not been identified in SMA-3, a relatively minor wood waste deposit would remain in the marine environment under the engineered containment alternative. Thus, this alternative has been given an absolute score of 4 for permanence.

As with engineered containment, existing bark deposits would not be removed under the ENR and MNR alternatives. While ENR and MNR remedies typically have a higher risk of a future need for further action, natural recovery in SMA-3 is already occurring, as summarized above. Thus, the ENR and MNR alternatives have also been assigned an absolute score of 4 for permanence.

6.2.3.3.3 Long-Term Effectiveness

As in the case of SMA-2, engineered containment was assigned an absolute score of 5 for long-term effectiveness. Both ENR and MNR have been demonstrated effective in the long term, and ongoing natural recovery is evident at the Site. Implementation of ENR would ensure the near-term deposition of sediment, equivalent to approximately 10 to 20 years of natural sedimentation under MNR. Thus, ENR has been assigned an absolute score of 4 for long-term effectiveness in SMA-3. Because it relies on natural processes, MNR has been assigned an absolute score of 3 for long-term effectiveness.

6.2.3.3.4 Management of Short-Term Risks

Engineered containment in SMA-3 has the same considerations for short-term risk as described for SMA-2. Accordingly, the same absolute score of 4 has been assigned for SMA-3.

As with engineered containment, ENR entails the placement of clean cover material over the mudline. Similar short-term construction risks and water quality impacts would be anticipated for ENR compared to capping, and thus the same score of 4 has been given to management of short-term risks in SMA-3.

MNR does not entail active construction. Thus, this alternative presents the lowest short-term risk. MNR has been given an absolute score of 5 for management of short-term risks in SMA-3.

6.2.3.3.5 Technical and Administrative Implementability

Implementability considerations for engineered containment in SMA-3 are the same as those described for SMA-2. Thus, this alternative has been given an absolute score of 4 for implementability in SMA-3.

ENR and MNR are straightforward from a construction standpoint and have similar ongoing monitoring and maintenance concerns as for engineered containment. Both alternatives have been assigned an absolute score of 4 for implementability in SMA-3.

6.2.3.3.6 Consideration of Public Concerns

Engineered containment, ENR, and MNR do not actively remove contamination. Even though wood waste would be effectively contained and ecological impacts mitigated through these alternatives, it is expected that the public would view these alternatives in the same fashion as they would for SMA-2. Thus, for SMA-3, an absolute score of 3 has been assigned to all alternatives for consideration of public concerns.

6.2.3.4 SMA-4

6.2.3.4.1 Protectiveness

ENR in SMA-4 has the same considerations as described for SMA-3. Given that only relatively low concentration wood waste deposits are present in SMA-4, the ENR remedy is protective and thus has been given an absolute score of 4 for protectiveness.

As described in SMA-3, given the relatively rapid natural recovery observed from 2002 to 2008 at the Site, including SMA-4, the design, permitting, and implementation timeframe to implement a more "active" remedy such as ENR in SMA-3 is at least 2 to 3 years, and relative to SMA-3 is likely to provide less of an improvement over the MNR remedy. Thus, MNR has also been given an absolute score of 4 for protectiveness in SMA-4.

6.2.3.4.2 Permanence

The same considerations for permanence described above for SMA-3 also pertain to SMA-4. Thus, the ENR and MNR alternatives were also assigned an absolute score of 4 for permanence in SMA-4.

6.2.3.4.3 Long-Term Effectiveness

Considerations for long-term effectiveness in SMA-4 are similar as for SMA-3. Accordingly, the ENR and MNR alternatives for SMA-4 were assigned an absolute score of 3 for long-term effectiveness.

6.2.3.4.4 Management of Short-Term Risks

As with the ENR discussion for SMA-3, short-term construction risks and water quality impacts would be anticipated for ENR. Thus an absolute score of 4 has been given to management of short-term risks in SMA-4.

As previously noted, MNR does not entail active construction and presents the lowest short-term risk. MNR has been given an absolute score of 5 for management of short-term risks in SMA-4.

6.2.3.4.5 Technical and Administrative Implementability

As with SMA-3, ENR and MNR would entail administrative factors that need to be considered for these remedies. An absolute score of 4 has been assigned to both ENR and MNR for implementability in SMA-4.

6.2.3.4.6 Consideration of Public Concerns

The public concerns related to ENR and MNR discussed for SMA-3 are considered to be similar for SMA-4. An absolute score of 3 has been assigned for both remedial alternatives for consideration of public concerns in SMA-4.

6.2.4 MTCA DCA for Marine Alternatives

Detailed cost estimates were prepared to support the FS evaluations. These estimates included the following major factors, and are presented in detail in Appendix A:

- Construction costs, including materials, equipment, and labor
- Environmental controls and surveys during construction
- Engineering design and project management
- Environmental monitoring and construction management
- Long-term monitoring and mitigation
- Ecology oversight costs

Tables 6-3 through 6-7 provide details of the DCA for the Marine Alternatives for SMA-1 through SMA-4, respectively. The conclusions that result from the DCA are described below.

6.2.4.1 SMA-1 DCA

The estimated cost for the dredge alternative in SMA-1 is $1.5 million, with the highest benefit ranking. The estimated cost for the dredge and cap alternative is $1.7 million, with a lower benefit ranking than the dredge alternative. Figure 6-16 presents the results of the DCA cost and benefit ranking graphically. Based on these factors, dredging is the preferred remedial alternative for SMA-1. The restoration timeframe for the preferred alternative is approximately 2 to 3 years for design, permitting, and implementation.

6.2.4.2 SMA-2 DCA

The dredging remedy in SMA-2 has an estimated cost of approximately $3.3 million, and the dredge and cap remedy has an estimated cost of $1.8 million. Engineered containment in SMA-2 is estimated to cost approximately $1.9 million. The total benefit score for dredging is highest, with the dredge and cap alternative slightly lower, and engineered containment the lowest, as depicted in Figure 6-16. The dredge and cap alternative provides the best balance of cost versus benefit. Thus, the dredge and cap option is the preferred alternative for SMA-2. The restoration timeframe for the preferred alternative is approximately 2 to 3 years.

6.2.4.3 SMA-3 DCA

The estimated cost of engineered containment in SMA-3 is $1.7 million and the estimated cost of ENR is $1.1 million. The estimated cost of MNR in SMA-3 is $400,000. The benefit ranking of engineered containment is highest, while ENR ranks lowest. The MNR benefit is lower than the ranking for containment, and only slightly higher than for ENR, as depicted on Figure 6-17. Based on these results, both engineered containment and ENR have disproportionately high costs compared to MNR. MNR is the preferred remedial alternative for SMA-3.

The restoration timeframe for an MNR remedy is a function of the rate of natural recovery in the system. As described previously, substantial recovery has been documented from test results between 2002 and 2008. Recovery is expected to continue rapidly under the MNR scenario, and periodic monitoring would be performed to document the rate at which the recovery is occurring. The scope and frequency of monitoring would be defined in the CAP. Based on the ongoing recovery observed to date in SMA-3, the estimated restoration timeframe for MNR is 5 to 10 years.

6.2.4.4 SMA-4 DCA

For cost and evaluation purposes, SMA-4 was subdivided into two areas—the northern embayment (SMA-4a) and the south mill area (SMA-4b). ENR is estimated to cost $1.0 million for SMA-4a and $2.9 million for SMA-4b, for a total of $3.9 million in SMA-4. MNR is estimated to cost $400,000 for each area individually.

The overall benefits associated with the MNR alternative are slightly lower than the ENR alternative in SMA-4, as shown in Tables 6-6 and 6-7, and on Figure 6-17. Because the cost of ENR is substantially higher, this option is disproportionately expensive compared to MNR when relative benefits are compared. Thus, the MNR alternative is the preferred option for SMA-4. The scope and frequency of long-term monitoring would be defined in the CAP.

7 INTEGRATED CLEANUP ACTION ALTERNATIVE

7.1 Cleanup Decisions under SMS

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

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

Like MTCA, the SMS regulations include a requirement for a reasonable restoration timeframe. However, SMS includes a preference for restoration timeframes that are less than 10 years [WAC 173-204-580(3)]. Longer restoration timeframes may be authorized, but only where it is not practicable to accomplish the cleanup action within a 10-year period.

Of the SMS evaluation criteria listed above, all but two are addressed as part of the MTCA evaluation of alternatives presented in this FS. The two exceptions are: 1) the completion of a SEPA analysis of environmental impacts; and 2) consideration of the net environmental effects of the alternatives.

7.2 Recommended Cleanup Action Alternative

The recommended cleanup action alternative at the Site includes the following elements:

- **Upland Areas**. Interim actions performed from 2002 to 2005 successfully removed soils exceeding cleanup levels from the Site. For the final remedy, restrictive covenants will be implemented to continue to preclude use of the shallow aquifer at the Site for future drinking water supply, given a conditional point of compliance for natural background-based groundwater arsenic cleanup levels at the Site shoreline. In addition, the presence of soil covers minimizing the potential for future terrestrial wildlife impacts at the Site will also be documented in Kitsap County property records. Using Kitsap County's existing permitting (e.g., grading permit) process, such documentation will further control the potential for future disturbances and wildlife risks within these areas. The specific scope and form of such institutional controls will be determined during development of the CAP.
- **SMA-1**. Based on the outcome of the DCA, dredging is the preferred remedial alternative for SMA-1. The additional cost associated with dredging versus a dredge and cap option in SMA-1 is not disproportionate to the higher incremental degree of protectiveness achieved with dredging. Since sediments with porewater sulfide and/or TVS concentrations below site-specific CSL chemical criteria have a mixed weight of evidence of adverse biological effects, dredging in SMA-1 is appropriately targeted towards those areas that exceed the CSL, addressing areas of moderate or greater effects. Under the recommended dredging alternative, approximately 8,000 cy (delineated using coring and sub-bottom survey data, excluding overdredge allowances) of mixed wood chips and sediments exceeding site-specific CSL chemical criteria (porewater sulfide greater than 19 mg/L and/or TVS greater than 21 percent) will be removed to reduce risks to the marine environment. Demolition of approximately 290 existing piles will be performed to accommodate dredging (see Figure 7-1). Large debris present in the dredged materials (greater than 2 feet in any dimension) will be screened for upland disposal, and suitable sediments will be transported to the Port Gardner non-dispersive DMMP open-water disposal site or another similarly protective facility. The entire SMA-1 area (approximately 1.4 acres) will receive a minimum 6-inch sand cover to address sediments exceeding SQS chemical criteria and to control anticipated dredging residuals. The restoration

timeframe for the preferred SMA-1 alternative is approximately 2 to 3 years for design, permitting, and implementation.

- **SMA-2**. Based on the outcome of the DCA, the dredge and cap option is the preferred remedial alternative for SMA-2. In this case, the cost for the dredging alternative is disproportionately high compared to the nearly equally protective dredge and cap option. Key remedy selection and design considerations are summarized below:
  - Similar to SMA-1, dredging in SMA-2 is appropriately targeted towards those areas that exceed the CSL, addressing areas of moderate or greater effects. Under the recommended dredge and cap alternative, approximately 10,000 cy (over 1.3 acres) of mixed wood chips and sediments shallower than -25 feet MLLW that exceed site-specific CSL chemical criteria will be removed to reduce risks to the marine environment. Demolition of approximately 350 existing piles will be performed to accommodate dredging. Large debris present in the dredged materials will be screened for upland disposal, and suitable sediments will be transported to the Port Gardner non-dispersive DMMP open-water disposal site or another similarly protective facility.
  - Engineered caps will be designed to ensure that wood waste is effectively confined below the cap and that post-cap surface sediment (0 to 10 cm) porewater sulfide concentrations are either maintained below the no effects threshold of 3.4 mg/L established by the DMMP for *Neanthes* testing (Kendall and Barton 2004), or are otherwise within the Puget Sound background surface sediment range based on sampling at appropriate reference locations (e.g., DMMP reference sites; Caldwell 2005). Cap designs to ensure that porewater sulfide exposure is maintained below these background-based performance standards will be developed considering elevated subsurface sediment porewater concentrations measured during the RI/FS, also considering groundwater upwelling and tidally induced transient porewater flow reversal processes at the Site.
  - Because of elevated groundwater upwelling velocities and tidally induced transient porewater flow reversal processes in shallow areas of the Site, including parts of SMA-2, dredging of significant wood waste deposits in these relatively shallow areas is the preferred remedial option. However, in other Puget Sound areas, groundwater upwelling and tidal reversals appear to diminish with greater sediment depths. If this is confirmed in deeper areas of SMA-2, engineered caps

will be designed to meet the performance objectives outlined above to provide permanent protection.

- While the boundary between dredging and capping remedies at SMA-2 is estimated to be approximately -25 feet MLLW based on available sampling data (e.g., surface sediment porewater sulfide measurements and bioassay data), the final extent of dredging and capping actions will be determined based on more detailed evaluations of groundwater advection and tidal-induced porewater flow reversals to be performed during remedial design. Appropriate sampling and/or modeling procedures to make this determination will be developed as part of the remedial design work plan to be approved by Ecology. Final delineation of the SMA-2 cap and cover boundaries will also be performed during remedial design, and may include extension of the southern boundary of SMA-2 to include additional locations as necessary.
- In areas of SMA-2 that are at or below -25 feet MLLW, protective containment will be achieved by placing a Type II cap consisting of 18 inches of sand. The remaining area of SMA-2 exceeding SQS chemical criteria (approximately 1.75 acres) will receive a minimum 6-inch sand cover to accelerate natural recovery observed in this area. The restoration timeframe for the preferred SMA-2 alternative is approximately 2 to 3 years for design, permitting, and implementation. Long-term monitoring to ensure the continued protectiveness of the caps and covers constructed in SMA-2 will be integrated with the SMA-3 and -4 remedy, as described below.

- **SMA-3 and -4**. Based on the DCA results, costs for the engineered containment and ENR options are disproportionately high compared to the equally protective MNR option. Thus, MNR is the preferred remedial alternative for both SMA-3 and SMA-4. As discussed in Section 2.5 and as generally depicted in Figures 6-7 and 6-8, substantial biological recovery occurred in these SMAs (and also in parts of SMA-2) from 2002 and 2008, and recovery is expected to continue under the MNR scenario. Periodic monitoring will be performed to verify the anticipated effectiveness of natural recovery. The first round of MNR sampling will likely occur in 2011 (concurrent with remedial design of the SMA-1 and -2 remedies), and follow-on monitoring will be scheduled to allow confirmation that full recovery would occur within 10 years from cleanup construction. During the first (2011) MNR sampling, surface sediment samples obtained from approximately 10 representative locations within SMA-3 and -4, along with suitable reference sediments, will be submitted for SMS bioassay tests and supporting sediment conventional analyses, including grain size and TVS analyses. Sampling beyond 2011 within SMA-3 and SMA-4 would only be performed at locations exceeding cleanup standards during the 2011 sampling, and will be coordinated as appropriate (given that different purposes may dictate different times) with similar long-term performance monitoring of the SMA-2 cap and cover areas. Sediment recovery at the Site will be complete when Site MNR sampling locations are below SMS biological criteria. The scope and frequency of MNR sampling and recovery endpoints will be defined in the CAP. As shown on Figure 6-7, substantial recovery has occurred at the Site over the 6-year timeframe between 2002 and 2008. It is expected that at this rate of recovery, the restoration timeframe for MNR will be within 10 years.

The combined alternative outlined above satisfies the MTCA expectations for cleanup actions, including protection of human health and the environment, management of short- and long-term risks, and use of permanent solutions to the maximum extent practicable. The total cost of the combined alternative is approximately $3.9 million (Table 7-1), to be refined during remedial design. The final selection of the cleanup action alternative will be made following public review and comment on the RI/FS and will be formally documented in the CAP.

7.3 Human Health Protection

As part of this RI/FS, Ecology performed a focused screening-level human health risk evaluation to evaluate exposure of tribal members to chemicals from direct contact to sediment during shellfish gathering and from consumption of shellfish using tribal ingestion rates. For the screening-level analysis, Ecology used an upper-bound daily subsistence-level shellfish consumption rate of 499 grams per day (g/day), or nearly 20 times greater than the upper-bound recreational consumption rate of 27 g/day (incorporating a diet fraction of 0.5) used to derive MTCA surface water cleanup levels (WAC 173-340-730). Appendix G of the RI (Anchor QEA and EPI 2010) presents the methods and results of Ecology's risk assessment, and also includes comparisons of Port Gamble Bay surface sediments with representative regional background concentrations of human health chemicals of potential concern. Sediment concentrations of carcinogenic polynuclear aromatic hydrocarbons (cPAHs) and cadmium detected at the Site, and at other locations in Port Gamble Bay sediment, exceed regional background concentrations and have the potential to pose risks to tribal members under Ecology's assumed subsistence-level exposure conditions. Further evaluations of cPAHs and cadmium concentrations in the Site area were performed as part of this FS to ensure that the recommended cleanup action alternative summarized in Section 7.2 is adequately protective of human health.

There are a wide range of natural and anthropogenic sources of cPAHs that are ubiquitous across the Puget Sound region. The distribution of surface sediment cPAH concentrations in the Site area is presented in Figure 7-2. Sediment cPAH concentrations greater than roughly 4 times regional background (i.e., greater than 0.023 mg/kg; see Appendix G of the RI) occur throughout the Site area and south along most of the western portion of Port Gamble Bay. The average cPAH concentration in the Site area is approximately 0.075 mg/kg (roughly 10 times higher than regional background), and the highest sample concentrations tended to be located near creosote piling clusters and regional storm drain outfalls, including road runoff from the state highway running the length of the western shore. Prior to the 2003 and 2007 interim actions, higher sediment cPAH concentrations (up to approximately 1.0 mg/kg) were present in the Site area, but have since been removed and disposed off-site.

Cadmium is also ubiquitous across the Puget Sound region. Surface sediment cadmium concentrations in the Site area are presented in Figure 7-3. Sediment cadmium concentrations greater than regional background (i.e., greater than 1.1 mg/kg; see Appendix G of the RI) occur throughout most the Site and Port Gamble Bay, and concentrations are generally uniform in depositional areas containing relatively fine-grained sediment. In contrast to the cPAH data, there is no apparent local source of cadmium in the Site area. Thus, the human health protection evaluation is appropriately focused on cPAHs.

Anthropogenic inputs of cPAHs from a wide range of urban sources are well documented in the Puget Sound region, and several studies have reported a linkage between increased traffic volumes in urban areas and increased cPAH concentrations in regional sediments (e.g., see Yake 2001). A recent increase in sediment cPAH concentrations has been documented in

Puget Sound as a result of expanding development in the basin; runoff from residential and roadway areas have been identified by Ecology as primary ongoing sources of cPAH loading to regional waterbodies. Creosote piling and associated wood debris are also pervasive in Puget Sound and can be a locally significant source of cPAHs (Brooks 2003).

Differentiating between creosote-related sources and "urban background" inputs (e.g., atmospheric fallout of combustion-derived particles and channelized stormwater runoff from communities) can inform cleanup and related management decisions, and often rely on chemical "fingerprinting" comparisons of PAH concentration profiles to inform the differentiation (Brenner et al. 2002; Stout and Graan 2010). Figure 7-4 presents shellfish tissue and sediment concentration profiles for those Site samples that contained the highest cPAH concentrations, along with comparisons to representative creosote and urban background source materials. The fingerprinting comparison (especially the relative absence of indeno[1,2,3-cd]pyrene and dibenzo[a,h]anthracene at the Site) suggests that cPAHs detected in both Site shellfish tissue and sediments are primarily due to creosote piling-related sources in the Site area, which could be ongoing.

As discussed in Section 7.2, the recommended cleanup action alternative for the Site includes the removal/demolition of approximately 640 existing piles, many of which are creosote-treated, to accommodate dredging. There are also a larger number of creosote-treated piles in the Site area that are targeted for removal as part of other coordinated restoration programs. The removal of creosote-treated piling that will be accomplished as part of these combined cleanup and restoration programs is expected to result in significant reductions in cPAH releases to the Site and Port Gamble Bay, with corresponding reductions in risks to tribal members under Ecology's assumed exposure conditions. (Note that much lower human health risks are calculated for the upper-bound recreational consumption scenario used to derive MTCA surface water cleanup levels.) Future trends in tissue cPAH concentrations (and continued evaluations of creosote-related versus urban background inputs) would be monitored as part of the recommended bay-wide cleanup action. Details of the bay-wide tissue monitoring would be developed as part of the forthcoming CAP.

7.4 Protection of Cultural Resources

A bay-wide cultural resources overview was developed for Port Gamble Bay to identify and map areas of known or possible historical, archaeological, and cultural resources within the project area. The overview was developed by a professional archaeologist for OPG, WDNR, and the Port Gamble S'Klallam Tribe and provided specific steps to complete identification, evaluation, and protection of cultural resources that may be affected by the Site cleanup action. Information from the overview was considered in developing the recommended cleanup action alternative for the Site summarized in Section 7.2. Significantly, none of the alternatives evaluated in this FS were eliminated based on cultural resource considerations.

Ecology's selected remedy for the Site, to be detailed in the forthcoming CAP, will further consider the results and recommendations provided by the overview. During the follow-on remedial design and permitting phase of the cleanup action, the implementing parties, in consultation with DAHP and the Port Gamble S'Klallam Tribe, will identify areas that may be affected by the cleanup action. These areas will include locations where cleanup-related disturbance may occur, including dredging areas, staging areas, transport routes, and mooring areas, as appropriate. Cultural resource considerations will be integrated as practicable with studies for the engineering design phase of the project.

The cleanup action selected by Ecology for the Site will also include appropriate compliance monitoring provisions during implementation of the action, consistent with Section 106 requirements of the National Historic Preservation Act (NHPA) and Washington State laws. As appropriate, detailed compliance monitoring plans will be developed during the remedial design and permitting phase, consistent with regulatory requirements. Appropriate cultural resource work plans including a cultural resources treatment plan and an inadvertent discovery plan will be included in the engineering design reports as required.

7.5 Habitat Restoration Opportunities

As part of early planning for the redevelopment of Port Gamble, OPG retained NewFields Northwest, L.L.C. to evaluate existing marine resources in the Port Gamble area. The NewFields (2007) report, which summarizes available data from state, tribal, and private sources, as well as reconnaissance surveys performed by NewFields and others within the nearshore and subtidal areas of Port Gamble Bay, is presented as Appendix B of the Ecology-approved RI/FS Work Plan (Anchor and EPI 2008). Ecology and WDNR recently updated habitat resource maps for Port Gamble Bay, building on the NewFields report.

There are several classes of priority habitat that exist in the nearshore areas of the Site, including steep banks, emergent marsh, intertidal and subtidal eelgrass beds, and hardened reef structures. Eelgrass beds are critical habitat for a number of fish and invertebrate species in the Site area, including juvenile salmonids. Within the Site area immediately adjacent to the former mill facility, there are considerable opportunities for subtidal and intertidal eelgrass restoration, as currently there is no documented eelgrass within this former industrial area. There are also a number of constructed structures present at the Site, including docks, piers, and piles, and many of these are aging, creosote structures. Abandoned dock structures within the Site area include more than 31,000 square feet of overwater surface (NewFields 2007).

As discussed in the sections above, near-surface woody debris deposits result in degraded habitat conditions at the Site, consistent with locally elevated levels of porewater sulfide, TVS, and bioassay results that exceed SQS biological criteria. Site cleanup actions selected by Ecology will address these habitat impacts directly.

7.6 Future Land Use Considerations

As is true with many brownfields sites, OPG and Kitsap County are currently evaluating long-term land use plans for Port Gamble and the other 8,000 acres owned by OPG and/or its parent company Pope Resources. This planning effort, known as the North Kitsap Legacy Partnership, involves an array of local and regional stakeholders and is occurring simultaneously with the Site cleanup effort. Both of these activities will likely create cross-program opportunities for integrated implementation efforts. The timing of these initiatives is being planned to facilitate holistic consideration of related issues.

The Site cleanup action to be selected by Ecology will consider future land uses, in part to ensure that cleanup actions continue to be protective given prospective redevelopment actions planned for the Site. For example, OPG has proposed to construct a dock in the

SMA-1 area that will serve as both a community dock and marine terminal. Construction of the dock will involve replacing, refurbishing, or reconstructing the existing pier and steel truss, constructing a new gangway, and installing a new concrete float. The dock will serve as a recreational community dock and will also be used as a marine terminal for loading and unloading of commercial vessels (including fishing boats), tour boats, charter boats, private vessels, and float planes that visit Port Gamble. The dock will also be used for mooring vessels associated with the adjacent upland industrial area, such as tugboats, barges, or other work-related vessels. The recommended dredging remedy for SMA-1 is consistent with this proposed redevelopment action.

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TABLES

Table 3-1
Soil Cleanup Levels

Analyte	Unit	Simplified TEE Cleanup Levels	MTCA Method A or B Soil Cleanup Level	Selected Soil Cleanup Level	Basis
TPH Diesel Range Organics	mg/kg	15,000	2,000	460	MTCA Method A
Benzo(a)anthracene	mg/kg	No Value Available	0.22	0.22	Modified MTCA Method B
Benzo(b)pyrene	mg/kg	No Value Available	0.1	0.1	MTCA Method A
Benzo(b)fluoranthene	mg/kg	No Value Available	0.74	0.74	Modified MTCA Method B
Benzo(k)fluoranthene	mg/kg	No Value Available	0.74	0.74	Modified MTCA Method B
Chrysene	mg/kg	No Value Available	0.25	0.25	Modified MTCA Method B
Dibenz(a,h)anthracene	mg/kg	No Value Available	1.1	1.1	Modified MTCA Method B
Indeno(1,2,3-cd)pyrene	mg/kg	No Value Available	2.2	2.2	Modified MTCA Method B
Total cPAHs [a]	mg/kg	No Value Available	0.1 [a]	0.1 [a]	MTCA Method A
Chlorinated dibenzofurans (total)	mg/kg	3×10^{-6}	160	3×10^{-6}	Simplified TEE
Chlorinated dibenzo-p-dioxins (total)	mg/kg	5×10^{-6}	1.1×10^{-5} [b]	5×10^{-6}	Simplified TEE
Arsenic	mg/kg	20[c]	20	20	MTCA Method A
Chromium	mg/kg	135[d]	19 [f]	19 [f]	MTCA Method A
Lead	mg/kg	220	250	220	Simplified TEE
Mercury	mg/kg	0.7[e]	0.16	0.16	Modified MTCA Method B

Notes:

a The total cPAHs concentration for each sample was calculated using the Method B toxicity equivalency factor (TEF) methodology described in WAC 173-340-708(8)(e)(ii)

b Based on 2,3,7,8 tetrachlorodibenzo-p-dioxin

c Cleanup level for arsenic (III). Arsenic V cleanup level is 260 mg/kg.

d Cleanup level for total chromium

e Cleanup level for organic mercury. Inorganic mercury cleanup level is 9 mg/kg.

f Assumes all chromium is present as chromium VI, cleanup level for chromium III is 2,000 mg/kg

Simplified Terrestrial Ecological Evaluation Soil Cleanup Levels for Industrial or Commercial Sites (WAC 173-340-900, Table 749-2)

MTCA Method A – based on MTCA Method A Soil Cleanup Levels for Unrestricted Land Use (WAC 173-340-900, Table 740-1)

Modified MTCA Method B - based on MTCA Equation 747-1 Values, Soil Cleanup Level based on Protection of Human Health for Consumption of Aquatic Organisms, National Toxics Rule (40 CFR 131.36).

Table 3-2
Groundwater Cleanup Levels

Analyte	Units	Groundwater Cleanup Level	Basis
TPH Diesel Range Organics	µg/L	500	MTCA Method A
Benzo(a)anthracene	µg/L	0.031	NTR Criteria
Benzo(b)pyrene	µg/L	0.031	NTR Criteria
Benzo(b)fluoranthene	µg/L	0.031	NTR Criteria
Benzo(k)fluoranthene	µg/L	0.031	NTR Criteria
Chrysene	µg/L	0.031	NTR Criteria
Dibenzo(a,h)anthracene	µg/L	0.031	NTR Criteria
Indeno(1,2,3-cd)pyrene	µg/L	0.031	NTR Criteria
Total cPAHs [(a)]	µg/L	0.1	MTCA Method A
Antimony	µg/L	4,300	NTR Criteria
Arsenic	µg/L	8	Natural Background
Beryllium	µg/L	No Value Available	
Cadmium	µg/L	9.3	WA Surface Water Quality
Chromium	µg/L	50	WA Surface Water Quality
Copper	µg/L	3.1	WA Surface Water Quality
Lead	µg/L	8.1	WA Surface Water Quality
Mercury	µg/L	0.025	WA Surface Water Quality
Nickel	µg/L	8.2	WA Surface Water Quality
Selenium	µg/L	71	WA Surface Water Quality
Silver	µg/L	1.9	WA Surface Water Quality
Thallium	µg/L	6.3	NTR Criteria
Zinc	µg/L	81	WA Surface Water Quality

Notes:

a The total cPAHs concentration for each sample was calculated using the TEF methodology described in WAC 173-340-708(8)(e)(ii)

MTCA Method A – MTCA Method A Cleanup Levels for Groundwater (WAC 173-340-900, Table 720-1)

NTR Criteria - National Toxics Rule (40 CFR 131.36), protection of human health for consumption of aquatic organisms

WA Surface Water Quality - Washington Marine Water Chronic Criteria; WAC 173-201A-040, based on protection of aquatic organisms

Table 4-1
Regional Sediment Capping Projects

Water Body	Project	Regulatory Program	Year	COC	Cap Design(s)
Bellingham Bay	G-P Log Pond	MTCA	2001	Mercury, wood debris, phenols	3' thick sand cap
Eagle Harbor	Eagle Harbor (East Harbor)	CERCLA	1994	PAHs, metals	3' thick cap of dredged material
Elliott Bay	King County - Denny Way CSO	Corps of Engineers	1990	PCBs, PAHs, metals	2.5' thick cap of dredged material
Elliott Bay	Pier 51 - Coleman Dock	Corps of Engineers	1989	PCBs, PAHs, metals	1.5' thick cap of dredged material
Elliott Bay	Pier 53 - Washington St. CSO	Corps of Engineers	1992	PCBs, PAHs, metals	1' thick and 3' thick cap of dredged material
Elliott Bay	Pier 64 - Port of Seattle	MTCA	1994	PCBs, PAHs, metals	1' thick ENR layer of dredged material
Elliott Bay	Pacific Sound Resources (PSR)	CERCLA	2004	PAHs,	6' thick sand & gravel cap; armored in places. 54" sand & gravel cap. 42" sand cap.
Duwamish Waterway	Duwamish/Diagonal CSO	NRDA	2005	PCBs, mercury, phthalates	3' thick sand cap or armored cap. Restore grade
Duwamish Waterway	Norfolk CSO	NRDA	1998	PCBs, mercury, BEHP,1,4-dichlorobenzene	3' thick sand cap. Restore grade
Duwamish Waterway	West Waterway CAD	Corps of Engineers	1984	PCBs, metals	2' thick sand cap
Commencement Bay	Thea Foss	CERCLA	2003	Metals, PAHs, PCBs, phenols, phthalates	
Commencement Bay	Middle Waterway	CERCLA	2003	Metals, PCB, phthalates	3' thick sand cap or armored cap.
Commencement Bay	Head of Thea Foss	CERCLA	2003	PAHs, NAPLs	HDPE plus 3' thick sand cap.
Commencement Bay	Simpson Tacoma Kraft	Corps of Engineers	1988	PAHs	4' thick sand cap
Budd Inlet	One Tree Island Marina		1987	Metals, PAHs	4' thick sand cap

Table 6-1
Sample-by-Sample Weight of Evidence Scoring

Station Code	Sample Date	PSEP Larval Percent Normal Survivorship - Point-by-Point	Amphipod Percent Survival - Point-by-Point	Neanthes Mean Individual Growth Rate - Point-by-Point	Microtox Light Output - Point-by-Point	*PSEP Larval Percent Normal Survivorship - Average Reference*	Amphipod Percent Survival - *Kriging*	Neanthes Mean Individual Growth Rate - *Kriging*	Microtox Light Output - *Kriging*	TVS - *Kriging*	Porewater Sulfide - *Kriging*	Total Score
Site Samples												
B1	Jul-02	2	N/A	1		2	2	0		1	1	9
B2	Jul-02	1	N/A	0		1	2	0		0	2	6
B3	Jul-02	1	N/A	0		0	1	0		2	0	4
B4	Jul-02	2	N/A	0		2		0		2	0	6
B5	Jul-02	2	N/A	2		1	2	0		1	0	8
B6	Jul-02	2	N/A	0		1	1	0		2	0	6
B7	Jul-02	0	N/A	0		0	1	0		2	0	3
B8	Jul-02	2	N/A	0		2	1	0		1	0	6
B9	Jul-02	1	N/A	0		1	1	0		0	0	3
B10	Jul-02	2	N/A	0		1	0	0		2	0	5
B11	Jul-02	2	N/A	0		2	1	0		1	0	6
B12	Jul-02	2	N/A	0		2	1	0		0	0	5
B13	Jul-02	2	N/A	0		2	0	0		2	0	6
B14	Jul-02	2	N/A	0		2	1	0		0	0	5
B15	Jul-02	2	N/A	0		2	0	0		0	0	4
B16	Jul-02	2	N/A	1		2	0	0		0	0	5
B17	Jul-02	2	N/A	1		2	1	0		1	0	7
AS-01	Aug-06	1	1	0		0	1	1		0	0	4
AS-02	Aug-06	1	0	0		0	1	1		0	1	4
AS-03	Aug-06	2	1	0		1	2	1		0	2	9
AS-05	Aug-06	1	0	1		0	2	2		1	0	7
AS-07	Aug-06	1	0	0		0	0	1		2	0	4
AS-09	Aug-06	1	0	0		0	0	1		0	0	2
AS-13	Aug-06	1	0	0		0	0	0		0	0	1
AS-14	Aug-06	2	0	0		0	2	1		0	0	5
AS-101	Sep-08	0	0		0	0	2		0	0		2
AS-102	Sep-08	0	0		0	0			0			0
AS-106	Sep-08	1	0		0	0	1		0	0	0	2
AS-108	Sep-08	0	0		0	0	0		0	0		0
AS-112	Sep-08	1	0		0	0	2		0	0	1	4
AS-113	Sep-08	1	0		0	0	2		0	1	0	4
AS-B08/B18	Sep-08	1	0		0	0	1		0	1	0	3
AS-B09	Sep-08	1	0		0	0	0		0	0	0	1
AS-B11	Sep-08	2	0		0	0	1		0	1	0	4
AS-B14	Sep-08	2	0		0	0	0		0	0	0	2
AS-B15	Sep-08	1	0		0	0	0		0	0	0	1
AS-B16	Sep-08	1	0		0	0	0		0	0	0	1
SS-77A	Dec-08	0	0	0		0		0	0			0
SS-92	Dec-08	0	0	0		0	0	0	0	0		0

Table 6-2
Summary of Technologies Retained for Detailed Evaluation

Area	Dredging	Dredge and Cap	Engineered Containment	ENR	MNR
SMA-1	•	•			
SMA-2	•	•	•		
SMA-3			•	•	•
SMA-4				•	•

Table 6-3
MTCA DCA for SMA-1

Area	Criteria	Alternative	
		Dredge to Maximum Extent Practicable	Dredge and Cap
SMA-1	**MTCA Threshold Criteria**		
	1. Protection of Human Health and the Environment	Yes	Yes
	2. Compliance with Cleanup Standards	Yes	Yes
	3. Compliance with ARARs	Yes	Yes
	4. Provision for Compliance Monitoring	Yes	Yes
	Restoration Time Frame	2 to 3 years	2 to 3 years
	Relative Benefits Ranking (1= lowest; 5 = highest)		
	Protectiveness	5	3
	Permanence	5	3
	Long-term Effectiveness	5	3
	Management of Short Term Risks	3	3
	Technical and Administrative Implementability	4	3
	Consideration of Public Concerns	4	3
	Weighted Benefits - Disproportionate Cost Analysis		
	Protectiveness (30%)	1.5	0.9
	Permanence (20%)	1	0.6
	Long-term Effectiveness (20%)	1	0.6
	Management of Short Term Risks (10%)	0.3	0.3
	Technical and Administrative Implementability (10%)	0.4	0.3
	Consideration of Public Concerns (10%)	0.4	0.3
	Total of Scores	4.6	3
	Estimated Cost (+50%/-30% rounded)	$1,500,000	$1,700,000
	Cost/Benefit ratio (rounded)	33 E+04	57 E+04
	Cost disproportionate to Incremental Benefits?	N/A (baseline)	Yes
	Overall Alternative Ranking	1	2
% Benefit Increase over Baseline			65%
% Cost Increase over Baseline			113%

Table 6-4
MTCA DCA for SMA-2

Area	Criteria	Alternative: Dredge to Maximum Extent Practicable	Alternative: Dredge and Cap	Alternative: Engineered Containment
SMA-2	**MTCA Threshold Criteria**			
	1. Protection of Human Health and the Environment	Yes	Yes	Yes
	2. Compliance with Cleanup Standards	Yes	Yes	Yes
	3. Compliance with ARARs	Yes	Yes	Yes
	4. Provision for Compliance Monitoring	Yes	Yes	Yes
	Restoration Time Frame	2 to 3 years	2 to 3 years	2 to 3 years
	Relative Benefits Ranking (1= lowest; 5 = highest)			
	Protectiveness	5	5	3
	Permanence	5	4	3
	Long-term Effectiveness	5	5	3
	Management of Short Term Risks	2	3	4
	Technical and Administrative Implementability	3	4	4
	Consideration of Public Concerns	4	3	3
	Weighted Benefits - Disproportionate Cost Analysis			
	Protectiveness (30%)	1.5	1.5	0.9
	Permanence (20%)	1	0.8	0.6
	Long-term Effectiveness (20%)	1	1	0.6
	Management of Short Term Risks	0.2	0.3	0.4
	Technical and Administrative Implementability (10%)	0.3	0.4	0.4
	Consideration of Public Concerns	0.4	0.3	0.3
	Total of Scores	4.4	4.3	3.2
	Estimated Cost (+50%/-30% rounded)	$3,300,000	$1,800,000	$1,900,000
	Cost/Benefit ratio (rounded)	75 E+04	42 E+04	59 E+04
	Cost disproportionate to Incremental Benefits?	Yes	No	N/A (baseline)
	Overall Alternative Ranking	2	1	3
% Benefit Increase over Baseline		138%	134%	
% Cost Increase over Baseline		174%	95%	

Table 6-5
MTCA DCA for SMA-3

Area	Criteria	Alternative		
		Engineered Containment	**Enhanced Natural Recovery**	**Monitored Natural Recovery**
SMA-3	**MTCA Threshold Criteria**			
	1. Protection of Human Health and the Environment	Yes	Yes	Yes
	2. Compliance with Cleanup Standards	Yes	Yes	Yes
	3. Compliance with ARARs	Yes	Yes	Yes
	4. Provision for Compliance Monitoring	Yes	Yes	Yes
	Restoration Time Frame	2 to 3 years	5 to 10 years	5 to 10 years
	Relative Benefits Ranking (1= lowest; 5 = highest)			
	Protectiveness	5	4	4
	Permanence	4	4	4
	Long-term Effectiveness	5	3	3
	Management of Short Term Risks	4	4	5
	Technical and Administrative Implementability	4	4	4
	Consideration of Public Concerns	3	3	3
	Weighted Benefits - Disproportionate Cost Analysis			
	Protectiveness (30%)	1.5	1.2	1.2
	Permanence (20%)	0.8	0.8	0.8
	Long-term Effectiveness (20%)	1	0.6	0.6
	Management of Short Term Risks (10%)	0.4	0.4	0.5
	Technical and Administrative Implementability (10%)	0.4	0.4	0.4
	Consideration of Public Concerns (10%)	0.3	0.3	0.3
	Total of Scores	4.4	3.7	3.8
	Estimated Cost (+50%/-30% rounded)	$1,700,000	$1,100,000	$400,000
	Cost/Benefit (rounded)	39 E+04	30 E+04	11 E+04
	Cost disproportionate to Incremental Benefits?	Yes	Yes	N/A (baseline)
	Overall Alternative Ranking	3	2	1
% Benefit Increase over Baseline		116%	97%	
% Cost Increase over Baseline		425%	275%	

Table 6-6
MTCA DCA for SMA-4a

Area	Criteria	Alternative	
		Enhanced Natural Recovery	Monitored Natural Recovery
SMA-4a	**MTCA Threshold Criteria**		
	1. Protection of Human Health and the Environment	Yes	Yes
	2. Compliance with Cleanup Standards	Yes	Yes
	3. Compliance with ARARs	Yes	Yes
	4. Provision for Compliance Monitoring	Yes	Yes
	Restoration Time Frame	5 to 10 years	5 to 10 years
	Relative Benefits Ranking (1= lowest; 5 = highest)		
	Protectiveness	4	4
	Permanence	4	4
	Long-term Effectiveness	5	3
	Management of Short Term Risks	4	5
	Technical and Administrative Implementability	4	4
	Consideration of Public Concerns	3	3
	Weighted Benefits - Disproportionate Cost Analysis		
	Protectiveness (30%)	1.2	1.2
	Permanence (20%)	0.8	0.8
	Long-term Effectiveness (20%)	1	0.6
	Management of Short Term Risks (10%)	0.4	0.5
	Technical and Administrative Implementability (10%)	0.4	0.4
	Consideration of Public Concerns (10%)	0.3	0.3
	Total of Scores	4.1	3.8
	Estimated Cost (+50%/-30% rounded)	$1,000,000	$400,000
	Cost/Benefit ratio (rounded)	24 E+04	11 E+04
	Cost disproportionate to Incremental Benefits?	Yes	N/A (baseline)
	Overall Alternative Ranking	2	1
% Benefit Increase over Baseline		108%	
% Cost Increase over Baseline		250%	

Table 6-7
MTCA DCA for SMA-4b

Area	Criteria	Alternative: Enhanced Natural Recovery	Alternative: Monitored Natural Recovery
SMA-4b	**MTCA Threshold Criteria**		
	1. Protection of Human Health and the Environment	Yes	Yes
	2. Compliance with Cleanup Standards	Yes	Yes
	3. Compliance with ARARs	Yes	Yes
	4. Provision for Compliance Monitoring	Yes	Yes
	Restoration Time Frame	5 to 10 years	5 to 10 years
	Relative Benefits Ranking (1= lowest; 5 = highest)		
	Protectiveness	4	4
	Permanence	4	4
	Long-term Effectiveness	5	3
	Management of Short Term Risks	4	5
	Technical and Administrative Implementability	4	4
	Consideration of Public Concerns	3	3
	Weighted Benefits - Disproportionate Cost Analysis		
	Protectiveness (30%)	1.2	1.2
	Permanence (20%)	0.8	0.8
	Long-term Effectiveness (20%)	1	0.6
	Management of Short Term Risks (10%)	0.4	0.5
	Technical and Administrative Implementability (10%)	0.4	0.4
	Consideration of Public Concerns (10%)	0.3	0.3
	Total of Scores	4.1	3.8
	Estimated Cost (+50%/-30% rounded)	$2,900,000	$400,000
	Cost/Benefit ratio (rounded)	71 E+04	11 E+04
	Cost disproportionate to Incremental Benefits?	Yes	N/A (baseline)
	Overall Alternative Ranking	2	1
% Benefit Increase over Baseline		108%	
% Cost Increase over Baseline		725%	

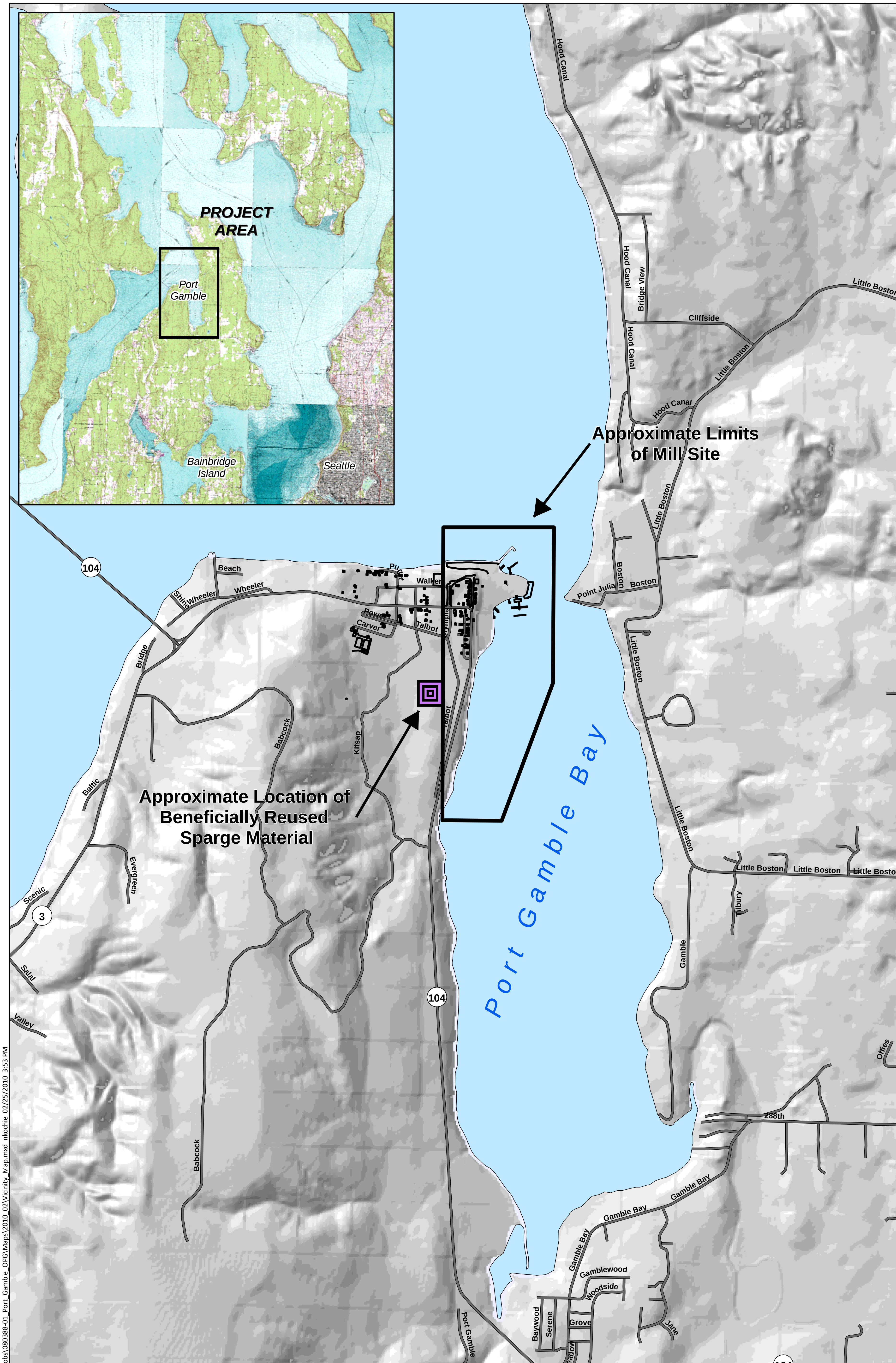
Table 7-1
Cost Estimate; Recommended Site-Wide Remedial Action

Item	Amount	Units	Unit Cost	Total Cost	Notes
Mobilization and Demobilization					
Mobilization	1	LS	$ 100,000	$ 100,000	
Demobilization	1	LS	$ 75,000	$ 75,000	
SMA-1					
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	290	EA	$ 625	$ 181,250	
Transportation and Disposal	290	TON	$ 100	$ 29,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	10,500	CY	$ 20	$ 210,000	
Transportation and Disposal (Open Water)	10,500	CY	$ 5	$ 52,500	
Debris Screening/Offload/Transport & Dispose	788	TON	$ 75	$ 59,063	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cover Sand	3,600	TON	$ 22	$ 79,200	12-inch thick (including overplacement)
Place Cover Sand	3,600	TON	$ 20	$ 72,000	
SMA-2					
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	350	EA	$ 625	$ 218,750	
Transportation and Disposal	350	TON	$ 100	$ 35,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	10,000	CY	$ 20	$ 200,000	
Transportation and Disposal (Open Water)	10,000	CY	$ 5	$ 50,000	
Debris Screening/Offload/Transport & Dispose	750	TON	$ 75	$ 56,250	Assume 5 % of dredged material
Capping/Cover					
36-inch Cap					
Purchase & Transport 12" Habitat Mix	300	TON	$ 20	$ 6,000	
Purchase & Transport 12" Armor Layer	300	TON	$ 25	$ 7,500	
Purchase & Transport 12" Cap Sand	300	TON	$ 22	$ 6,600	
Purchase & Transport 18" Cap Sand	2,700	TON	$ 22	$ 59,400	18-inch thick (including overplacement)
Purchase & Transport 6" Cover Sand	2,100	TON	$ 22	$ 46,200	6-inch thick (including overplacement)
36-inch Cap					

Table 7-1
Cost Estimate; Recommended Site-Wide Remedial Action

Item	Amount	Units	Unit Cost	Total Cost	Notes
Place 12" Habitat Mix	300	TON	$ 20	$ 6,000	
Place 12" Armor Layer	300	TON	$ 20	$ 6,000	
Place 12" Cap Sand	300	TON	$ 20	$ 6,000	
Place Cap Sand	2,700	TON	$ 20	$ 54,000	
Place Cover Material	2,100	TON	$ 20	$ 42,000	
SMA-3 & 4					
MNR Sampling & Analysis					
Prepare Sampling Plan	1	LS	$ 25,000	$ 25,000	
Collect & Analyze Reference Samples	5	Event	$ 6,000	$ 30,000	
Collect Site Samples	5	Event	$ 17,000	$ 85,000	Assumes 1 week for each sampling event (crew; boat; supplies)
Analyze Site Samples	5	Event	$ 30,000	$ 150,000	Assumes 20 bioassay samples per event
Prepare Summary Report	5	LS	$ 20,000	$ 100,000	Assumes 5 sampling events
Site Wide					
Environmental Controls	1	LS	$ 20,000	$ 20,000	
Bathymetric Surveys	3	EA	$ 15,000	$ 45,000	
Subtotal Remedial Action Costs				$ 2,112,713	
Contingency	30	%		$ 633,814	
Total Remedial Cost				**$ 2,746,526**	
Non-Construction Costs					
Project Management	5	%		$ 137,326	
Pre-design Characterization	1	LS	$ 50,000	$ 50,000	
Engineering and Design	10	%		$ 274,653	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 274,653	
Environmental Monitoring during Construction	12	WEEK	$ 12,500	$ 150,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 25,000	$ 25,000	
Long Term Monitoring	1	LS	$ 30,000	$ 30,000	
Ecology Oversight Costs	5	%		$ 137,326	
Total Non-Construction Cost				**$ 1,153,958**	
Total Site-Wide Cost				**$ 3,900,484**	

FIGURES



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Feet
0 1,000 2,000 3,000 4,000

Figure 1-1
Site Vicinity Map
Former Pope & Talbot Sawmill Site

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Figure 1-2
Historical Site Operations (date unknown)
Former Pope & Talbot Sawmill Site

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Feet
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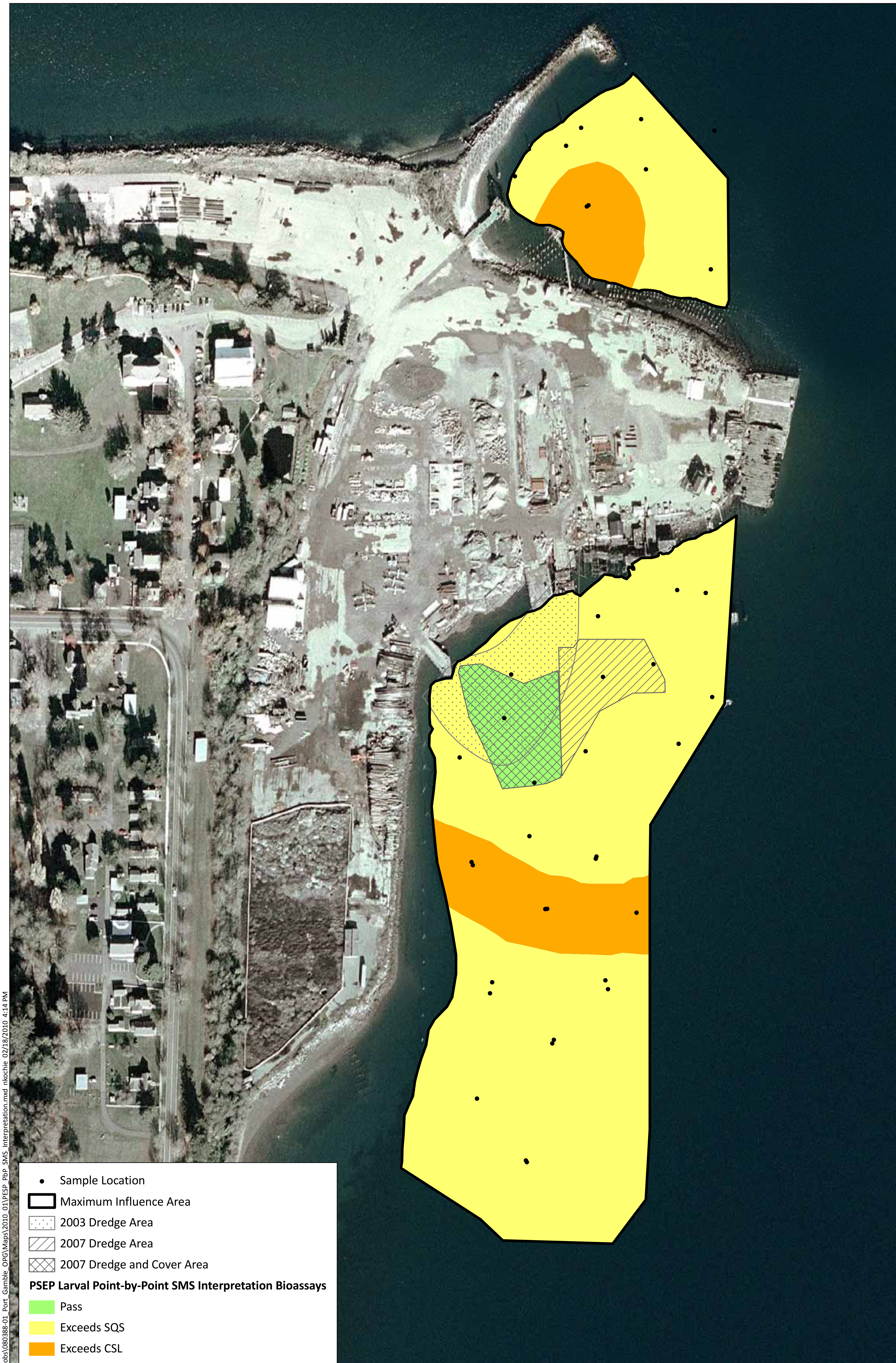
Figure 6-1
Amphipod Point-by-Point SMS Bioassay Interpretation
Former Pope & Talbot Sawmill Site



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Feet
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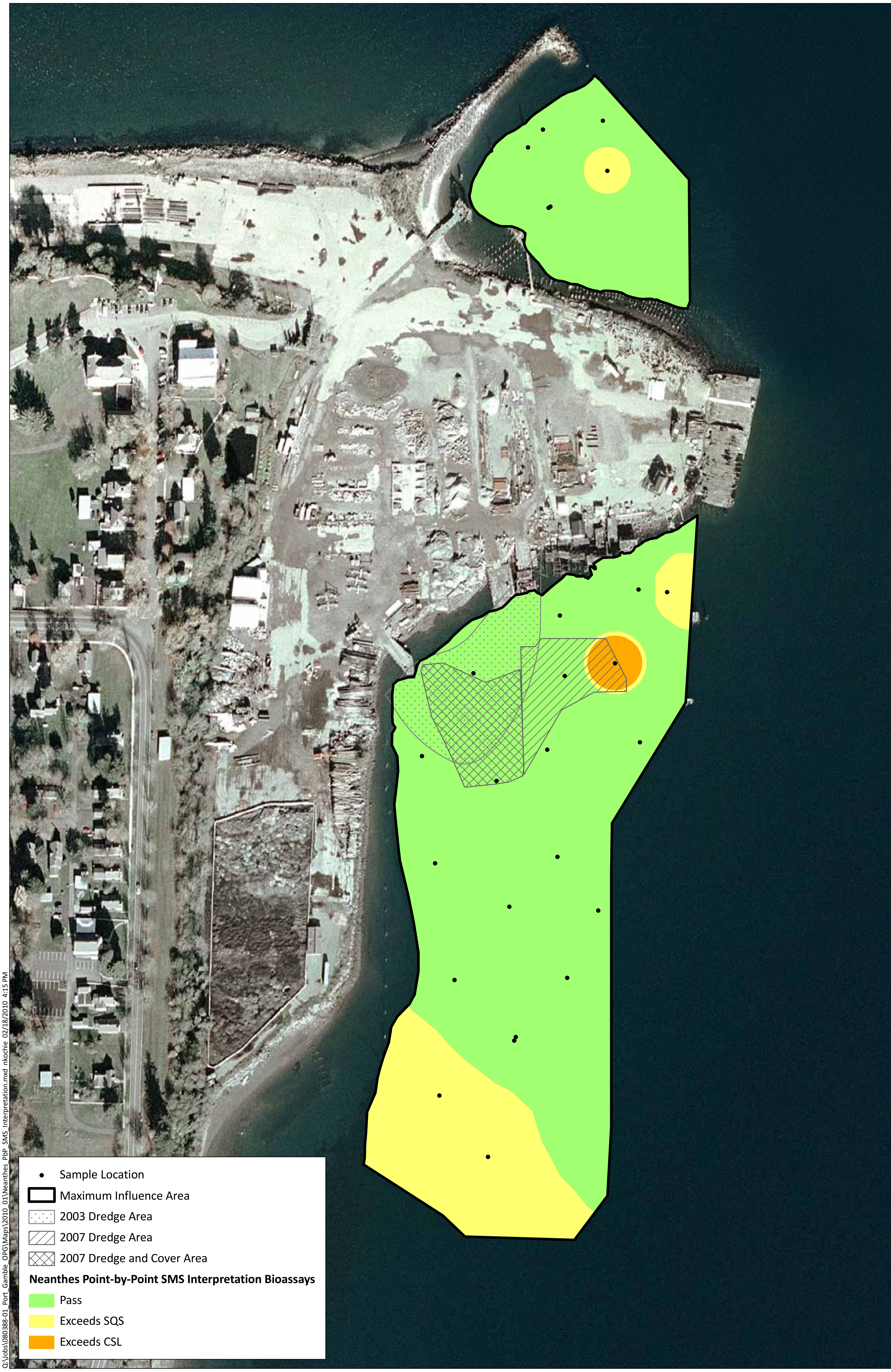
Figure 6-2
PSEP Larval Point-by-Point SMS Bioassay Interpretation
Former Pope & Talbot Sawmill Site



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Feet
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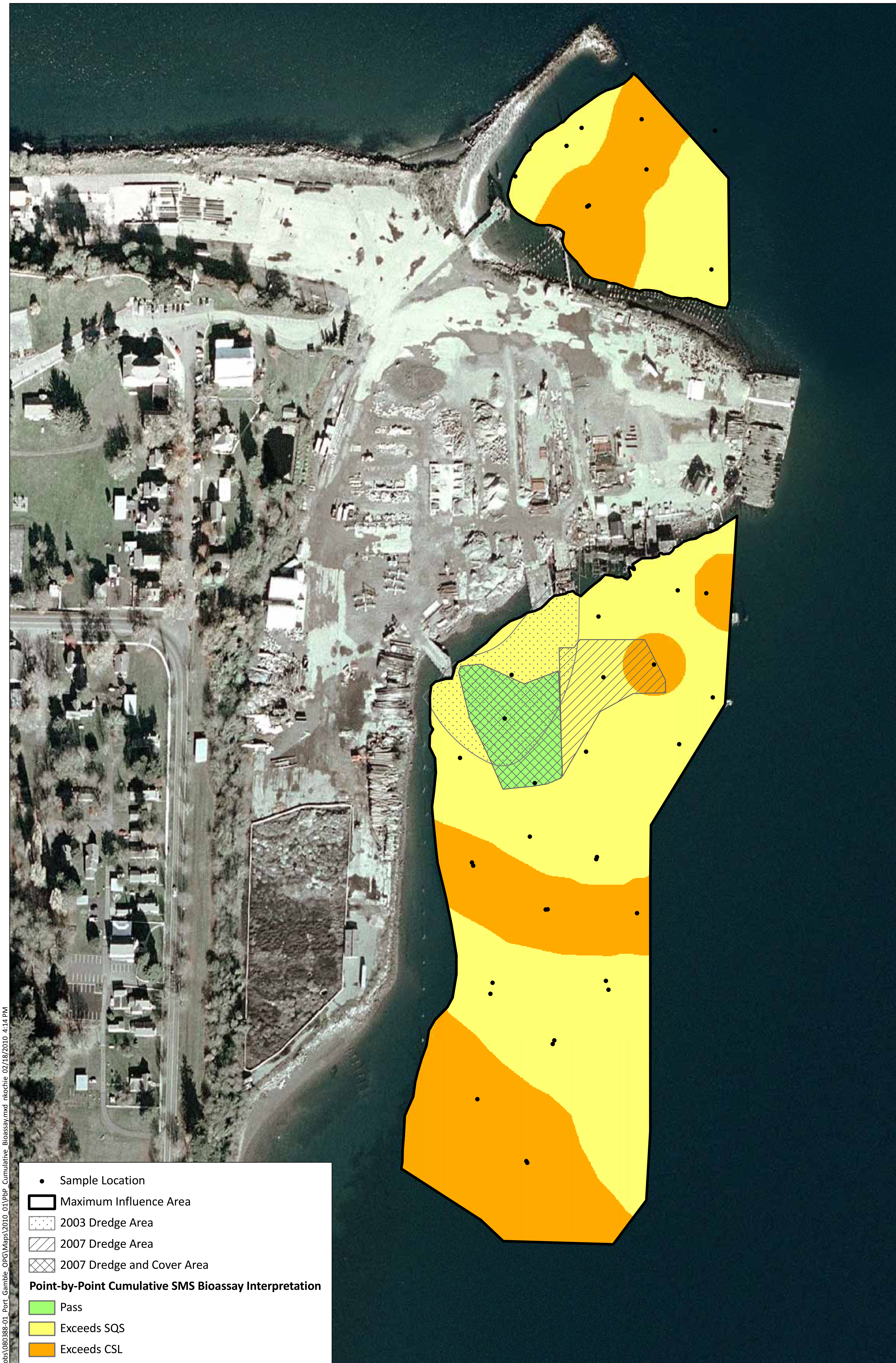
Figure 6-3
Neanthes Point-by-Point SMS Bioassay Interpretation
Former Pope & Talbot Sawmill Site



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Feet
0 100 200 400

Figure 6-4
Cumulative Point-by-Point SMS Bioassay Interpretation
Former Pope & Talbot Sawmill Site

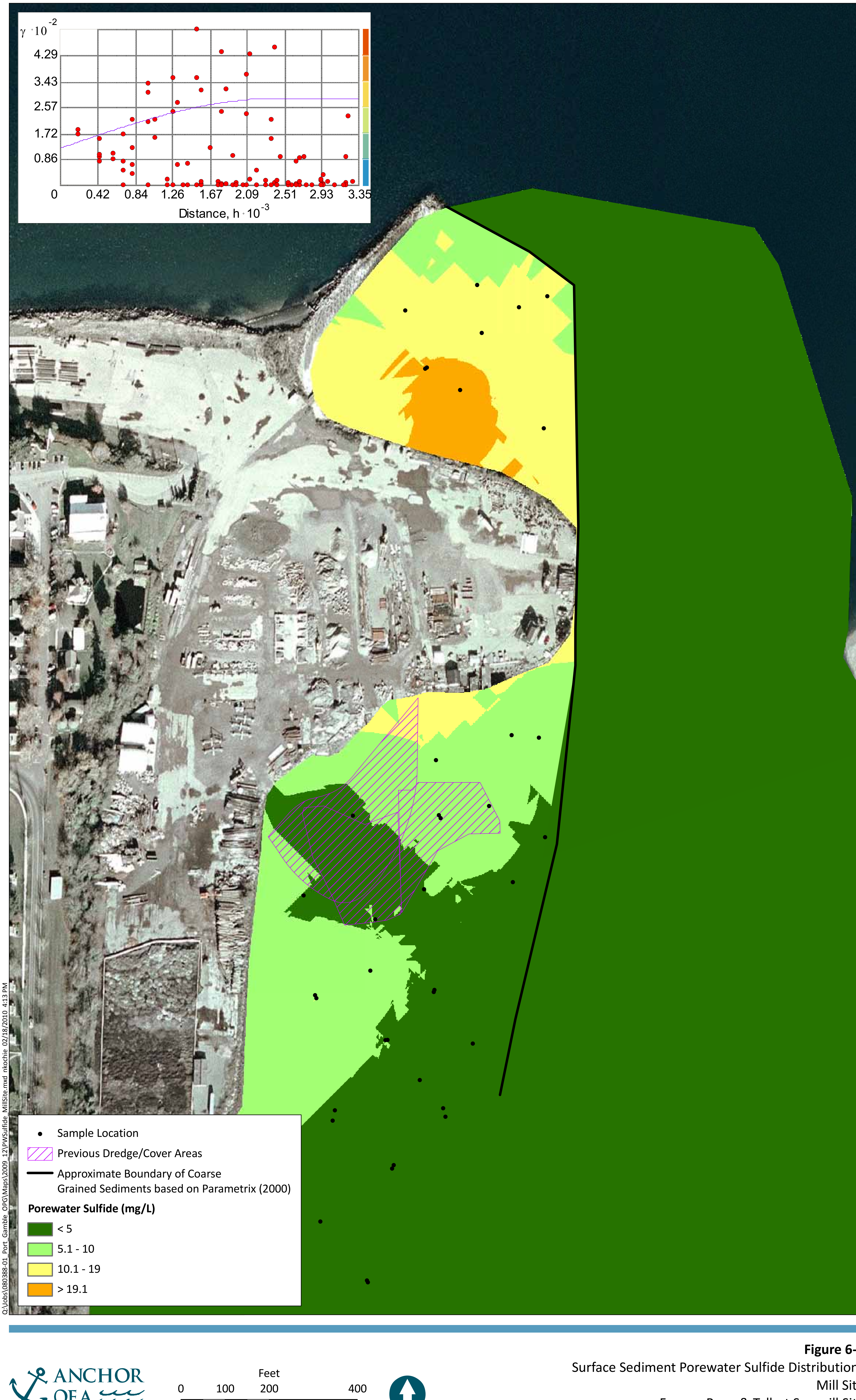

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Figure 6-5
Surface Sediment Porewater Sulfide Distributions
Mill Site
Former Pope & Talbot Sawmill Site

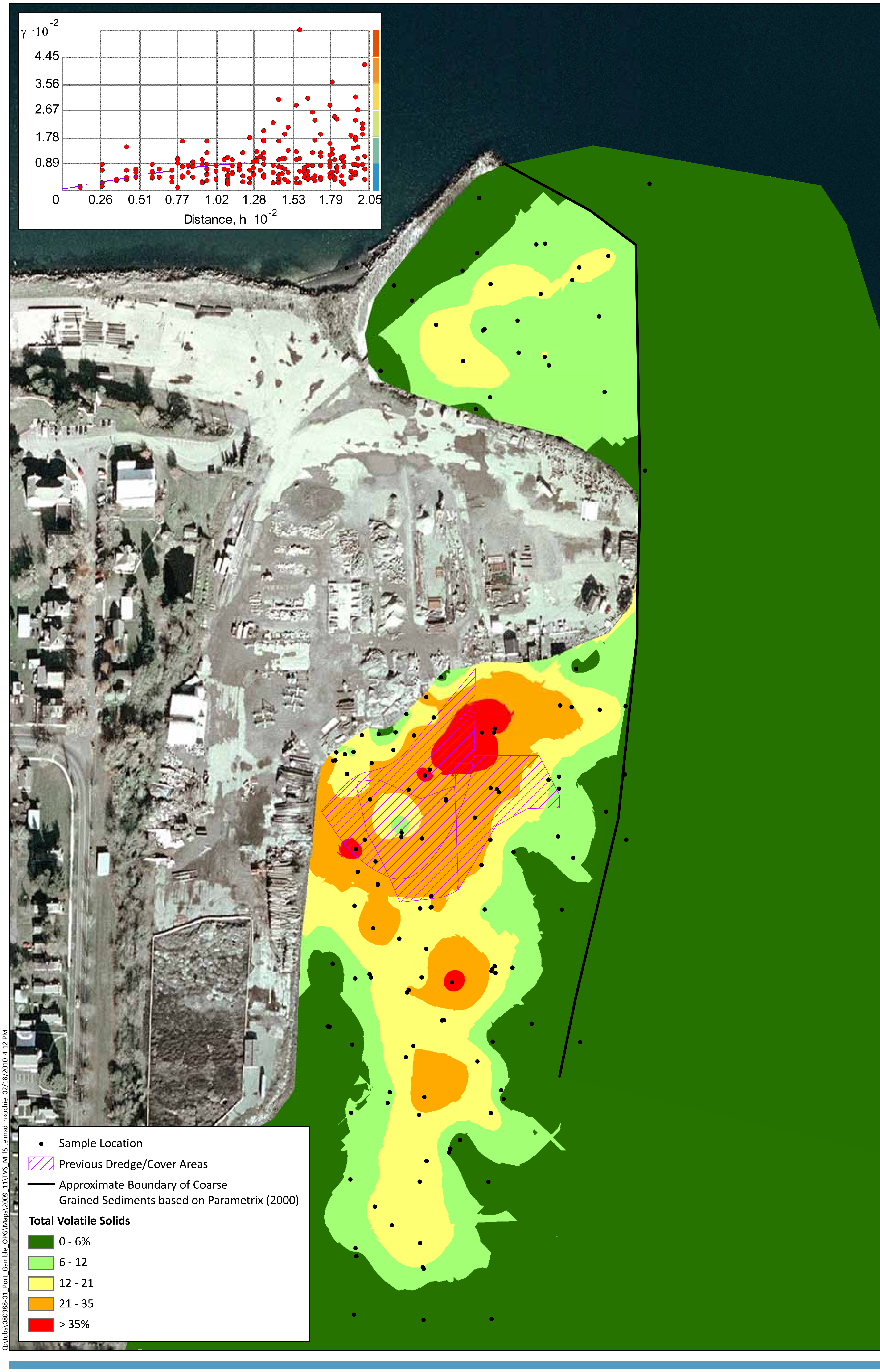

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Figure 6-6
Surface Sediment Total Volatile Solids Distributions
Mill Site
Former Pope & Talbot Sawmill Site

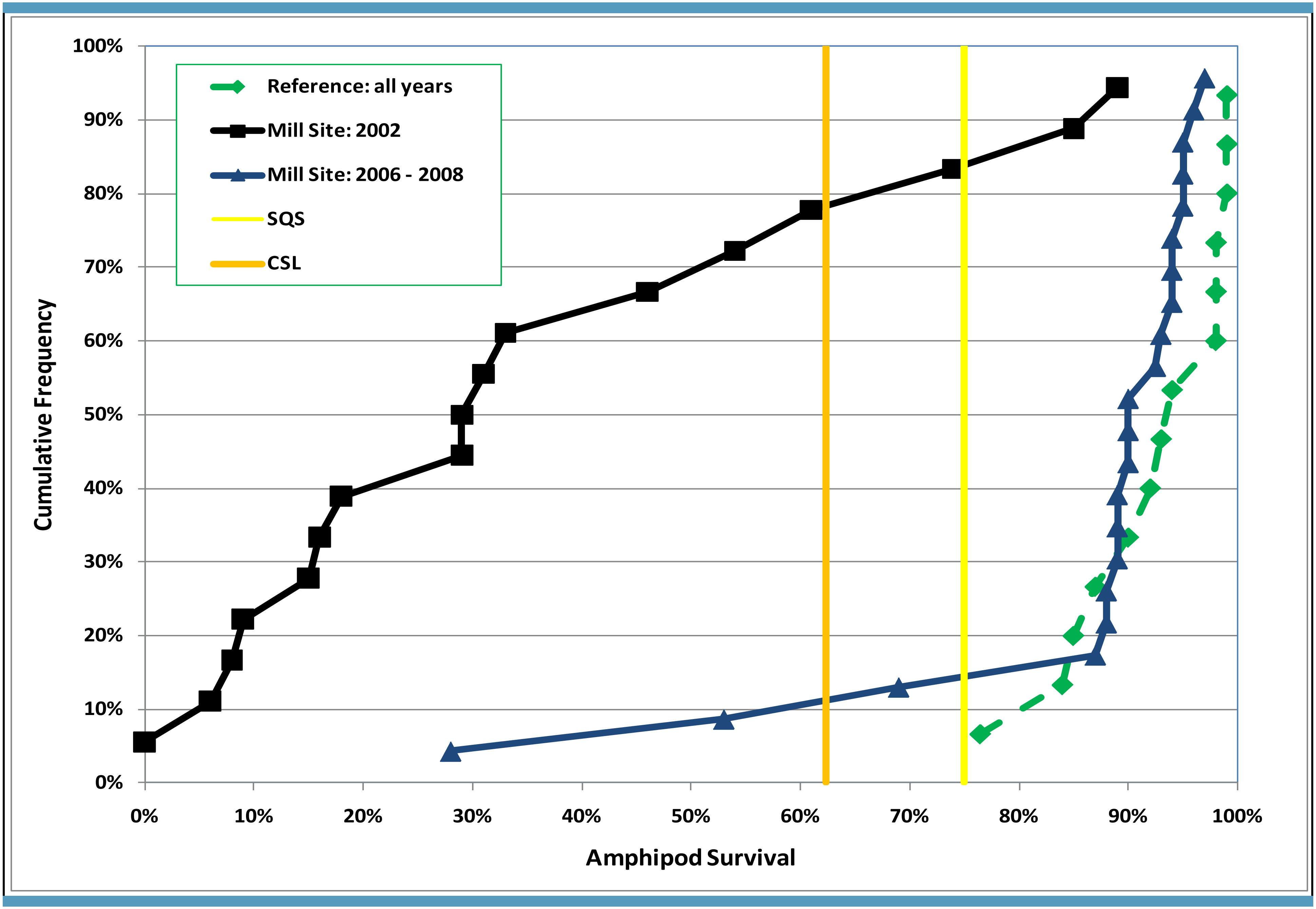

Figure 6-7
Amphipod Bioassay Cumulative Frequency Distributions
Draft Feasibility Study
Former Pope & Talbot, Inc. Sawmill Site

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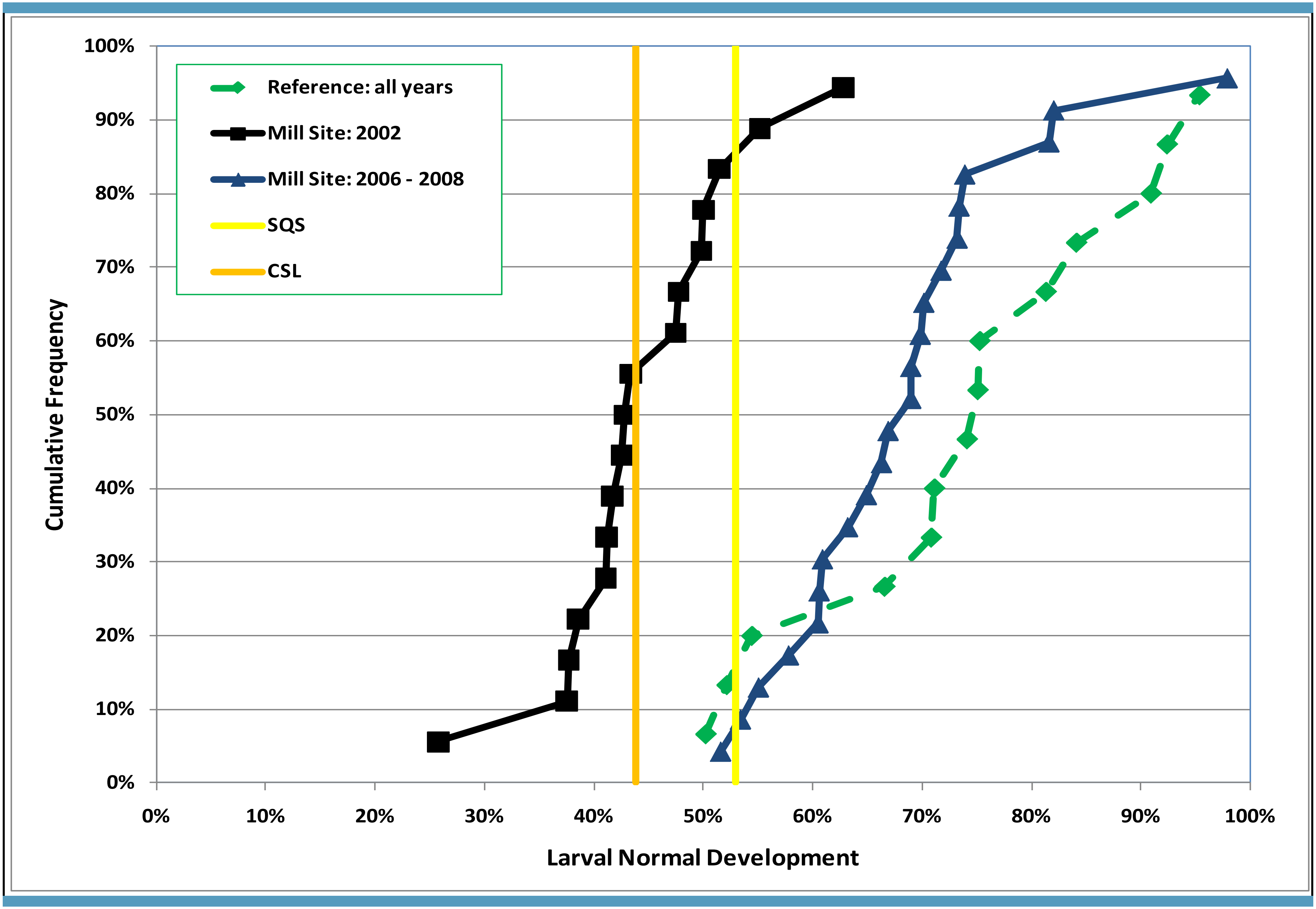

Figure 6-8
PSEP Larval Bioassay Cumulative Frequency Distributions
Draft Feasibility Study
Former Pope & Talbot, Inc. Sawmill Site

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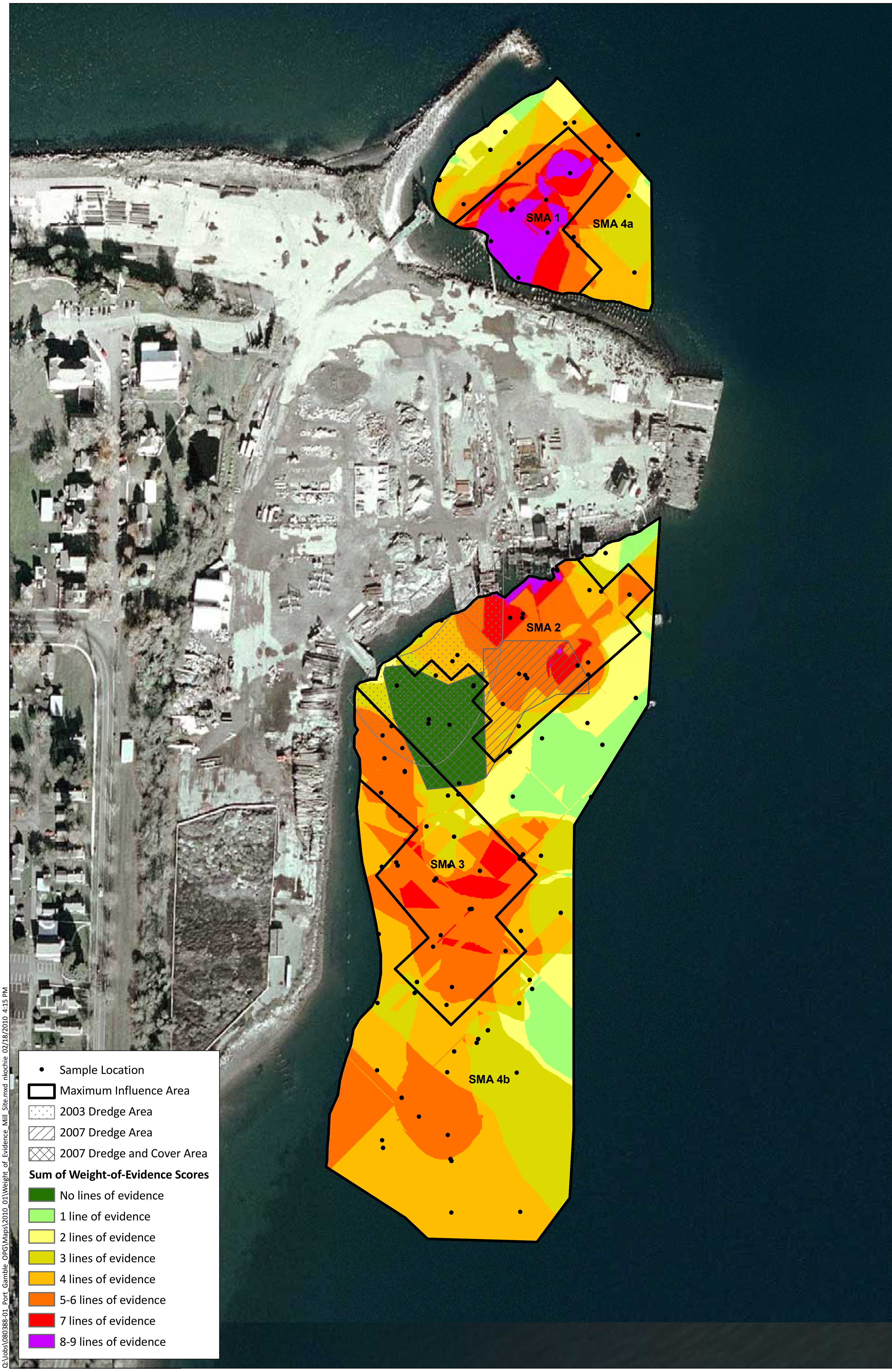

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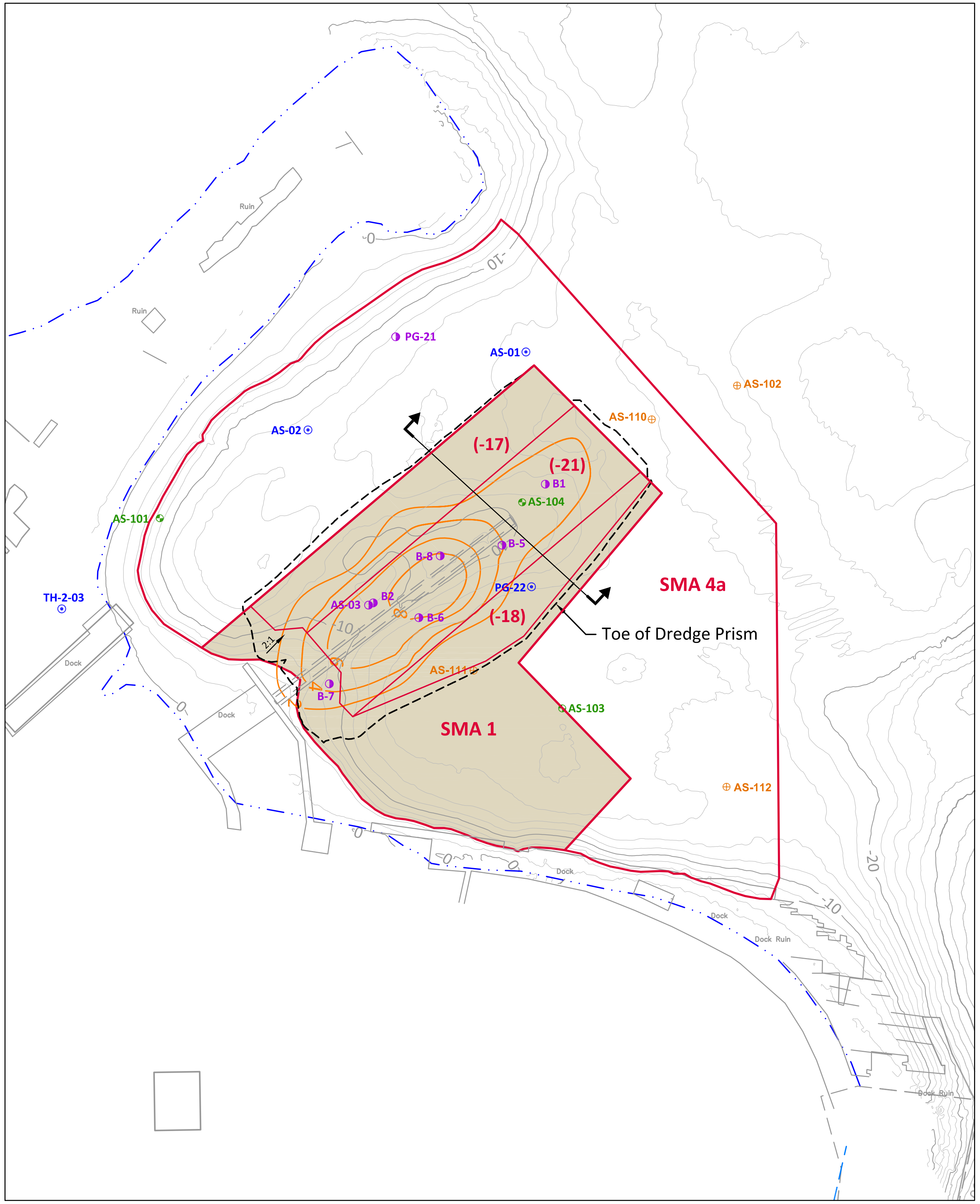
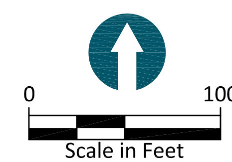
Figure 6-9
Sediment Management Areas
Based on Overall Weight-of-Evidence
Former Pope & Talbot Sawmill Site



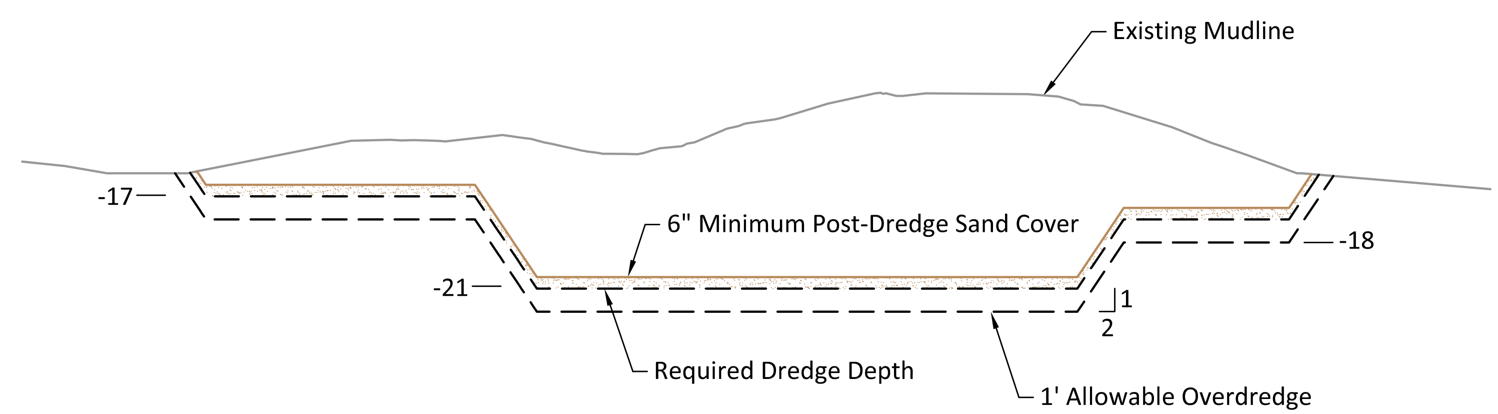
LEGEND:

AS-103	2008 Core Sample
AS-B14	2008 Surface Sediment Sample
PG-06	Existing Sediment Core Sample
PGSP-116	Existing Surface Sediment Sample
	MHHW (Mean Higher High Water)
	Approximate MLLW (Mean Lower Low Water)
8	Thickness of Woody Debris in Feet (Identified by Geophysical Survey)
	SMA Boundary
-10	Bathymetric Contour in Feet
	Proposed Dredge Footprint Daylight Line
(-21)	Proposed Dredge Depth in Feet
	Minimum 6-Inch-Thick Sand Cover



HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: MLLW
NOTE: Bathymetry outside 2007 dredging areas from 2003. Bathymetry inside 2007 areas from 2007.

ESTIMATED DREDGE VOLUME = 9004 cubic yards
ESTIMATED DREDGE VOLUME OF 1-FOOT ALLOWABLE OVERDREDGE = 1509 cubic yards



Cross Section Schematic
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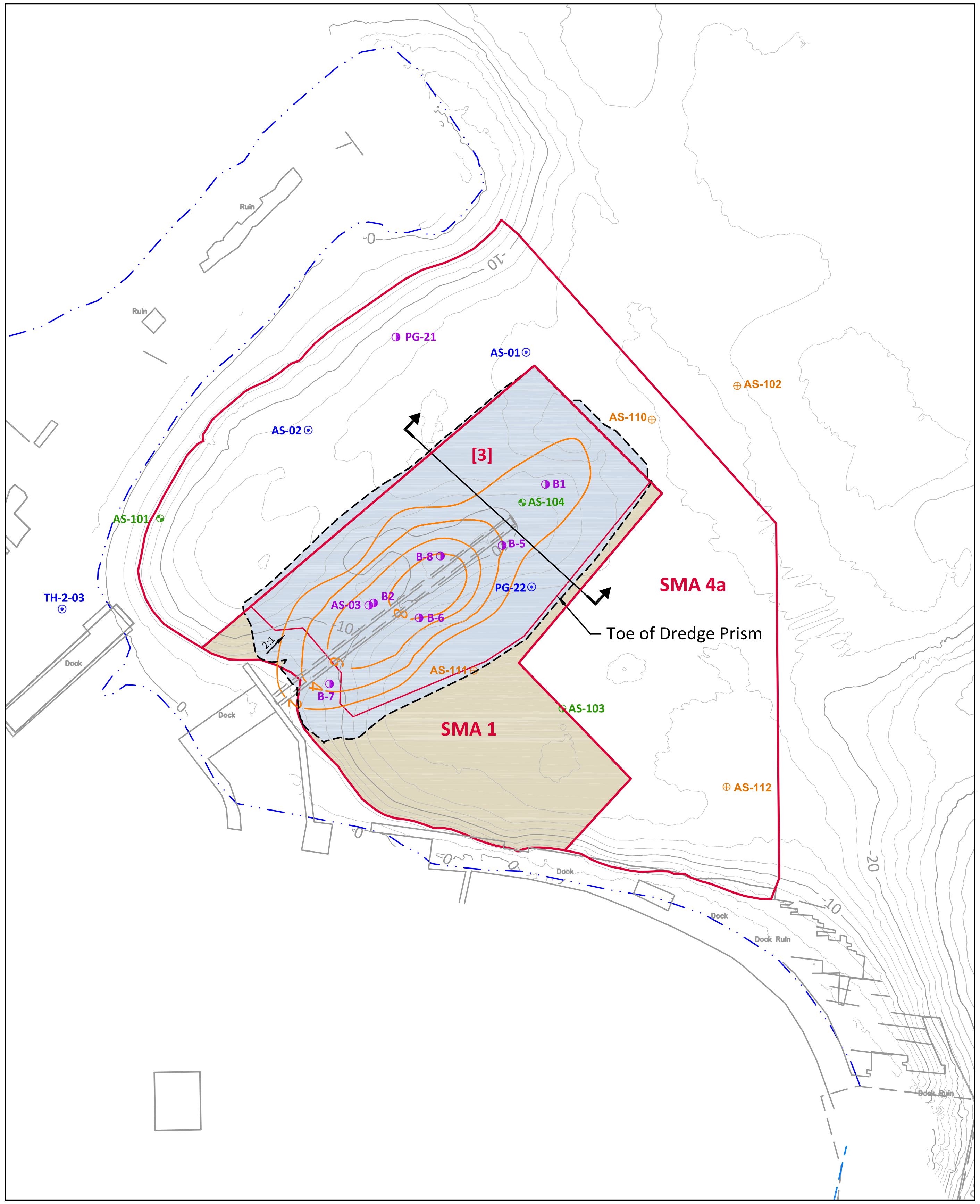
Figure 6-10
Conceptual Dredge Alternative in SMA-1
Former Pope & Talbot Sawmill Site



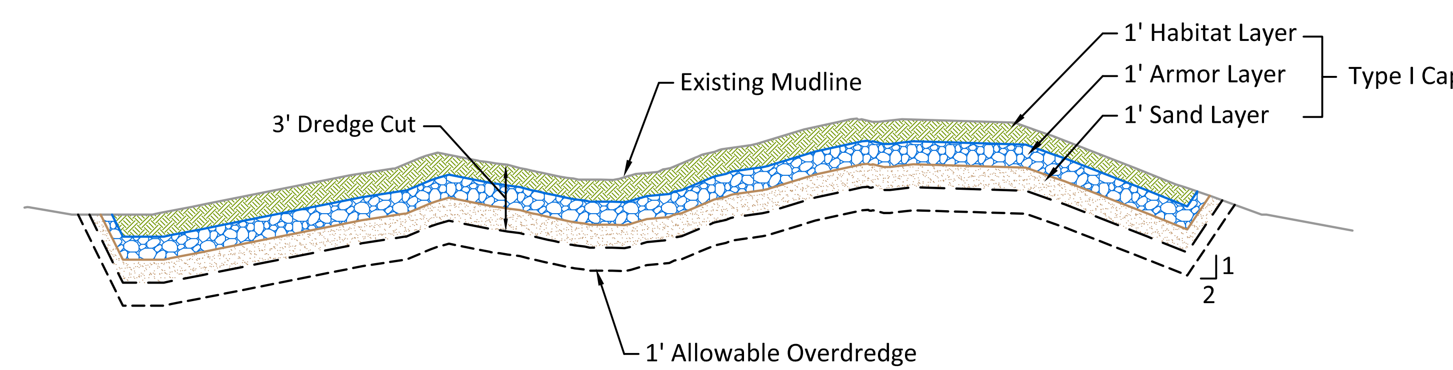
LEGEND:

- AS-103 2008 Core Sample
- AS-B14 2008 Surface Sediment Sample
- PG-06 Existing Sediment Core Sample
- PGSP-116 Existing Surface Sediment Sample
- MHHW (Mean Higher High Water)
- Approximate MLLW (Mean Lower Low Water)
- 8 Thickness of Woody Debris in Feet (Identified by Geophysical Survey)
- SMA Boundary
- -10 Bathymetric Contour in Feet
- Proposed Dredge Footprint Daylight Line
- [3] Proposed Dredge Depth in Feet
- 3-Foot-Thick Armored Cap (Type I)
- Minimum 6-Inch-Thick Sand Cover

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: MLLW
NOTE: Bathymetry outside 2007 dredging areas from 2003. Bathymetry inside 2007 areas from 2007.

ESTIMATED DREDGE VOLUME = 4,500 cubic yards
ESTIMATED DREDGE VOLUME OF 1-FOOT ALLOWABLE OVERDREDGE = 1,500 cubic yards



Cross Section Schematic
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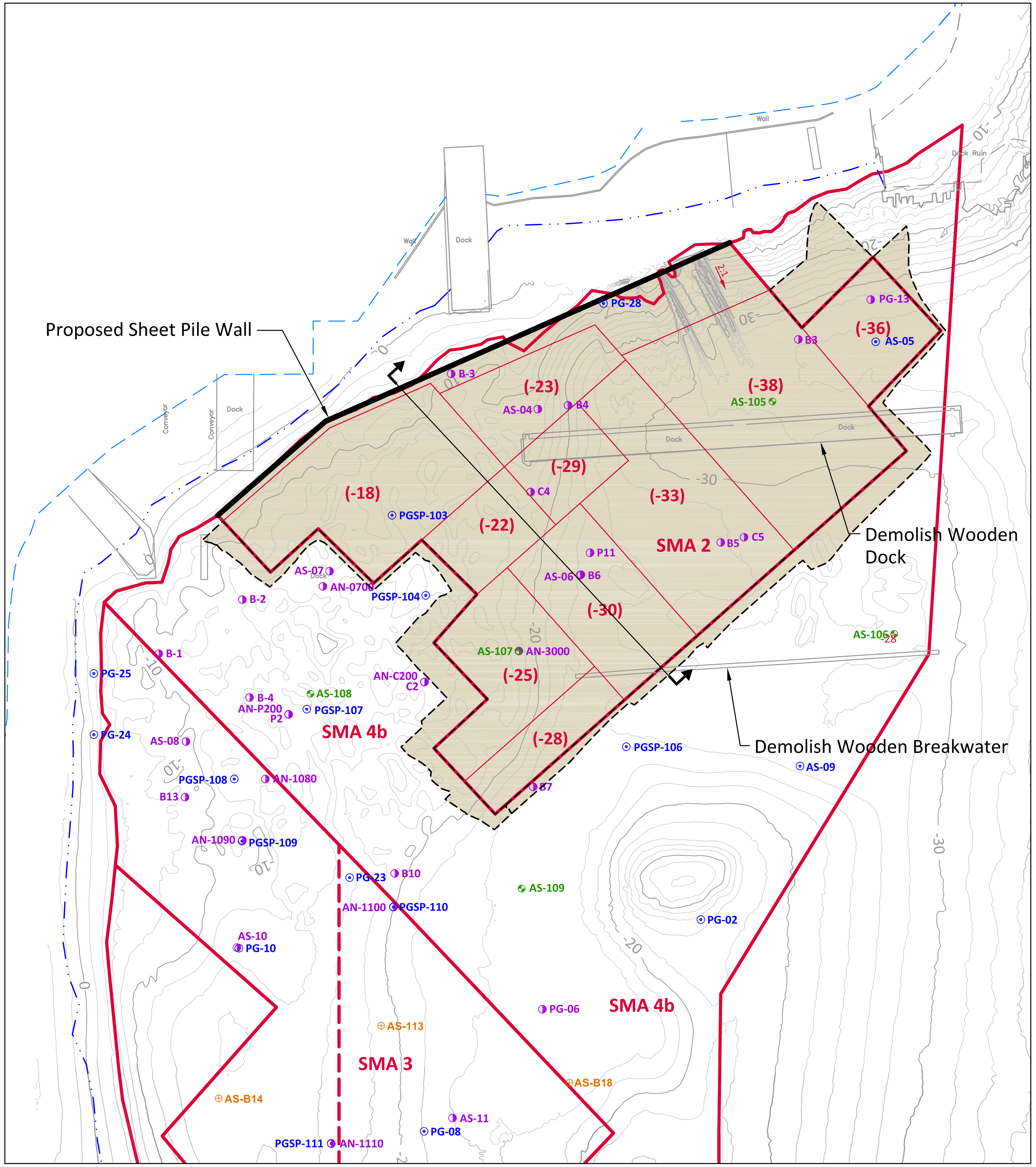
Figure 6-11
Conceptual Dredge and Cap Alternative in SMA-1
Former Pope & Talbot Sawmill Site



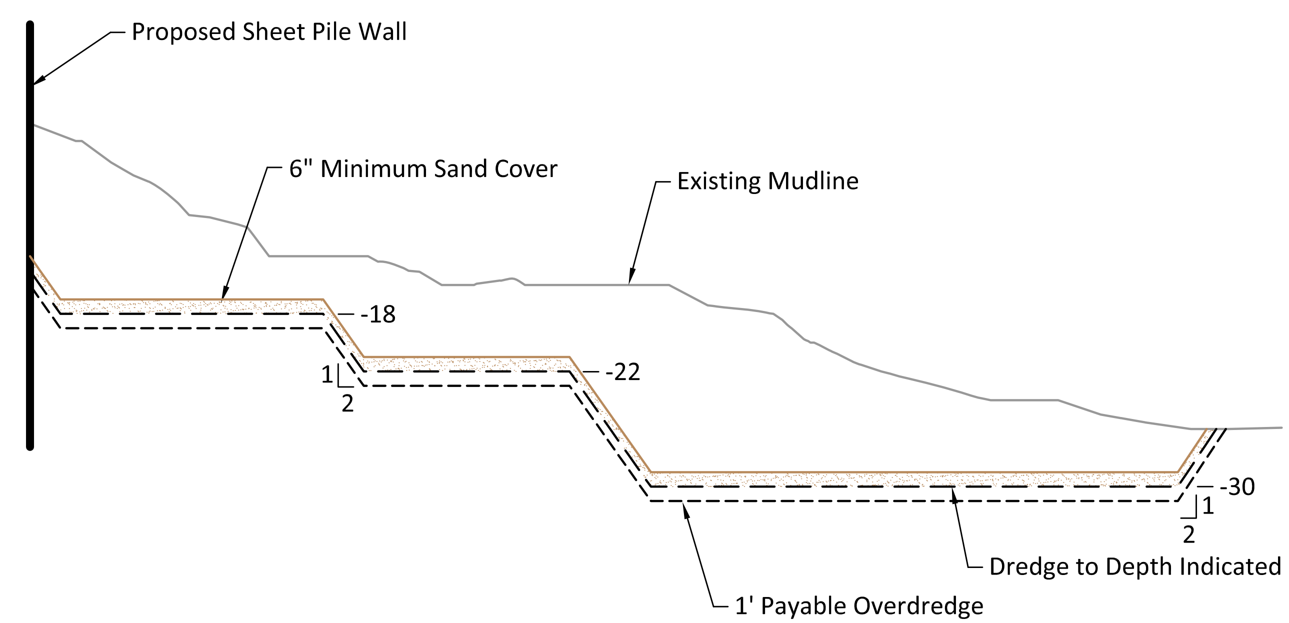
LEGEND:

AS-108	2008 Core Sample		SMA Boundary
AS-113	2008 Surface Sediment Sample	10	Bathymetric Contour in Feet
PG-13	Existing Sediment Core Sample		Proposed Dredge Footprint Daylight Line
PGSP-103	Existing Surface Sediment Sample	(-38)	Proposed Dredge Depth in Feet
	MHHW (Mean Higher High Water)		Minimum 6-Inch-Thick Sand Cover
	Approximate MLLW (Mean Lower Low Water)		

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: MLLW
NOTE: Bathymetry outside 2007 dredging areas from 2003.
Bathymetry inside 2007 areas from 2007.

ESTIMATED DREDGE VOLUME: 28567 cubic yards.



Cross Section Schematic
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Figure 6-12
Conceptual Dredge Alternative in SMA-2
Former Pope & Talbot Sawmill Site

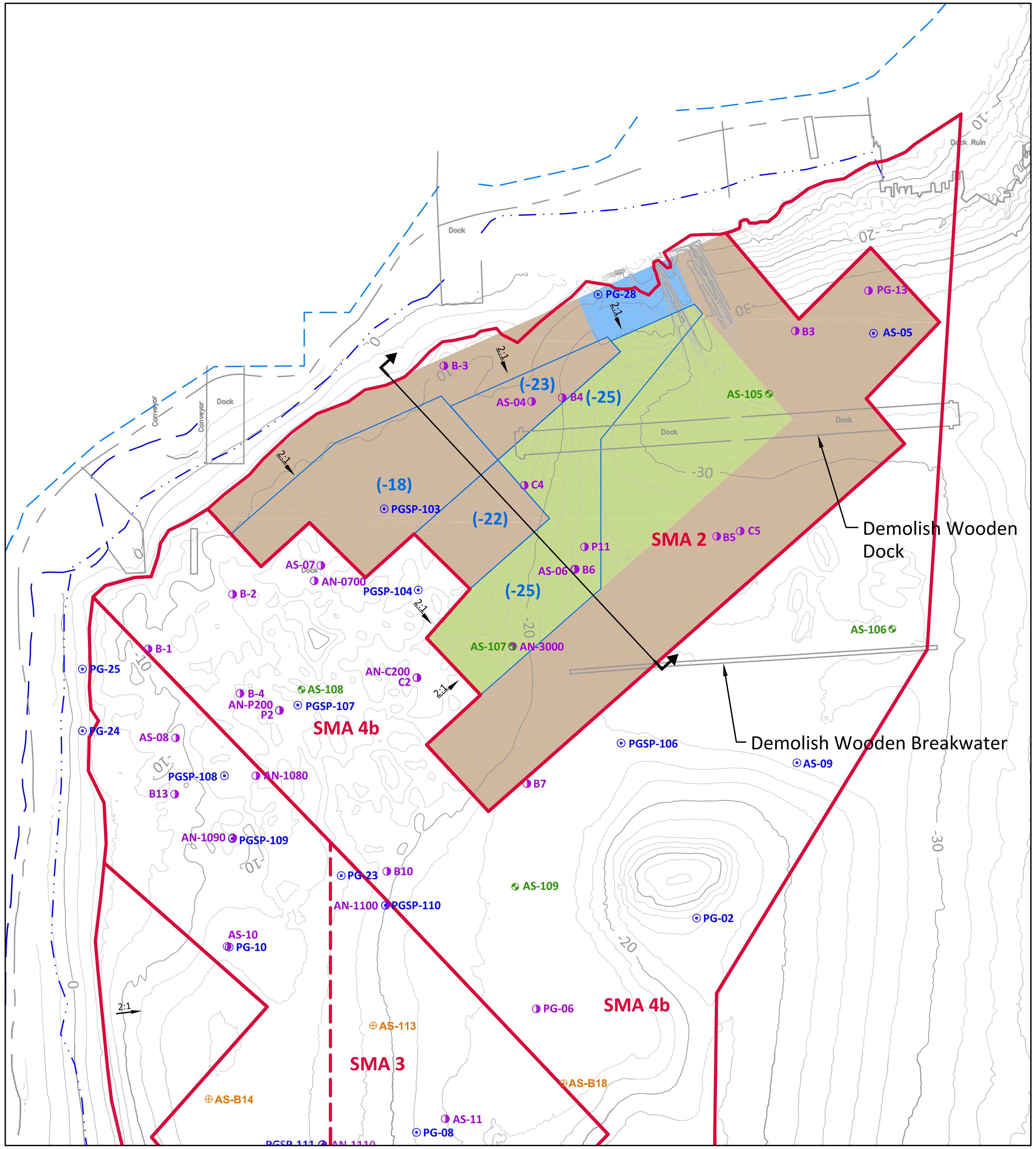
LEGEND:

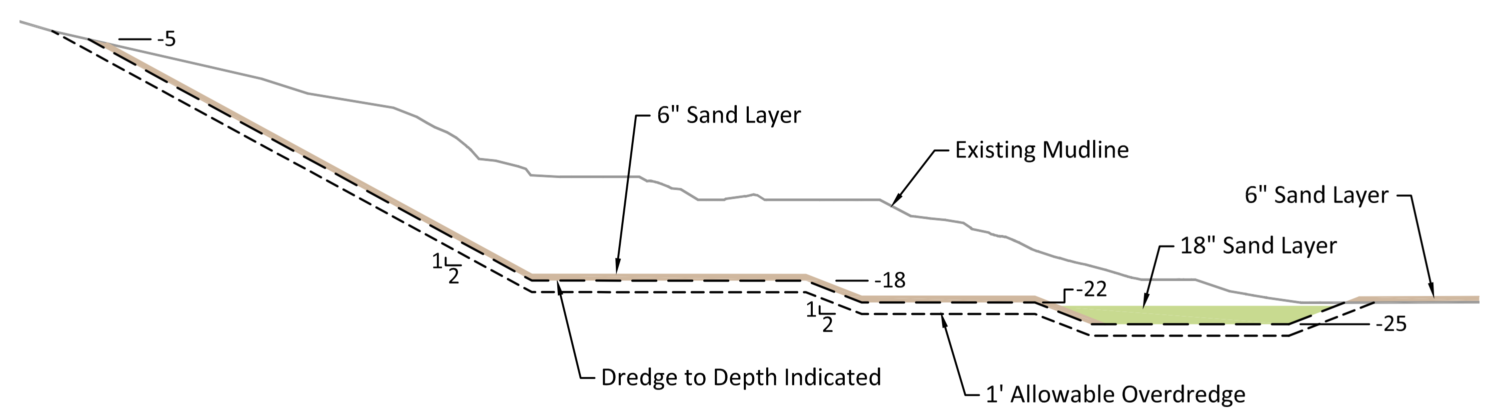
AS-108	2008 Core Sample
AS-113	2008 Surface Sediment Sample
PG-13	Existing Sediment Core Sample
PGSP-103	Existing Surface Sediment Sample
	MHHW (Mean Higher High Water)
	Approximate MLLW (Mean Lower Low Water)
	SMA Boundary
-10	Bathymetric Contour in Feet
	Proposed Dredge Footprint Daylight Line
(-32)	Proposed Dredge Depth in Feet
	3-Foot-Thick Armored Cap (Type I)
	18-Inch-Thick Sand Cap (Type II)
	6-Inch-Thick Sand Cover (Type III)

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: MLLW
NOTE: Bathymetry outside 2007 dredging areas from 2003. Bathymetry inside 2007 areas from 2007.

ESTIMATED DREDGE VOLUME: 10,070 cubic yards
ESTIMATED OVERDREDGE VOLUME: 727 cubic yards





Cross Section Schematic
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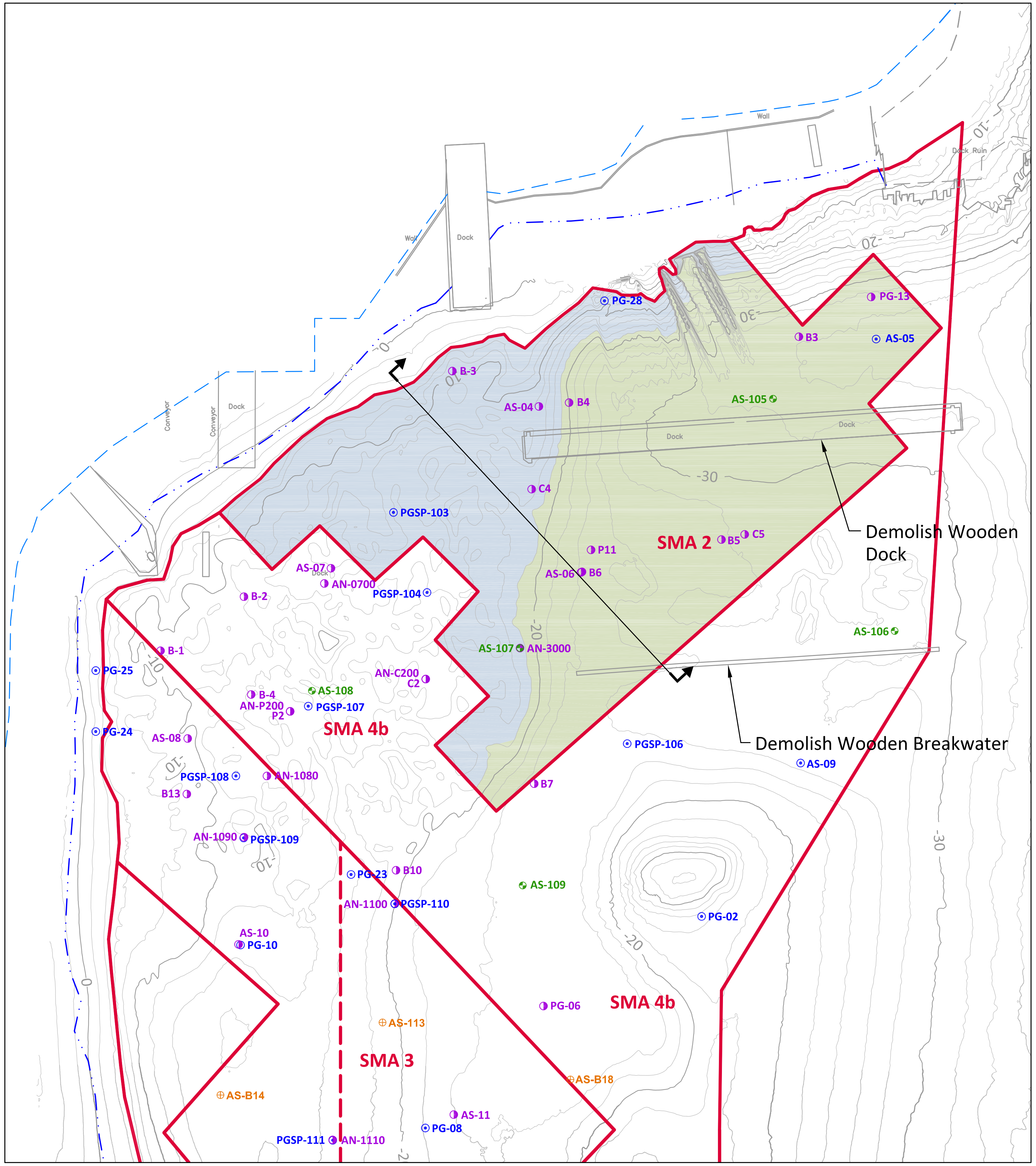
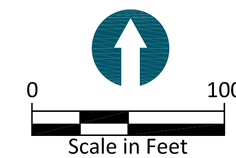
Figure 6-13
Conceptual Dredge and Cap Alternative in SMA-2
Former Pope & Talbot Sawmill Site

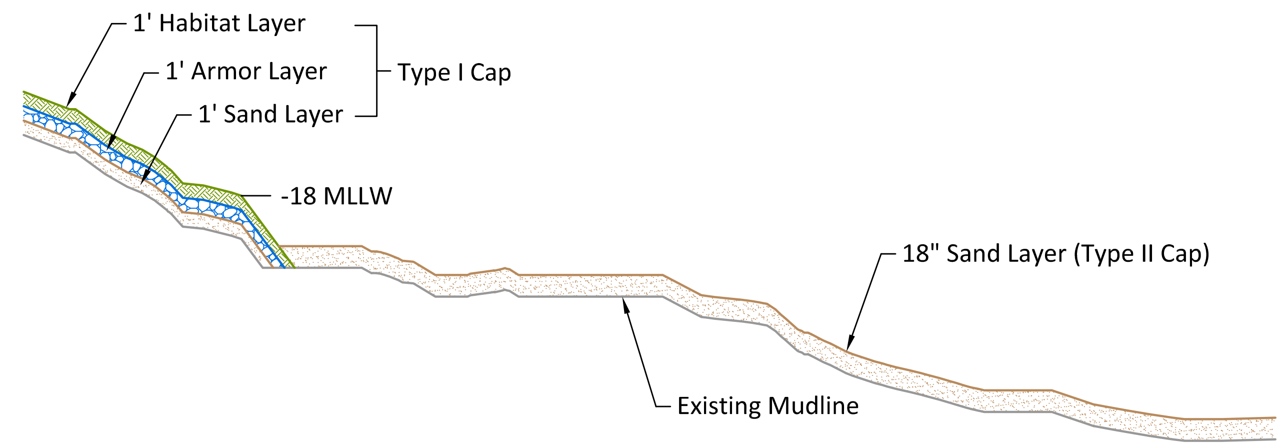


LEGEND:

AS-108	2008 Core Sample
AS-113	2008 Surface Sediment Sample
PG-13	Existing Sediment Core Sample
PGSP-103	Existing Surface Sediment Sample
	MHHW (Mean Higher High Water)
	Approximate MLLW (Mean Lower Low Water)
	SMA Boundary
-10	Bathymetric Contour in Feet
	3-Foot-Thick Armored Cap (Type I)
	18-Inch-thick Sand Cap (Type II)



HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM:
NOTE: Bathymetry outside 2007 dredging areas from 2003. Bathymetry inside 2007 areas from 2007.



Cross Section Schematic
Not to Scale

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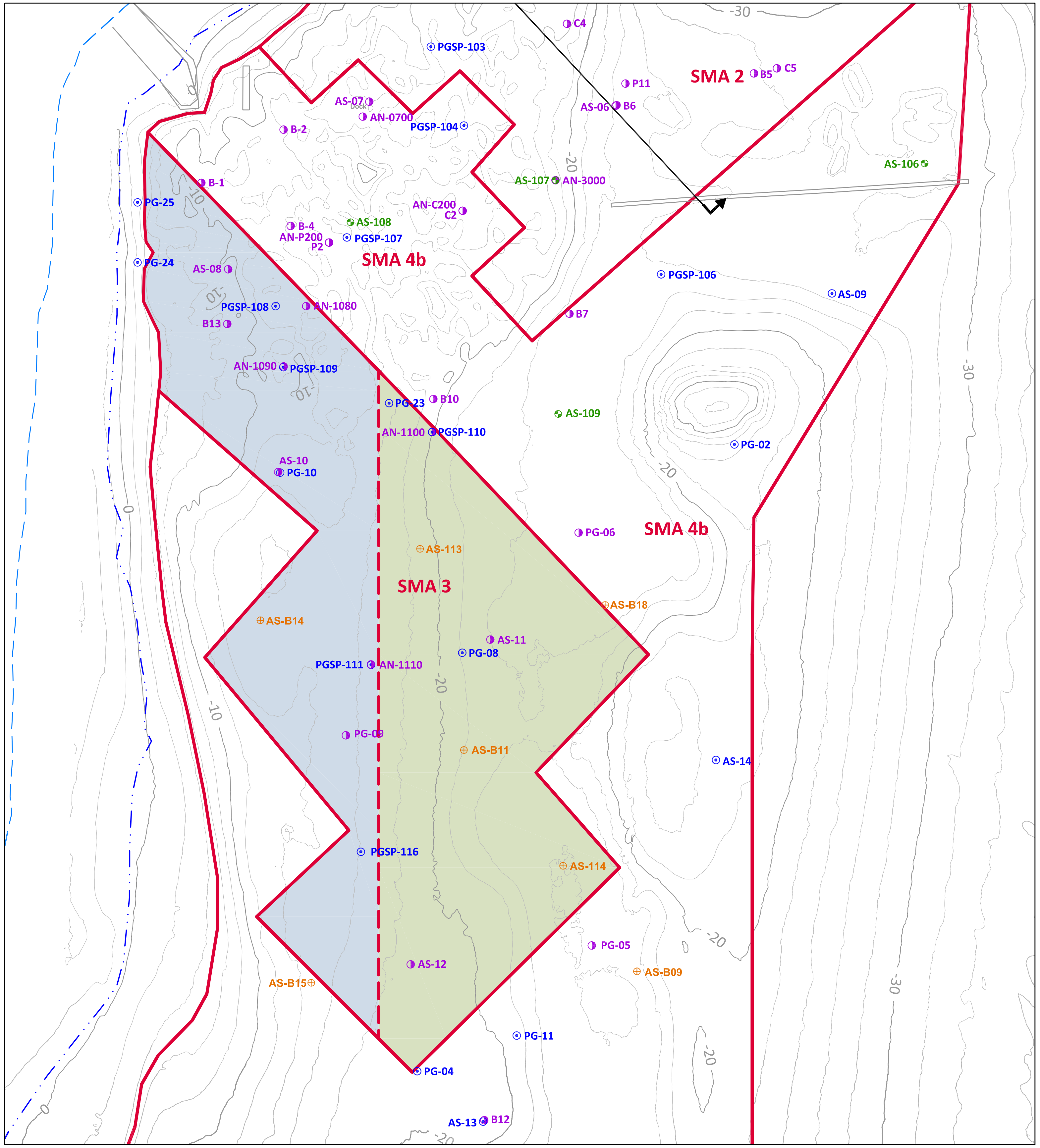
ANCHOR QEA

Figure 6-14
Conceptual Engineered Cap Alternative in SMA-2
Former Pope & Talbot Sawmill Site

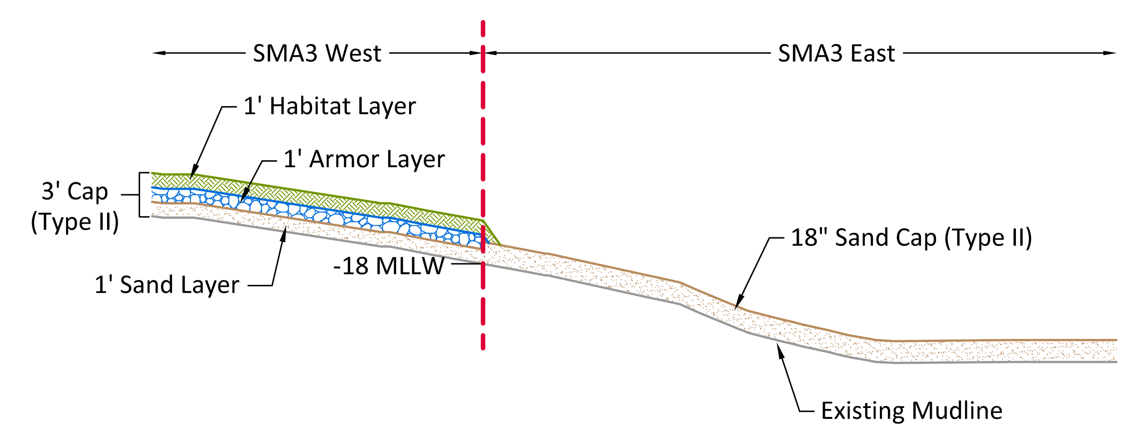


LEGEND:

- AS-108 2008 Core Sample
- AS-113 2008 Surface Sediment Sample
- PG-13 Existing Sediment Core Sample
- PGSP-103 Existing Surface Sediment Sample
- MHHW (Mean Higher High Water)
- Approximate MLLW (Mean Lower Low Water)
- SMA Boundary
- Bathymetric Contour in Feet
- 3-Foot-Thick Armored Cap (Type I)
- 18-Inch-thick Sand Cap (Type II)

0 100
Scale in Feet

HORIZONTAL DATUM: Washington State Plane North, NAD83.
VERTICAL DATUM: MLLW
NOTE: Bathymetry outside 2007 dredging areas from 2003. Bathymetry inside 2007 areas from 2007.



Cross Section Schematic
Not to Scale

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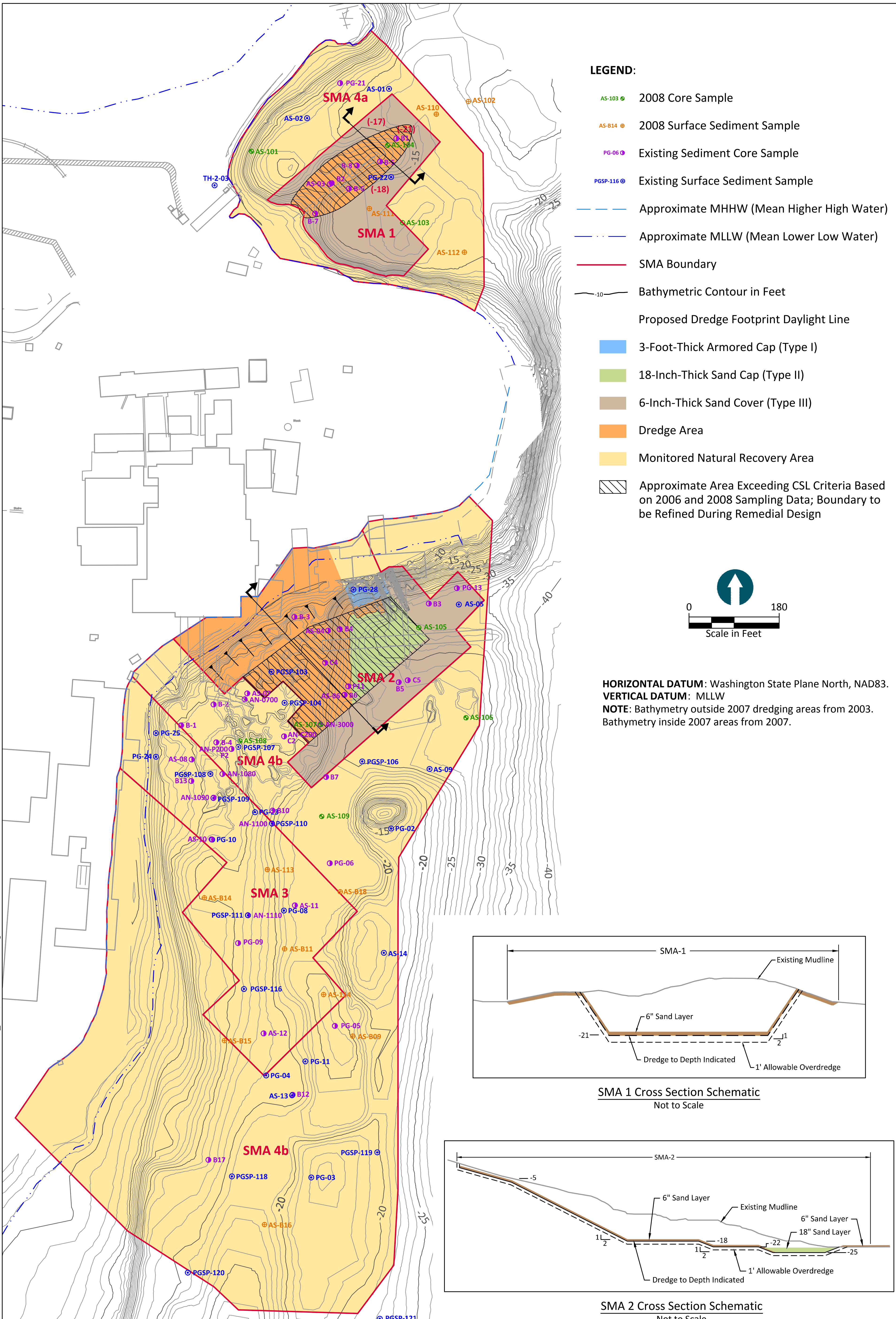
Feb 17, 2010 4:59pm heriksen

ANCHOR QEA

Figure 6-15
Conceptual Engineered Cap Alternative in SMA-3
Former Pope & Talbot Sawmill Site



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Feb 17, 2011 10:47am heriksen

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Figure 7-1
Recommended Site-Wide Sediment Cleanup Action
Former Pope & Talbot Sawmill Site

Non-Detected cPAH Dry Weight Concentration (mg/kg)
- <0.0061 mg/kg
- ≥0.0061 - 0.0151 mg/kg
- ≥0.0151 - 0.0231 mg/kg
- >0.0231 mg/kg

Detected cPAH Dry Weight Concentration (mg/kg)
- <0.0061 mg/kg
- ≥0.0061 - 0.0151 mg/kg
- ≥0.0151 - 0.0231 mg/kg
- >0.0231 mg/kg

- 2007 Dredge and Cover Area
- 2007 Dredge Area
- 2003 Dredge Area
- Mill Site Sediment Management Area

NOTES:
1. Horizontal Datum: WA State Plane North Zone NAD83 Feet.
2. Aerial Photo: 2009 National Agriculture Imagery Program.
3. Data presented is 2000 and 2008.
4. U=Non-Detected
5. Background dry weight cPAH is 0.0077 mg/kg.
6. The cleanup level for cPAH's is set at the PQL of 20 μg/kg corresponding to a cPAH TEQ of approximately 15.1 μg/kg.

0 125 250 500
Feet

\\hamster\gis\Jobs_PortGamble\Maps\2010_10\DryWeight_cPAH.mxd epipkin 10/20/2010 9:55 AM

Figure 7-2
Port Gamble Surface Sediment cPAH Concentrations Relative to PQL and Regional Background
Port Gamble, WA

ANCHOR QEA

\\hamster\gis\Jobs_PortGamble\Maps\2010_10\Cadmium.mxd epipkin 10/20/2010 8:20 AM

NOTES:
1. Horizontal Datum: WA State Plane North Zone NAD83 Feet.
2. Aerial Photo: 2009 National Agriculture Imagery Program.
3. Data presented is 2000 and 2008.
4. U=Non-Detected
5. Background is 1.1 mg/kg

Cadmium Concentrations (mg/kg)
- ≤1.1 mg/kg
- >1.1 mg/kg

- 2007 Dredge and Cover Area
- 2007 Dredge Area
- 2003 Dredge Area
- Mill Site Sediment Management Area

0 125 250 500
Feet

Figure 7-3
Port Gamble Surface Sediment Cadmium Concentrations Relative to Regional Background
Port Gamble, WA

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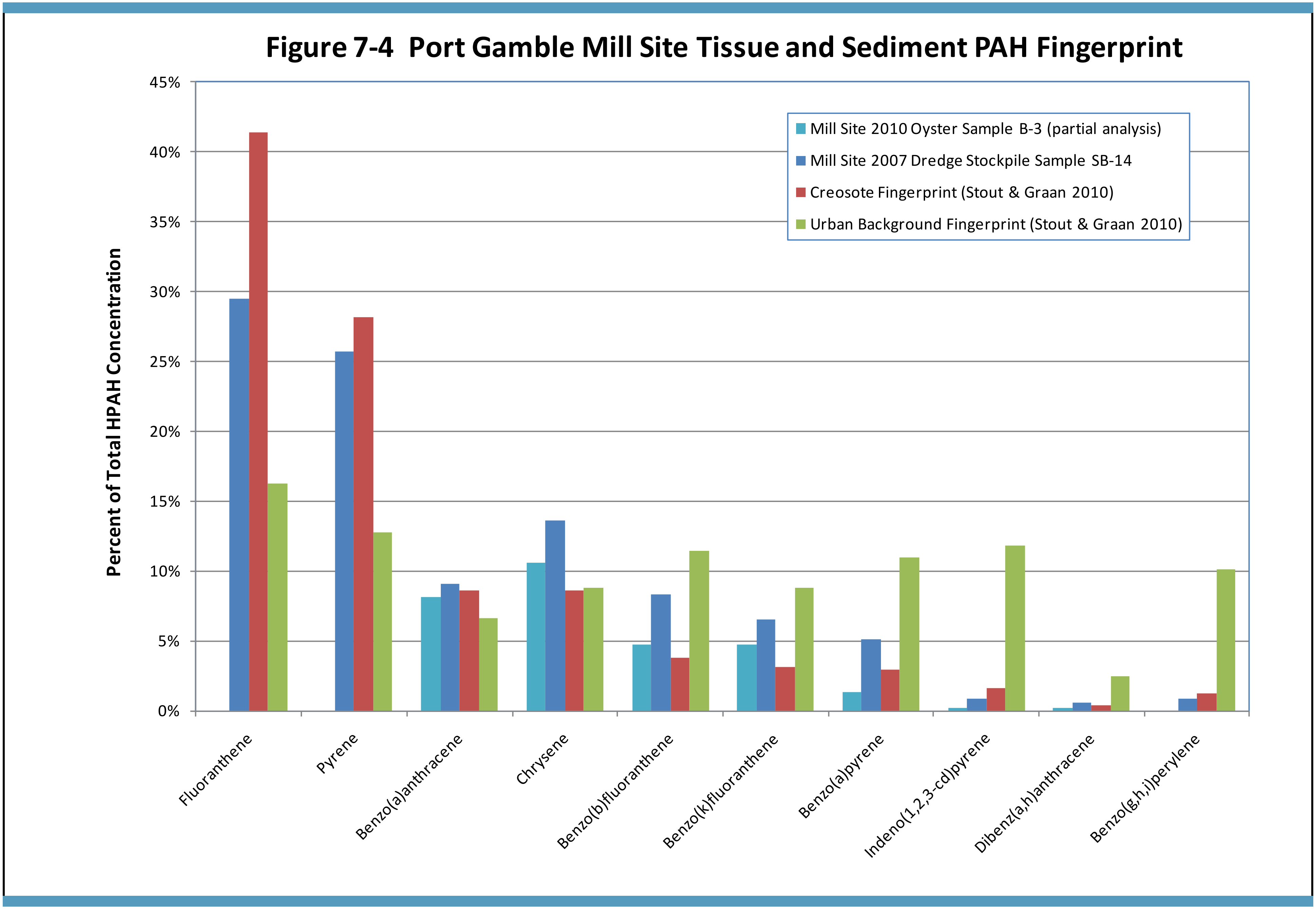

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Figure 7-4
Port Gamble Mill Site Tissue and Sediment PAH Fingerprint
Former Pope & Talbot Sawmill Site

APPENDIX A
MARINE AREA COST ESTIMATES

Summary of Detailed Costs for Disproportinate Cost Analysis (DCA)

Remedial Options per Sediment Management Area 7/1/2010

SMA 1		Rounded
SMA-1 - Dredge to Maximum Extent and Residuals Management.	$ 1,497,036	$ 1,500,000
SMA-1 - Dredge and Engineered Cap	$ 1,708,115	$ 1,700,000
SMA 2		
SMA-2 - Dredge to Maximum Extent and Residuals Management.	$ 3,253,165	$ 3,300,000
SMA-2 - Dredge and Engineered Cap	$ 1,843,371	$ 1,800,000
SMA-2 - Engineered Cap	$ 1,871,574	$ 1,900,000
SMA 3		
SMA-3 - Engineered Cap	$ 1,676,836	$ 1,700,000
SMA-3 - ENR and Monitor Recolonization	$ 1,131,932	$ 1,100,000
SMA-3 - Monitored Natural Recovery	$ 360,000	$ 400,000
SMA 4 (4a)		
SMA-4a - ENR and Monitor Recolonization	$ 957,693	$ 1,000,000
SMA-4a - MNR and Monitor Recovery	$ 360,000	$ 400,000
SMA 5 (4b)		
SMA-4b - ENR and Monitor Recolonization	$ 2,921,135	$ 2,900,000
SMA-4b - MNR and Monitor Recovery	$ 360,000	$ 400,000

SMA-1 - Dredge to Maximum Extent and Residuals Management					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	290	EA	$ 625	$ 181,250	
Transportation and Disposal	290	TON	$ 100	$ 29,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	10,500	CY	$ 20	$ 210,000	
Transportation and Disposal (Open Water)	10,500	CY	$ 5	$ 52,500	
Debris Screening/Offload/Transport & Dispose	788	TON	$ 75	$ 59,063	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	3,556	TON	$ 22	$ 78,222	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	3,556	TON	$ 20	$ 71,111	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 791,146	
Construction Contingency	30	%		$ 237,344	
Total Construction Cost				**$ 1,028,490**	
Project Management	5	%		$ 51,424	
Engineering and Design	10	%		$ 102,849	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 102,849	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	0	LS	$ 50,000	$ -	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 51,424	
Total Non-Construction Cost				**$ 468,547**	
Total Cost				**$ 1,497,036**	

SMA-1 - Dredge and Engineered Cap					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	290	EA	$ 625	$ 181,250	
Transportation and Disposal	290	TON	$ 100	$ 29,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	7,000	CY	$ 20	$ 140,000	
Transportation and Disposal (Open Water)	7,000	CY	$ 5	$ 35,000	
Debris Screening/Offload/Transport & Dispose	525	TON	$ 75	$ 39,375	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	3,556	TON	$ 22	$ 78,222	12-inch thick (including overplacement)
Purchase & Transport Armor Material	2,250	TON	$ 25	$ 56,250	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix	2,250	TON	$ 20	$ 45,000	12-inch thick (including overplacement)
Place Cap/Cover Sand	3,556	TON	$ 20	$ 71,111	
Place Armor Material	2,250	TON	$ 20	$ 45,000	
Place Habitat Mix	2,250	TON	$ 25	$ 56,250	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 886,458	
Construction Contingency	30	%		$ 265,938	
Total Construction Cost				**$ 1,152,396**	
Project Management	5	%		$ 57,620	
Engineering and Design	10	%		$ 115,240	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 115,240	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	1	LS	$ 50,000	$ 50,000	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 57,620	
Total Non-Construction Cost				**$ 555,719**	
Total Cost				**$ 1,708,115**	

SMA-2 - Dredge to Maximum Extent and Residuals Management					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	432	EA	$ 625	$ 270,000	
Transportation and Disposal	432	TON	$ 100	$ 43,200	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	33,000	CY	$ 20	$ 660,000	
Transportation and Disposal (Open Water)	33,000	CY	$ 5	$ 165,000	
Debris Screening/Offload/Transport & Dispose	2,475	TON	$ 75	$ 185,625	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	6,225	TON	$ 22	$ 136,950	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	6,225	TON	$ 20	$ 124,500	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install	450	LF	$ 300	$ 135,000	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 1,830,275	
Construction Contingency	30	%		$ 549,083	
Total Construction Cost				**$ 2,379,358**	
Project Management	5	%		$ 118,968	
Engineering and Design	10	%		$ 237,936	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 237,936	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	0	LS	$ 50,000	$ -	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 118,968	
Total Non-Construction Cost				**$ 873,807**	
Total Cost				**$ 3,253,165**	

SMA-2 - Dredge and Engineered Cap					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	432	EA	$ 625	$ 270,000	
Transportation and Disposal	432	TON	$ 100	$ 43,200	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	10,000	CY	$ 20	$ 200,000	
Transportation and Disposal (Open Water)	10,000	CY	$ 5	$ 50,000	
Debris Screening/Offload/Transport & Dispose	750	TON	$ 75	$ 56,250	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	5,001	TON	$ 22	$ 110,022	
Purchase & Transport Armor Material	300	TON	$ 25	$ 7,500	
Purchase & Transport Habitat Mix	300	TON	$ 20	$ 6,000	
Place Cap/Cover Sand	5,001	TON	$ 20	$ 100,020	
Place Armor Material	300	TON	$ 20	$ 6,000	
Place Habitat Mix	300	TON	$ 25	$ 7,500	
Sheet Pile Wall					
Sheet Pile Provide and Install	-	LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 966,492	
Construction Contingency	30	%		$ 289,948	
Total Construction Cost				**$ 1,256,440**	
Project Management	5	%		$ 62,822	
Engineering and Design	10	%		$ 125,644	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 125,644	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	1	LS	$ 50,000	$ 50,000	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 62,822	
Total Non-Construction Cost				**$ 586,932**	
Total Cost				**$ 1,843,371**	

SMA-2 - Engineered Cap					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	432	EA	$ 625	$ 270,000	
Transportation and Disposal	432	TON	$ 100	$ 43,200	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	8,190	TON	$ 22	$ 180,180	18-inch thick (including overplacement)
Purchase & Transport Armor Material	2,400	TON	$ 25	$ 60,000	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix	2,400	TON	$ 20	$ 48,000	12-inch thick (including overplacement)
Place Cap/Cover Sand	8,190	TON	$ 20	$ 163,800	
Place Armor Material	2,400	TON	$ 20	$ 48,000	
Place Habitat Mix	2,400	TON	$ 25	$ 60,000	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 983,180	
Construction Contingency	30	%		$ 294,954	
Total Construction Cost				**$ 1,278,134**	
Project Management	5	%		$ 63,907	
Engineering and Design	10	%		$ 127,813	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 127,813	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	1	LS	$ 50,000	$ 50,000	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 63,907	
Total Non-Construction Cost				**$ 593,440**	
Total Cost				**$ 1,871,574**	

SMA-3 - Engineered Cap					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	102	EA	$ 625	$ 63,750	
Transportation and Disposal	102	TON	$ 100	$ 10,200	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	9,000	TON	$ 22	$ 198,000	18-inch thick (including overplacement)
Purchase & Transport Armor Material	3,400	TON	$ 25	$ 85,000	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix	3,400	TON	$ 20	$ 68,000	12-inch thick (including overplacement)
Place Cap/Cover Sand	9,000	TON	$ 20	$ 180,000	
Place Armor Material	3,400	TON	$ 20	$ 68,000	
Place Habitat Mix	3,400	TON	$ 25	$ 85,000	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 867,950	
Construction Contingency	30	%		$ 260,385	
Total Construction Cost				**$ 1,128,335**	
Project Management	5	%		$ 56,417	
Engineering and Design	10	%		$ 112,834	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 112,834	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	1	LS	$ 50,000	$ 50,000	Based on 5 events at $10,000 each for each SMA
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 56,417	
Total Non-Construction Cost				**$ 548,501**	
Total Cost				**$ 1,676,836**	

SMA-3A - ENR and Monitor Recolonization					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	102	EA	$ 625	$ 63,750	
Transportation and Disposal	102	TON	$ 100	$ 10,200	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	7,200	TON	$ 22	$ 158,400	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	7,200	TON	$ 20	$ 144,000	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 486,350	
Construction Contingency	30	%		$ 145,905	
Total Construction Cost				**$ 632,255**	
Project Management	5	%		$ 31,613	
Engineering and Design	10	%		$ 63,226	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 63,226	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 30,000	$ 150,000	Based on 5 events at $30,000 each for ENR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 31,613	
Total Non-Construction Cost				**$ 499,677**	
Total Cost				**$ 1,131,932**	

SMA-3 - Monitored Natural Recovery					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	-	LS	$ 40,000	$ -	
Demobilization	-	LS	$ 40,000	$ -	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	-	EA	$ 625	$ -	
Transportation and Disposal	-	TON	$ 100	$ -	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	-	TON	$ 22	$ -	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	-	TON	$ 20	$ -	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	-	LS	$ 10,000	$ -	
Bathymetric Surveys	-	EA	$ 10,000	$ -	
Subtotal Construction Costs				$ -	
Construction Contingency	30	%		$ -	
Total Construction Cost				**$ -**	
Project Management	5	%		$ -	
Engineering and Design	10	%		$ -	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ -	
Environmental Monitoring during Construction	0	WEEK	$ 12,500	$ -	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 50,000	$ 250,000	Based on 5 events at $30,000 each for ENR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	1	LS	$ 25,000	$ 25,000	
Total Non-Construction Cost				**$ 360,000**	
Total Cost				**$ 360,000**	

SMA-4a - ENR and Monitor Recolonization					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	80	EA	$ 625	$ 50,000	
Transportation and Disposal	80	TON	$ 100	$ 8,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	5,125	TON	$ 22	$ 112,750	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	5,125	TON	$ 20	$ 102,500	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 383,250	
Construction Contingency	30	%		$ 114,975	
Total Construction Cost				**$ 498,225**	
Project Management	5	%		$ 24,911	
Engineering and Design	10	%		$ 49,823	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 49,823	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 30,000	$ 150,000	Based on 5 events at $30,000 each for each ENR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 24,911	
Total Non-Construction Cost				**$ 459,468**	
Total Cost				**$ 957,693**	

SMA-4a - MNR and Monitor Recovery					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	-	LS	$ 40,000	$ -	
Demobilization	-	LS	$ 40,000	$ -	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	-	EA	$ 625	$ -	
Transportation and Disposal	-	TON	$ 100	$ -	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	-	TON	$ 22	$ -	12-inch thick (including overplacement)
Purchase & Transport Armor Material	-	TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix	-	TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	-	TON	$ 20	$ -	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	-	LS	$ 10,000	$ -	
Bathymetric Surveys	-	EA	$ 10,000	$ -	
Subtotal Construction Costs				$ -	
Construction Contingency	30	%		$ -	
Total Construction Cost				**$ -**	
Project Management	5	%		$ -	
Engineering and Design	10	%		$ -	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ -	
Environmental Monitoring during Construction	0	WEEK	$ 12,500	$ -	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 50,000	$ 250,000	Based on 5 events at $50,000 each for MNR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	1	LS	$ 25,000	$ 25,000	
Total Non-Construction Cost				**$ 360,000**	
Total Cost				**$ 360,000**	

SMA-4b - ENR and Monitor Recolonization					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	1	LS	$ 40,000	$ 40,000	
Demobilization	1	LS	$ 40,000	$ 40,000	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling	450	EA	$ 625	$ 281,250	
Transportation and Disposal	450	TON	$ 100	$ 45,000	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	26,400	TON	$ 22	$ 580,800	12-inch thick (including overplacement)
Purchase & Transport Armor Material		TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix		TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	26,400	TON	$ 20	$ 528,000	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	1	LS	$ 10,000	$ 10,000	
Bathymetric Surveys	2	EA	$ 10,000	$ 20,000	
Subtotal Construction Costs				$ 1,545,050	
Construction Contingency	30	%		$ 463,515	
Total Construction Cost				**$ 2,008,565**	
Project Management	5	%		$ 100,428	
Engineering and Design	10	%		$ 200,857	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ 200,857	
Environmental Monitoring during Construction	6	WEEK	$ 12,500	$ 75,000	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 30,000	$ 150,000	Based on 5 events at $30,000 each for ENR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	5	%		$ 100,428	
Total Non-Construction Cost				**$ 912,570**	
Total Cost				**$ 2,921,135**	

SMA-4b - MNR and Monitor Recovery					
Item	**Amount**	**Units**	**Unit Cost**	**Total Cost**	**Notes**
Mobilization and Demobilization					
Mobilization	-	LS	$ 40,000	$ -	
Demobilization	-	LS	$ 40,000	$ -	
Demolition					
Dock Demolition (including piles)	-	SF	$ 45	$ -	
Pile Pulling		EA	$ 625	$ -	
Transportation and Disposal	-	TON	$ 100	$ -	Assume dead load of 50 psf for pier (including piles) and 1 ton per pile
Dredging and Disposal					
Dredging	-	CY	$ 20	$ -	
Transportation and Disposal (Open Water)	-	CY	$ 5	$ -	
Debris Screening/Offload/Transport & Dispose	-	TON	$ 75	$ -	Assume 5 % of dredged material
Capping/Cover					
Purchase & Transport Cap/Cover Sand	-	TON	$ 22	$ -	12-inch thick (including overplacement)
Purchase & Transport Armor Material	-	TON	$ 25	$ -	12-inch thick (including overplacement)
Purchase & Transport Habitat Mix	-	TON	$ 20	$ -	12-inch thick (including overplacement)
Place Cap/Cover Sand	-	TON	$ 20	$ -	
Place Armor Material	-	TON	$ 20	$ -	
Place Habitat Mix	-	TON	$ 25	$ -	
Sheet Pile Wall					
Sheet Pile Provide and Install		LF	$ 300	$ -	Allows for 10 ft excavation.
Eelgrass planting	-	ACRE	$ 50,000	$ -	
Environmental Controls	-	LS	$ 10,000	$ -	
Bathymetric Surveys	-	EA	$ 10,000	$ -	
Subtotal Construction Costs				$ -	
Construction Contingency	30	%		$ -	
Total Construction Cost				**$ -**	
Project Management	5	%		$ -	
Engineering and Design	10	%		$ -	
Permitting	1	LS	$ 75,000	$ 75,000	
Construction Management	10	%		$ -	
Environmental Monitoring during Construction	0	WEEK	$ 12,500	$ -	Assume 2 FTE + boat and monitoring equipment
Verification Sampling	1	LS	$ 10,000	$ 10,000	
Long Term Monitoring	5	LS	$ 50,000	$ 250,000	Based on 5 events at $50,000 each for each MNR
Mitigation	0	LS	$ 50,000	$ -	
Ecology Oversight Costs	1	LS	$ 25,000	$ 25,000	
Total Non-Construction Cost				**$ 360,000**	
Total Cost				**$ 360,000**	